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PREFATORY ESSAY.

METHODS AND RESULTS IN MODERN THEOLOGY.

By the Rev. W. E. Collins, M.A.

PROFESSOR OF ECCLESIASTICAL HISTORY AT KING'S COLLEGE, LONDON.

Religion and Theology.

AT the present day there is no special tendency to make a confusion between religion and theology; on the contrary, it would seem that we are almost too ready to conclude that they may be regarded as entirely distinct. From one point of view religion has recently been defined, by Professor William James, as "the feelings, acts, and experiences of individual men in their solitude so far as they apprehend themselves to stand in relation to whatever they may consider the Divine." From a rather different standpoint, Matthew Arnold has defined it as "morality touched by emotion": a definition which is felt to be unsatisfactory unless it denotes morality, in the largest sense of that much misused word, as traced back to and springing from the motive power which gives it birth, viz., the devotion of a personal being to that which is recognized as the end of conduct and the goal of aspiration. Theology, on the other hand, is the study which deals with what is known, or assumed to be known, of that end and goal, both in its essential nature and in all its relations with conduct and being; in a word, it is the science of the Divine. Religion and theology differ, therefore, both in idea and in scope. It may indeed be questioned whether they ever are or can be entirely separable: many would contend that a theology of some kind, more or less definite or indefinite, is presupposed in all religion, at any rate implicitly. But those who repudiate the one would resent, and not unnaturally, any assertion or implication that they had thereby abandoned the other; and although it is possible that the tendency of to-day is to separate them overmuch, at least it is clear that they can in no sense be identified.

Faith and Theology.

But there is another distinction which must not be lost sight of; viz., the distinction between theology in a narrower and theology in a wider sense; or better perhaps between the faith itself and its intellectual embodiment in a theology. The faith itself declares the relations existing (or believed to exist) between religious people and the object or objects of their religion. But the human mind is such that these relations must inevitably find their expression in certain statements or propositions, which in turn must take their place side by side with the remainder of our intellectual stock in trade. Hence arises a developed theology. The Christian faith, to which from this point we confine ourselves, represents certain truths in the spiritual universe and states certain historic facts, or what are believed to be such; theology endeavours to correlate these with our other knowledge. The faith itself is common to simple and learned; theology is primarily a domain of the intellect. The faith cannot be said to change, generally speaking, excepting in so far as its adherents enter in course of time more or less fully into the depths of its meaning; there is a sense in which it must be said that theology, like natural science, is always changing. For theology is the attempt to express this unchanging faith in the terms of philosophy and to embody it in a historical and logical system; to correlate it with the facts of life and the highest knowledge and thought of the day; to apply it afresh to the satisfaction of human aspirations in the light of ever-varying circumstances. To accomplish this end, it becomes of necessity subject to the dominant intellectual methods and processes of the day, and it absorbs or makes use of such material as is current in its day. By applying itself to the resolution of problems which are always changing, it systematizes itself in a shape which has reference to circumstances which are merely transitory. By bracing itself to meet new modes of thought which would cut away the ground beneath its feet, or discoveries which threaten to demolish its former presuppositions, it learns to breathe more freely and to accommodate itself to ampler quarters, only to find in time that these likewise must be vacated, and that there is yet more beyond. The theological difficulties of one generation furnish the theological armoury of the next: the apologetic of one age is the basis of the scepticism of the age that follows.

Theology ever changing.

Theology must then of its very nature be constantly modifying its affirmations, constantly shifting its ground and changing its centre of gravity. It thrives by submitting to new laws. It grows by the accumulation of new facts, by the assimilation of ways of thought at first strange to itself, by the development of its latent power and the manifestation of its inherent truth under the pressure of new necessities. It is preserved from stagnation and death by the confession, or at least the repudiation, of its own mistakes; by the rejection of ways of thought which have grown old, of antiquated theories and exploded facts which it once accepted in common with every form of human thought; by the retracing, sometimes frankly acknowledged, more often concealed and disguised or not even recognized, of its own footsteps. Above all, it lives and flourishes whenever, and in proportion as, it learns to enter afresh into the meaning of some element of the Christian faith: whenever, in the words of the Master, some "scribe instructed unto the kingdom of heaven" is enabled to "bring forth out of his treasure things new and old." Christian theology, in a word, seems always to be on the losing side, and yet it always comes out without loss in the long run. That this is so is the result of the fact that there is in it one element which is always dying, and one which never dies. For, as Dr George Salmon has said: "Every union of philosophy and religion is the marriage of a mortal with an immortal; the religion lives; the philosophy grows old and dies. When the philosophic element of a religious system becomes antiquated, its explanations which contented one age become unsatisfactory to the next, and there ensues what is spoken of as a conflict between religion and science; whereas, in reality, it is a conflict between the science of one generation and that of the succeeding one."

That such a change is continually going on in the theological thought of every age is a matter of constant observation. It is impossible to glance through any substantial theological writing of a former century, say the fourth, or the sixteenth, or the eighteenth, without finding that, although there may be much that at once appeals to the modern mind, there is even more which no longer does so. Of the latter, there may indeed be some elements which would be useful as correctives, simply because they deal, from a point of view other than our own, with that which is common to us and to them. But there will probably be much more which, owing to the fact that it is moulded in accordance with the presuppositions and the theories of a former day, has now come to be evacuated of all possible meaning for us. In fact, its analogies with the philosophical and other writings of its own day, even with those which are non-religious, or even sceptical in tone, are in some respects closer than with those of modern theological writings. Theology has shifted its ground: it has given way on all hands. Again and again it has renounced pretensions which were once made on its behalf with the utmost boldness; and it has been content to learn its own lesson at the feet of philosophy and natural science. And yet few thoughtful men would say that theology has become enfeebled as the result of the process. It has learned to submit to certain limitations indeed, but limitation is not always loss. The theologian may claim that, in the process of restriction within the modified intellectual content of the age, theology is continually being maintained in its proper sphere, as supplying the clue to all life and being—that clue which alone gives meaning and purpose to a world which would otherwise be without any real significance.

Causes of the Change which has come over Modern Theology.

Seldom, if ever, has a greater change come over the theology of any age than that which was observed in the last sixty or seventy years of the nineteenth century. At the beginning of that period, as Dr J. B. Mayor has said, "Theology was the repetition of the formulas of the fourth and sixteenth centuries; every word of the Bible was divinely dictated, equally important and equally infallible; human reason was out of place in the sphere of religion, which consisted mainly in emotional utterance or ritual observance; the operation of Divine grace was limited by the recognition of the three Orders and of Apostolical Succession, or else by the assurance of conversion on the part of the individual; art, science, politics, and social life belonged to the world, which was either forbidden ground, or at least so full of snares as to make it hazardous for the ordinary Christian to venture upon." As late as 1848, when Robertson of Brighton said that one of the duties of the library committee of a Working Men's Society was to furnish books of amusement, he was greatly sneered at. "Many well-meaning and religious persons said I had forgotten my place as a clergyman in speaking of works of fiction as fit for labouring men. They were shocked and startled that I dared to reckon it a matter of rejoicing that there is a moral tone in that well-known publication which is dedicated to wit and humour, or that I even named it." Many changes, both religious and theological, have come about since then. Old landmarks have been removed entirely; phrases formerly all-powerful have ceased to have any meaning for us; old watchwords, such as verbal inspiration, substitution, experimental religion, and the like, have been evacuated of much of their force. On the one hand, there has sprung up a widespread feeling which is not so much anti-religious as unreligious, but which is at any rate frankly untheological; and its results are to be seen on all sides, in the decay of church-going, the decrease of Bible-reading, the non-observance of Sunday, and the like. On the other hand, there has been, not only in the British Isles but on the mainland of Europe, a decided increase of religious earnestness, which has shown itself especially in the direction of a very notable "Catholic revival." Meanwhile, the conflict between religion and science has gone on, and neither has been a loser by it. One thing after another has been denounced as absolutely contrary to the Christian faith: in course of time it has come to be a household word to us, and yet the faith is none the worse for it. Nevertheless, it would be hard to imagine a change more far-reaching.

The causes which have led to this change are not far to seek; nor have they influenced theology alone. For it is in fact part and parcel of the change which has come over all human life and thought; and the causes which have revolutionized every other activity of the human mind have not left theology untouched. An attempt must be made to summarize them here, difficult though it is, or impossible, to summarize them completely.

(a) The Romantic Movement.

(*a*) First in order must be placed the widespread Romantic Movement which, seeking its inspiration in the art and literature and the ideals of the Middle Ages, has recovered and recreated for us conceptions of beauty, truth, and fellowship which had almost died out of our conscious life. At times it has been erratic and extravagant; it has degenerated at times into the barrenness of a mere mediæval eclecticism. But nothing could have been further from its normal character than this. As a whole it has been eminently sane and clear-sighted; and Coleridge and Shelley, Scott and Southey, Blake and Ruskin in England, not to speak of even greater leaders elsewhere, gave a new tone and a new direction to men's thoughts. Its influence has by no means passed away yet. Nowhere has it been more conspicuously felt than in theology; and the Oxford Movement, with its watchword "Hear the Church," was but an exemplification, though by far the most conspicuous and fruitful one, of a process which infused new life into the Catholicism of France, which for a time deeply affected the Lutheranism of Germany and Denmark, and which even touched orthodox Russia in the persons of Khomiakoff and others.

(*b*) Hardly less important in its influence upon theology has been the great social movement of modern days, which has altogether inverted, so far at least as words are concerned, our sense of the relative importance of the individual and the society; which has given us both the conception of "solidarity" and the word by which to express it; which has deepened our sense of the corporate life of the State, and enabled us once more to speak the language of Aristotle's *Politics*. It is easy to exaggerate the permanent, or even the temporary, effects of such a movement as this; and nothing is more certain than that human nature does not change itself when it adopts a new form of speech. But the fact remains that human life is largely dominated by great ideas; and, however transitory the victory may prove to be, modern political history is, more largely than anything else, a record of the triumphs of the new social creed in a succession of peaceful conflicts. Here again theology has been largely influenced by what it at first regarded with the greatest suspicion, and indeed has found in it a revelation of its own teaching; for the conception of the relation between the society and the individual finds at once its source and its most complete fulfilment in that of the Body and its members. The results are to be seen in the liberal movement in France which centres round Lamennais and his friends, and in that which for a moment seemed likely to place Pope Pius IX. at the head of a united Italy. They are to be seen in the early Christian Socialist movement which had Maurice and Kingsley and Ludlow for its leaders, and in the more developed movements of later days; in the zeal for social work which has taken hold of all the churches; in the remarkable revival of devotion to the ideals of St Francis of Assisi in our own day, the full results of which are perhaps still to be seen. Above all, they have left their record, and find their inspiration, in the larger realization of the fellowship of God and men in the Body of Christ which runs through modern theology. One striking instance of the change may be given. Cardinal Newman has declared in the *Apologia* that from his earliest days he had never had any conviction so strong as "the thought of two, and two only, supreme and luminously self-evident beings, myself and my Creator." In *The Gospel of Life* and elsewhere the late Bishop Westcott, with the words of Newman in this mind, has expressed his firm conviction that they do not exhaust the truth, and that man is or may be conscious of three self-evident final existences, Self, the World, and God. Perhaps each writer may be held to have expressed accurately the view most generally current in the period during which he wrote.

(b) The Social Movement.

(*c*) Still more profound and far-reaching has been the change which has come over all human thought as the result of the bursting of the bonds of eighteenth-century philosophy on the one hand, and the great discoveries of modern science on the other. As regards the former, thought has been delivered from the deadlock of a method which in reality involved the denial of the possibility of affirming even phenomena; thus the way was opened for a new philosophy, which was given to the world by Kant in his Transcendental Idealism. As regards the latter, partly by its actual discoveries and still more by its majestic inductions, it has altogether overturned our preconceived ideas of the life-history of the world, and placed before us a larger and more unitary conception of it than had been possible since the revival of learning. After years of repudiation or jealous suspicion, both philosophy and science have at length been allowed to deliver their message for the theologian. Hegel, Lotze, T. H. Green, and James Martineau have remodelled our religious philosophy, Coleridge and Maurice have linked it with history and brought it into contact with practical religion; and if for a time theories based on the metaphysics of Sir William Hamilton, such as those of Mansel, still prevailed and were made use of as a valuable bulwark of a traditional theology, further consideration has made it plain that their basis and their inevitable outcome is what is now known as agnosticism. Again, thoughts derived from natural science have been introduced into theology, to the great benefit of the latter. The ideas of evolution and development have been found to acquire an even fuller meaning when viewed in the light of the New Testament, *e.g.*, in the light of the teaching of St Paul as to the destiny of "the whole creation." Little by little they have permeated all theology, delivered it from some of the survivals of eighteenth-century deism, and given form and life to much that was otherwise mechanical and shapeless.

(c) Philosophy and Science.

(*d*) Nevertheless, the new ideas seemed at first sight only to emphasize a divorce between "profane" and "sacred" learning which had already become apparent. On the one hand, conflict could only be avoided by keeping the two carefully separated; on the other, physical science was rapidly enlarging its ground. Moreover, such a segregation of sacred learning could only mean stagnation and ever-

(d) Protests on behalf of Liberty and Thought.

increasing unreality. Against this the protests have been almost incessant; in fact, one of the most salient features of the theology of the nineteenth century has been its constant effort after reality and entire intellectual sincerity. It is this absolutely fearless honesty and freedom in dealing with the Bible which made Maurice's *Patriarchs and Lawgivers* (1851) and *Prophets and Kings of the Old Testament* (1853) such a revelation in his own day; and although they were published so many years ago, these qualities make them valuable still. The same thing is true, in some measure, of J. R. Mozley's *Ruling Ideas in Early Ages* (1876); and in a far larger degree of Seeley's *Ecce Homo* (1865), with its strikingly fresh presentment of the work and teaching of our Lord. The real importance of *Essays and Reviews*, which appeared in 1860, arises from the fact that they were "an attempt to illustrate the advantages derivable to the cause of religious and moral truth from a free handling, in a becoming spirit, of subjects peculiarly liable to suffer by the repetition of conventional language, and from traditional methods of treatment." Their permanent value as actual teaching is not great, but their real importance may be gauged by any one who will read them in the light of to-day, and then consider the outcry which they occasioned on their first appearance. And their significance as a landmark in theology may be appreciated by comparing them, both as regards method and scope, with the essays in *Lux Mundi*, which appeared in 1889 as the outcome of a "conviction that the epoch in which we live is one of profound transformation, intellectual and social, abounding in new needs, new points of view, new questions, and certain therefore to involve great changes in the outlying departments of theology, where it is linked on to other sciences, and to necessitate some general statement of its claim and meaning." Or they may be compared, again, with the essays in *Contentio Veritatis*, which appeared in 1902 and represents a much more markedly "liberal" standpoint. Such a comparison will suggest the inference that the trend of thought during the intervening period has been decidedly constructive rather than destructive; that, however much it may shrink from over-definition, its tendency certainly cannot be described as untheological; and above all, that it centres more whole-heartedly than ever about the Person of Christ.

(e) Scientific Analysis.

(*e*) This temper of free and candid examination has gone hand in hand with one of rigorous analysis. That this should have been so was but natural. When the bases of our knowledge in other spheres were being tested and overhauled, theology could not reasonably be held exempt from the same process. Nor could a merely ecclesiastical disintegration and reconstruction be judged sufficient. It was not enough that theology should overhaul its own fabric and reshape itself in accordance with its own presuppositions: its historical bases must be tested by the same rigorous methods which were employed elsewhere. And this is precisely what was done. The Bible, the creeds, and the institutions of the Church were placed on their trial; the accretions of ages were torn away, with more or less of skill and discrimination as the case might be. Christianity itself was cast into the crucible, and this not at the hands of indifferent or hostile unbelief but, on the whole, of precise and rigorous scientific scholarship. So much at least is clear to us now, for we are far enough away to see things in their true proportions. If there was much *a priori* reasoning, if many of the negative conclusions which were arrived at were inevitable in view of the assumed premisses upon which they really rested, there was surprisingly little of definite or conscious bias against the Christian faith, ready as people were to think otherwise at the time. Even when the conflict waxed fiercest, defenders and assailants of the received views were alike fellow-students; and Bishop Westcott has left it on record that he had often learned more from those with whom he disagreed most fundamentally than from those with whom he found himself in agreement. The methods adopted were those of rigorous analysis, which only became more exact and more scientific as time went on, and as the principles of historical and textual criticism came to be better understood. Moreover, the very eagerness with which the evidence was scanned led to the discovery of fresh evidence, which has often served to clinch the matter in dispute. The scholars of many nations have contributed their quota; and if it be allowed that Germany has done the lion's share of the work, exhibiting the most searching analysis and the most brilliant conjecture, it may fairly be claimed that the best British scholarship excels in soberness of judgment and scholarly completeness. The period of conflict has been prolonged and arduous. Little by little the inquiry may be said in a measure to have worked itself out. Not, indeed, that finality has been reached upon all or even upon most of the points involved; but, at least, certain tangible objects have been compassed, and certain tangible results have been obtained. Theological science would appear to have reached its limits for the present in certain directions, and to be tending towards fresh developments in others. It may therefore be possible to take stock of some elements of our progress as it would hardly have been some twenty years ago, and also to note and record the character which has been impressed upon the theology of the present day itself, as the result of this period of disintegration and growth.

The Characteristic Form of Modern Theology.

The historical method.

To speak first of the latter. Briefly, the great change which has come over theology itself, during the period under review, may be summed up in the formula, "Back to history." Theology has become historical. Its chief evidences are, and must ever be, those which appeal to the conscience; but it has become historical in such a sense that it can be both studied and taught historically by students of varying faiths, as is at the present time the case in the new University of London. It has become historical in its methods to a quite unprecedented degree. That this should be so is inevitable in an age which has so greatly enlarged our knowledge of the past, and has poured forth upon the theologian a continual stream of new documents and other evidence, which could only be interpreted, or correlated with our existing materials, by historical methods, and which reflect back a flood of light upon those materials in the process. In these circumstances, theology has of necessity become largely historical in its methods; to such an extent indeed that almost all the more notable theological literature of recent years has partaken largely of that character. It would not of course be true to say that *a priori* arguments have altogether lost their ground, or that deductive reasoning has no longer any place in theology; such a thing would obviously be impossible in a subject which deals so largely with matters which depend in the main upon the testimony of the individual consciousness, and which are not capable of immediate verification by actual experiment. But the fact remains that in theology, as distinguished from religion, the inductive method has come to precede and to underlie all else; and, so far as theology is concerned, the inductive method is the historical method. Here, at any rate, there would seem to be true and, it is to be hoped, permanent progress, and not merely a temporary phase of evolution. Most of the mistakes of theology in the past have resulted from a rooted habit of building hypotheses upon insufficient or unverified premisses, of failing to test alleged developments rigorously enough by a reference to the foundations upon which they profess to be based. The time has come for theorizing to give place to careful inquiry. The facts must be made to yield up their own evidence, and they will only do so as we learn to study and to interrogate them aright. In other words, the historical method is the proper and scientific method in theological study. And regarded from this point of view, our progress in theology falls into line with progress in other studies. Sir Frederick Pollock has pointed out, in his *History of the Science of Politics*, that in the century which has passed away, progress in physics, indeed in natural science generally, meant a fuller realization of the great principles first enunciated by Newton; that progress in philosophy meant "Back to Kant," and in politics "Back to Aristotle." In like manner it may be said that progress in theology means "Back to history."

"Back to history."

But it is not only as a method of accurate analysis that the theologian has recourse to the historical method. He does indeed make use of it in this way, as a means of delivering himself from the futility of baseless theorizing. He avails himself of every means at his command—exact linguistic and textual study, the method of survivals, and the comparative method—he seeks every sidelight that is offered by archæology or political history, by ethnology or physical geography, in order that he may get at the actual facts. But that is not all. History means more to the theologian than it did. It is more to him than a kind of prolegomena to a religious philosophy; it is more than the determination of a basis for sound reasoning or unassailable generalization. To the theologian of to-day history is, as Dr Fairbairn has said, "a continued creative process due to the continued, though conditioned, activity of the original creative Mind." To him the facts of life are not something extraneous which must be stripped off before he can penetrate to certain divine realities; they are in themselves a revelation of those realities. To him religion finds its highest expression not in human thought, but in human life.

This new reverence for human life, and for life in all its forms, is of course based upon a theological motive. It is the outcome of a fresh realization of the cosmic significance of Christianity itself, as being in its essence, in Bishop Westcott's words, neither a philosophy nor a law, but a Person and a Life. "Christianity announces in the plainest terms a vital union of the finite and the infinite as the fundamental Gospel. In the brief phrase, 'The Word became flesh,' the opposition and the reconciliation, the difference and the union in one Person, of Being eternal and temporal is set forth not as a speculation or as a thought, but as a historic event." From this point of view Christianity claims to be historical in an unique sense. "It was prepared for by a long national development, into which the typical elements of the ancient world entered as contributory forces. It is summed up in the facts of a divine-human life. It has been, and still is being, wrought out in the slow and unreturning life of a society." In other words, from the standpoint of to-day the Christian religion centres more than ever in the Person, rather than in the teaching of its Founder, and Christian theology centres in the Incarnation (which potentially includes all else) rather than in the Atonement. That this is so will not be doubted by any one who will consider the general character of the theological literature of the last forty or fifty years. It is concerned with the history and the Person of Christ to an extraordinary degree. Never before, as has been pointed out by Dr A. J. Mason, were there published so many professed Lives of Our Lord and books bearing immediately on that subject; never since the days of the great Greek fathers was the Incarnation, both in itself and in its bearing on life and conduct, the subject of so much thought and study. The problem of the Synoptic Gospels and their relation to St John, upon which so much excellent work has been done in recent years, derives its whole interest and importance from the fact that it aims at bringing us into an even closer contact with Him. And thus it may be said that the theological watchword, "Back to history," really amounts to "Back to Christ."

Some Elements of Theological Progress in Recent Years.

We turn now to the consideration of some particular elements of the theological progress of recent years. Here again our examination can only be partial and fragmentary; we can do no more than attempt to indicate results in outline, the full nature of which must be sought elsewhere.

1. Christianity and other Religions.

1. *Christianity and other Religions.*—The time has long passed away when it was possible for the theologian either to disregard every other religion but that of the Hebrews, or to regard them simply as so many forms of error. A faith which demanded for itself exceptional treatment or exclusive consideration would have thereby put itself out of court, so far as scientific inquiry is concerned. Such a thing would indeed have been impossible at the present day, when the researches of such scholars as Tiele, de la Saussaye, Waitz, Max Müller, Ratzel, de Quatrefages, Tyler, and Frazer have practically opened to us a wholly new world of religious knowledge. Modern Christian apologetic is based in this respect not upon the ignoring of other religions, but upon a presentment of them in their right relation with Christianity. In this view, they are so many partial and typical representations of the truth, whilst Christianity, which is "the Absolute Religion," alone fully satisfies the craving to which they all bear witness. It has been drawn out by many writers, but nowhere more ably than by the most recent of all, Dr A. M. Fairbairn. In his *Philosophy of the Christian Religion* (1902) he has endeavoured to show that "the conception of Christ stands related to history as the idea of God is related to nature, *i.e.*, each is in its own sphere the factor of order, or the constitutive condition of a rational system"; and that "the Son of God holds in his pierced hands the keys of all the religions, explains all the factors of their being and all the persons through whom they have been realized." Nor is this relation between Christianity and other religions to be discerned only in their general character; it may be seen also in particular institutions. Of these there is none which so well illustrates this fundamental solidarity of religion as that of sacrifice, the full significance of which was first set forth by the late Professor Robertson Smith. It was, he showed, the life, not the death of the victim that was

signified by its immolation; and this immolation was always accompanied by a sacrificial feast, in which others partook besides the offerer. In fact so essential was this participation that even a private sacrifice was not complete without guests, and the surplus of sacrificial flesh was not sold but distributed freely. Thus "every act of sacrifice expressed the idea that man does not live for himself only but for his fellows," and the fundamental idea of the sacrifice itself is that of "communion between the god and his worshippers by the joint participation in the living flesh and blood of a sacrificial victim." Dr F. B. Jevons can hardly be said to have over-estimated the significance of these facts when he summarizes them as follows: "The whole human race for thousands of years has been educated to the conception that it was only through a divine sacrifice that perfect union with God was possible for man. . . . Of all the great religions of the world it is the Christian Church alone which is so far heir of all the ages as to fulfil the dumb, dim expectation of mankind; in it alone the sacramental meal commemorates by ordinance of its founder the divine sacrifice which is a propitiation for the sins of mankind."

2. The Doctrine of God.

2. *The Doctrine of God.*—The change which has come over modern theological thought in this respect is most marked. It has been pointed out by Mr A. W. Robinson that the dominant conception of theology was until quite recently, as it had been since the early part of the eighteenth century, the Moral Government of God. To this all else was subsidiary, and the attributes of God which were most dwelt upon were such as were most directly connected with it. Law was the expression of his will: reverent submission and obedience were the right attitude of human beings towards him, and all else drew down upon itself the inevitable penalties due to a broken law and an outraged holy will. Now all this is altered: theology has rediscovered the great cardinal truth of the Fatherhood of God, and learned to see in it that upon which all else depends. This of course is pure gain; but it has not been achieved without loss. Our age has seen at the same time "a widespread weakening of the meaning of Law." We have a much greater realization of the universality of its operation, but have largely lost the thought of a personal Will behind its manifestations; and law has come to be interpreted to us as only the inevitable sequence of events. This has greatly weakened the sense of sin amongst us, a fact which may be discerned in the absence of the note of severity in most of our moral teaching. Thus the thought of fatherly love has often been eviscerated, by the annihilation of those elements of moral uprightness and holy sternness which are really essential to it. And thus the idea of the Fatherhood of God has been whittled away into one of mere good nature.

3. Doctrine of Jesus Christ.

3. *The Doctrine of Jesus Christ.*—The fresh realization of the Fatherhood of God has brought with it a fresh realization of the meaning of the Incarnation. It was not arbitrary. There was already in human nature something cognate to the divine, of which the Son of God could take hold; and in doing so, he was fulfilling that which was foreshadowed for man from the first. Accordingly, as has been said already, the Incarnation has once more taken its place as being, rather than the Atonement, the central point of Christian doctrine. In fact, although there has been a constant development of thought and not in any sense a mere retrogression, that development has manifested itself in a return from the characteristic standpoint of Latin theology (*i.e.*, that which had its first home in Roman Africa) towards that of the Greek fathers. The former was largely man-centred, the latter God-centred. The former started from the point of view of human duty, and concerned itself too exclusively with the problems of man's nature and destiny; the latter started from the primary revelation of God's relation to man, as made known in concrete facts and witnessed to by every human aspiration. There can be no doubt that Christian theology in the West, where alone it has been a vital force in modern days, has been largely moulded by the former; and not less so in the North than in the churches of the Roman obedience. We have suffered not a little from what Bishop Westcott called "the evils of that Africanism which has been dominant in Europe since the time of Augustine"; and its one-sidedness has been the basis of not a few current misunderstandings of Christian doctrine, and of many of the objections which have been brought against it. "One of the most influential and rigorous philosophers of modern times," he says, "said not long ago with a voice from the grave [*i.e.*, John Stuart Mill] that the sufferings and disparities of life, the contrasts of the Law and the Gospel point to the action of rival spiritual powers or to a Creator limited by something external to himself. Not so,

was Origen's reply: they simply reveal [the fact] that what we see is a fragment of a vast system in which we can do no more than trace tendencies, convergences, signs, and rest upon the historic fact of the Incarnation." Thus the new standpoint in theology has had no little effect, both in illuminating faith and in removing current misunderstandings with regard to it. But it has done more than this. It has caused more stress than ever to be laid upon the reality of the Incarnation, and in particular upon the actuality of the Lord's human life upon earth. Upon this, it has been perceived, depends both the completeness of his fellowship with the human race and the truth of his human example. Accordingly, recent theological writers (the best known of whom in England is perhaps Dr Gore, Bishop of Worcester) have emphasized strongly the reality of the "self-emptying" (κένωσις, Phil. ii. 6*f.*) of the Lord. They have taught that in assuming human nature, he vouchsafed to lay aside the exercise of all powers which would have rendered a true human life impossible; that he submitted himself to be recipient of the Holy Spirit and to learn by human processes as we do; and that he so truly accepted and so consistently maintained these voluntary limitations throughout his human life that he was "in all things made like unto his brethren," sin only excepted. Naturally, these conclusions have not been received without considerable dissent, for it has been fully recognized by those who have put them forward that they are not in accordance with the bulk of past teaching on the subject. But in reply to this it is urged with great force that St Cyril of Alexandria, whose influence on the other side has been the strongest, undoubtedly goes too far, and "lays himself open to the charge of minimizing the significance of our Lord's humanity"; that the theological writers of former days have as a rule made no attempt to investigate the entire teaching of the New Testament on the subject; and above all, that this teaching itself, when so investigated, is quite unmistakably clear.

4. The Christian Church

4. *The Christian Church.*—Of course, this is not the place in which to speak in detail of the particular advances which have been made as the result of the historical study of the faith and institutions of the Church. Excellent work has been done in Gebhardt and Harnack's *Texte und Untersuchungen*, the Cambridge *Texts and Studies*, and other similar collections; by Lightfoot, Zahn, Harnack, Hilgenfeld, Langen, Duchesne, Hatch, and many more. It must suffice to summarize it shortly under three heads, and to say a few words on each. (*a*) Mention has been made already of the very numerous theological and other writings which have been discovered or first made available in our own day, and which have so largely widened the horizon of the student. Naturally, they are of very different character for different periods: great collections of state papers and confidential correspondence in later mediæval and modern days; chronicles, letters, liturgical books, theological treatises in the earlier mediæval period; earlier still, fragments of all sorts on a much smaller scale, but of even greater interest, coming as they often do from Armenia and other hitherto little-ransacked mines in the East. Two classes of documents of great value may be named in this last-mentioned period: the *Church Orders*, and the "heterodox" documents of early date. The former have already added much to our knowledge of the institutions of the Church, and will add yet more as they are more thoroughly studied. As regards the latter, writings which were thrown aside and forgotten in the post-Nicene period because of their theological vagaries are of course of the greatest value to-day in helping us to determine the true character of an age or the history of a doctrine. (*b*) Excellent work has been done, again, in the historical study of the development of dogma, which has found its chief home in Germany. Much excellent study has been given to the tracing back of theological watchwords to their earliest sources, and above all to the investigation of the relation between Christian ideas and the terms of Greek thought in which they have been expressed. And the result is to be found in a clearer recognition of the fact that, in Dr Sanday's words, "All doctrine is relative—relative in the first instance to the age in which it was drawn up, and relative at all times to the limitations of our human faculties aiming at that which is infinite and divine." (*c*) Not less notable is the work which has been done in the study of Christian institutions and the like, in their origin and development; with the general result that we are beginning to learn that in almost every case what is to be looked for is not some definite creation of a developed institution, but a growth from very insignificant and often chaotic beginnings.

5. *The Old Testament.*—In no department of theology has there been so great a change as that which has come over the study of the Old Testament since about 1870. In a word, these years have seen the triumph of the Higher Criticism; *i.e.*, that criticism which deals not merely with textual and documentary data, but which submits the documents themselves to analysis and reconstructs the history which they embody, by the consideration of the spirit which underlies them, the whole atmosphere which they exhale, and all the knowledge that we can derive from external sources; in other words, that very historical criticism which has given us such large results in other fields of study. In the later volumes of the ninth edition of the *Encyclopædia Britannica*, published under the editorship of Professor Robertson Smith, that great scholar was instrumental in making known to English readers, almost for the first time, many of the chief results of the Higher Criticism; and, so far as *assured* and *accepted* results are concerned, there is little to be added from later sources to the articles therein contained. The change is rather in the way in which the Higher Criticism is now regarded. Its main results, or rather its main principles, are now accepted on all hands amongst scholars; for even the French Catholics, as M. Houtin has reminded us in his *Question Biblique chez les Catholiques de France* (1902), are now accepting them freely, and have given to the world one Old Testament scholar at least who enjoys an European reputation, in the person of M. Loisy. It is agreed that the Prophets, not the Law, must be the starting-point of all our study of the history of Israel, and that the Hexateuch must be recognized as a compilation of late date, the chief constituent elements of which have been distinguished and identified; that the early parts of Genesis, down to the call of Abraham, are great religious prose poems, based upon the folk-lore which the early Israelites had inherited in common with their neighbours, and that the story of the Patriarchal period has reached us as recorded by much later generations, though it is probably based, to a large extent, upon genuine historical tradition; that much of the contents of the book of Judges is authentic; and that with the books of Samuel we enter upon real and authentic history, a history which is retold from a later and biassed point of view in the Chronicles; lastly, that the whole Levitical system was the result of a late growth, of which we can trace the stages with more or less of clearness. So far there is agreement; and indeed it cannot be doubted that results have been reached which, so far as they go, are assured. For if it be asked, as it has been, whether the present critical "results" of Old Testament study may not prove to be as entirely nugatory as many of those obtained in the New Testament by the scholars of the Tübingen school, the answer is that the methods of the two are entirely different. The results of modern Old Testament study have been obtained by the use of the very same historical method which has in our own day demolished many of the conclusions of the Tübingen school. "The Tübingen theories," writes Professor George Adam Smith, "were largely deductions from the principles of a certain philosophy of history. But the proofs of Old Testament criticism are not *a priori:* the argument is inductive, and the facts are furnished by the Old Testament itself." Although there will doubtless be much to learn and to unlearn in the future, much at any rate is certain. Recently (1902), however, an attempt has been made by Dr Cheyne in the *Encyclopædia Biblica* to use an analogous method to that of the Tübingen school, and to reconstruct the whole text of the Old Testament by a bold system of conjectural emendation, based upon what is largely an *a priori* assumption as to the whole course of the history of the Hebrew people. Briefly, his view is that the Hebrew people had really to do, not with Egypt and Syria, Babylon and Assyria, but with certain obscure tribes of North Arabia; and he has amended the text of the Old Testament throughout with a view to substantiating this hypothesis. No more need be said here than that these views do not find support amongst Old Testament scholars at large; nor would experience of the results of wholesale conjectural emendation in other fields of study (especially when made to support a preconceived idea) lead us to expect many permanent results here.

5. The Old Testament.

6. *The New Testament.*—It has been intimated already, and the fact is now generally acknowledged, that the result of modern critical work on the New Testament books has been to invalidate the objections which have been brought against their genuineness, and to substantiate in a remarkable degree the view which has always been held in the Church as to their age and character. Dr Adolf Harnack has recognized this plainly, in words to which Professor Sanday has more than once called

attention: "There was a time—the great mass of the public is still living in that time—when people felt obliged to regard the oldest Christian literature, including of course the New Testament, as a tissue of deceptions and falsifications. That time is past. For Science it was an episode in which she has learned much, and after which she has much to forget. . . . The oldest literature of the Church is in the main points and in most of its details trustworthy. In the whole New Testament there is probably but a single writing which can be called, in the strictest sense of the word, pseudonymous, the second Epistle of Peter. . . . Moreover, the number of writings interpolated in the second century (like the Pauline epistles) is very slight, and most of the interpolations are as harmless as the interpolations of our hymn-books and catechisms. . . . Baur and his school believed themselves able to sketch an intelligible and trustworthy picture of the development of primitive Christianity only by throwing over . . . the testimony of the writings themselves . . . and by bringing down the date of composition several decades. On the assumption from which they started, that Jewish Christianity and Gentile Christianity (which they called Paulinism) were the ruling factors of the development until far beyond the middle of the second century, there was nothing for them to do but to place most of the writings late, and to look in the rest for traces (it was impossible to find more than traces) of the gradually slackening conflict. . . . The assumptions of Baur's school are now, one may say, generally abandoned." And he adds: "A time will come, it is already drawing near, in which men will not trouble themselves much more about the working out of problems of literary history in the region of primitive Christianity, because whatever can be made out about that will have acquired a general assent, viz., the essential accuracy of tradition with but a few unimportant exceptions. It will be recognized that in part even before the destruction of Jerusalem, in part by the time of Trajan, all the fundamental expressions of Christian traditions, doctrines, preachings, and even ordinances, were essentially complete." No doubt this remarkable declaration would not be endorsed in every detail by all theological scholars either in England or abroad. Indeed a Dutch scholar, Professor van Manen of Leyden, has recently denied the genuineness of all St Paul's Epistles. But he appears to stand alone, and it is quite indubitable that the great stream of critical opinion runs in this direction, and that the assured results of New Testament study are very different from what people would have expected them to be thirty years ago. Dr Rendel Harris has truly said that "Catholic traditions have a remarkable way of vindicating themselves." Before leaving the subject of the New Testament, a few words must be said with regard to the problem of the Synoptic Gospels. Upon this subject much valuable work has been done, especially in England, and its results have been to throw no little light upon the subject of their origin and relation to one another. The theory that they represent independent forms of a common oral tradition, for instance, must now be given up. Material which had been orally conveyed may no doubt underlie them, but the problem is really one of the relation of written documents. Scholars are now practically agreed that we have to do with three distinct sources: one document in Greek, containing the recollections of St Peter, which corresponds closely with our St Mark, and was used by the writers of the First and Third Gospels; a second, also in Greek, containing discourses and very little narrative, which was also used by these two writers; and a third "special source," whether written or unwritten, which is to be found in the Third Gospel alone. This in turn was probably written by the writer of the *Acts*, who was also the companion of St Paul. Dr Armitage Robinson, the Dean of Westminster, goes further; he holds that "our St Mark" was used by the writers of both the other Synoptic Gospels, and that the Marcan and Lucan authorship of the Gospels which bear their names is practically certain, as also the Lucan authorship of the *Acts*. As to dates, he places St Mark about A.D. 65 (Harnack, 65–70); St Luke shortly after A.D. 70 (Harnack, 78–93); whilst he does not at present attempt to determine the date or authorship of the First Gospel with certainty (Harnack probably 70–75, except certain later additions).

6. The New Testament.

The Synoptic Gospels.

7. *The Outlook.*—It must of course be remembered, however, that this tendency towards agreement as to the genuineness of the New Testament records does not necessarily indicate acceptance of the traditional faith: quite the reverse. It rather indicates, as was stated above, that theological inquiry has come to a natural end in one respect and has taken a fresh direction. Dr Harnack himself goes

on to say, after the passage quoted above, that the problem of the *interpretation* of the documents yet remains. And since then he has given us an indication of his own solution of the problem in his brilliant course of lectures delivered in the University of Berlin in the winter term, 1899–1900, and subsequently published under the title *Das Wesen des Christenthums.* In attempting to sum up the teaching of this book very tersely, it may not be inaccurate to say that Dr Harnack finds the essence of Christianity rather in the teaching than in the Person of Christ, and indeed in his teaching as apart from what he said or implied of himself. He holds, in fact, that Christianity as such has no Christology: just as elsewhere he has said that the history of dogma, "by laying before us the process of the origin and development of dogma, offers the most appropriate means for delivering the Church from dogmatic Christianity." That this tendency is at variance with the tendency which has been predominant in theology during recent years is indubitable; and as little can it be doubted that it is at the present time very strong. There are not a few things which tend in the same direction. There is a widespread feeling of hesitation as to the Virgin Birth of our Lord, based not so much upon any intellectual difficulty as to Incarnation itself as upon the scientific difficulty of conceiving of such a breach of the order of nature. There are difficulties as to the Gospel miracles, as to the nature of Christ's offering for sin, and the like. There are, in brief, all the difficulties which arise from the fact that, in Sir Oliver Lodge's words, "Orthodox modern science shows us a self-contained and self-sufficient universe, not in touch with anything beyond or above itself—the general trend and outline of it known—nothing supernatural or miraculous, no intervention of beings other than ourselves being conceived possible."

7. The Outlook.

It would be at once fallacious and useless to endeavour to forecast in detail the probable course or the exact outcome of this new direction of theological speculation. But the theologian, with the experience of the past behind him, has no need to face the future with apprehension. He may easily be proved wrong: he knows, in fact, that his own partial view of Truth must fail, but not the Truth itself. Dr J. R. Illingworth has given expression as follows to the theologian's standpoint in the matter: "If we look back on the years that are past, we see that men have often thought the Christian Faith to be on its trial, when they, in fact, themselves were being tried by the Faith. It has remained, whether they in their brief lifetime kept or lost it, to test their sons, as it had tested them. Celsus would have been unknown to us but for Origen, and Julian but for Cyril; in each case it was the Christian who survived. And we may be sure that the same will be the case in the end with the various problems of the present day. Minds may doubt, and hearts may fail, when called to face new modes of thought, or points of view; but the time must come when what is false in all these things will fade, and what is true will no more seem strange; and we shall then see that the fears to which they once gave rise were but phases, that were soon to pass, in the age-long life of the great religion of the Incarnation."

ENCYCLOPÆDIA BRITANNICA.

(NEW VOLUMES.)

Strachey, Sir John (1823- ——), British Indian civilian, fifth son of Edward Strachey, was born in London on 5th June 1823. After passing through Haileybury, Strachey entered the Bengal civil service in 1842, and served in the North-Western Provinces until 1861, occupying many important positions. In 1861 Lord Canning appointed him president of a commission to investigate the great cholera epidemic of that year. In 1862 he became Judicial Commissioner in the Central Provinces. In 1864, after the report of the Royal Commission on the sanitary condition of the army, a permanent Sanitary Commission was established in India, and Lord Lawrence appointed Strachey as president. In 1866 he became Chief Commissioner of Oudh, having been chosen by Lord Lawrence to remedy as far as possible the injustice done after the Mutiny by the confiscation of the rights of tenants and small proprietors of land, maintaining at the same time the rights of the Talukdars. As member of the Legislative Council he introduced several Bills for that purpose, which, with the full approval of the Talukdars, passed into law. In 1868 he became member of the Governor-General's Council, and on the assassination of Lord Mayo in 1872 he acted temporarily as Viceroy. In 1874 he was appointed Lieutenant-Governor of the North-Western Provinces. In 1876, by request of Lord Lytton and the Secretary of State, he consented to relinquish that office, and returned to the Governor-General's Council as financial minister, which post he retained until 1880. During this time, while Lord Lytton was Viceroy, important reforms were carried out. The measures for decentralizing financial administration, initiated under Lord Mayo, were practically completed. The salt duties were reduced, and the system under which they were levied was altered, and that opprobrium of our administration, the inland customs duties, were abolished. The removal of all import duties, including those on English cotton goods, and the establishment of complete free trade, was declared to be the fixed policy of the Government, and this was in great measure carried into effect before 1880, when Strachey left India. The defective system on which the military accounts were kept occasioned a very erroneous estimate of the cost of the Afghan war of 1878–80. For this error Strachey was technically responsible, and it was made the occasion of a violent party attack which resulted in his resignation. The fact that almost the entire cost of the war was paid for out of revenue is a conclusive proof of the state of financial prosperity to which India attained as the result of his administration. From 1885 to 1895 Strachey was a member of the Council of the Secretary of State for India. He is joint author with Sir Richard Strachey of *The Finances and Public Works of India* (1882), besides writing *India* (2nd ed., 1894), and *Hastings and the Rohilla War* (1892).

See also the article INDIA: *Recent History.*

Strachey, Sir Richard (1817- ——), British soldier, Indian administrator, third son of Edward Strachey, was born 24th July 1817, at Sutton Court, Somersetshire. From Addiscombe he passed into the East India Company's Engineers in 1836, and was employed for some years on irrigation works in the North-Western Provinces. He served in the Sutlej campaign of 1845–46, and was at the battles of Aliwal (where he served on Sir Harry Smith's staff) and Sobraon, was mentioned in despatches, and received a brevet-majority. During the Mutiny of 1857 he served under Sir John Peter Grant as secretary to the government of the Central Provinces during the six months this government lasted. From 1858 to 1865 he was chiefly employed in the Public Works Department, either as acting or permanent secretary to the Government of India, and from 1867 to 1871 he filled the post of Director-General of Irrigation, then specially created. During this period the entire administration of public works was reorganized to adapt it to the increasing magnitude of the interests with which this department has had to deal since its establishment by Lord Dalhousie in 1854. For this reorganization, under which the accounts were placed on a proper footing and the forest administration greatly developed, Strachey was chiefly responsible. He also initiated the policy of constructing public works on a large scale by direct State agency with borrowed funds. Under his supervision plans were drawn up and the first steps taken for the systematic development by this means of irrigation canals and railways over the whole of India. Richard Strachey's work in connexion with Indian finance was important. In 1867 he prepared a scheme in considerable detail for decentralizing the financial administration of India, which formed the basis of the policy afterwards carried into effect by Sir John Strachey under Lord Mayo and Lord Lytton. He left India in 1871, but in 1877 he was sent there to confer with the Government on the purchase of the East Indian railway, and was then selected as president of the commission of inquiry into Indian famines. In 1878 he was appointed to act for six months as financial member of the Governor-General's Council, when he made proposals for meeting the difficulties arising from the depreciation of the rupee, then just beginning to be serious. These proposals did not meet with the support of the Secretary of State. From that time he continued to take an active part in the efforts made to bring the currencies of India and England into harmony, until in 1892 he was appointed a member of Lord Herschell's committee, which arrived at conclusions in accordance with the views put forward by him in 1878. He attended in 1892 the International Monetary Conference at Brussels as delegate for British India. Strachey was a member of the Council of the Secretary of State for India from 1875 to 1889, when he resigned his seat in order to accept the post of chairman of the East Indian Railway Company. Strachey's scientific labours in connexion with the geology, botany, and physical geography of the Himalaya were considerable. He devoted much time to meteorological research, was largely instrumental in the formation of the Indian Meteorological Department, and became chairman of the Meteorological Council of the Royal Society in 1883. From 1888 to 1890 he was president of the Royal Geographical Society. In 1897 he was awarded one of the Royal medals of the Royal Society, of which he has been a fellow since 1854.

Straits Settlements, the collective name given to the British possessions on or adjacent to the mainland of the Malay Peninsula, as opposed to the Federated Malay States, the British protectorates in the same region. The Straits Settlements consist of the island of Singapore, the town and territory of Malacca, the islands and territory of the Dindings, the island of Penang, sometimes called Prince of Wales Island, and Province Wellesley. The Cocos or Keeling Islands, which have been settled and are still owned by a Scotch family named Ross, and Christmas Islands were formerly attached to Ceylon, but in 1886 the care of these islands was transferred to the Straits Settlements. The Governor of the Straits Settlements is also High Commissioner for the Federated Malay States of the Peninsula and for Borneo. Resident councillors are stationed at Penang and Malacca. British Residents control the native states of Pêrak, Sĕlângor, Pahang, and the Nĕgri Sĕmbîlan, but since 1st July 1896, when the states were federated, a Resident-General, responsible to the High Commissioner, has been placed in supreme charge of all the protectorates of the Peninsula. The work of administration, both in the colony and in the Federated Malay States, is carried on by means of a civil service which is recruited by competitive examinations held annually for the purpose in London.

The following are the area and population, with details of race distribution, of the colony of the Straits Settlements:—

	Area in Square Miles.	Population in 1891.	Population in 1901.						
			Total.	Europeans.	Eurasians.	Chinese.	Malays.	Indians.	Other Nationalities.
Singapore	206	184,554	228,555	3824	4120	164,041	36,080	17,823	2667
Penang, Province Wellesley, and Dindings	381	235,618	248,207	1160	1945	98,424	106,000	38,051	2627
Malacca	659	92,170	95,487	74	1598	19,468	72,978	1,276	93
Total	1246	512,342	572,249	5058	7663	281,933	215,058	57,150	5387

The population, which was 306,775 in 1871, and 423,384 in 1881, had in 1901 reached a total of 572,249. As in former years, the increase is solely due to immigration, more especially of Chinese, though a considerable number of Tamils and other natives of India annually settle in the Straits Settlements. The total number of births registered in the colony during the year 1900 was 14,814, and the ratio per 1000 of the population during 1896, 1897, and 1898 respectively was 22·18, 20·82, and 21·57; while the number of registered deaths for the years 1896–1900 gave a ratio per 1000 of 42·21, 36·90, 30·43, 31·66, and 36·25 respectively, the number of deaths registered during 1900 being 23,385. The cause to which the excess of deaths over births is to be attributed is to be found in the fact that the Chinese and Indian population, which numbers 339,083, or over 59 per cent. of the whole, is composed of 261,412 males and 77,671 females, and only a small number of the latter are married women and mothers of families. The male Europeans also outnumber the females by about two to one; and among the Malays and Eurasians, who alone have a fair proportion of both sexes, the infant mortality is always excessive, this being due to early marriages and other well-known causes. In 1898, 133,558 Chinese immigrants landed in the Straits; in 1899 the number reached 149,697, and in 1900, 200,947. Of the immigrants in 1898, 106,983 landed in Singapore, the total number of males being 96,321, of females 6192, and of children 4470. The immigrants to Penang in 1898 numbered 25,939, 21,227 being males, 2939 being females, and 1770 being children. The immigrants to Malacca numbered 636—viz., 612 men, 12 women, and 12 children. The number of Indian immigrants from Madras ports during 1898 was 18,814, in 1899, 19,519, and in 1900, 41,707. In 1867, the date of the transfer of the colony to the Crown, the total population was estimated at 283,384.

The revenue, which in 1868 only amounted to $1,301,843, had risen in 1900 to $5,386,927. Of this sum $3,317,698 was derived from duties on opium and spirits, $288,540 from land revenue, $235,405 from postal revenue, and $199,552 from port and harbour dues. The expenditure, which in 1868 amounted to $1,197,177, had risen in 1900 to $6,037,084. The total cost of administrative establishments amounted to $1,775,771, the military expenditure to $956,651, public works to $1,814,621, while $110,675 were expended on education.

The ports of the colony are all free. In 1867 the total burden was 1,237,700 tons of shipping entering and leaving the ports of the colony, as against 17,440 ships in 1900, with an aggregate tonnage of 14,469,400. This is exclusive of 33,941 native craft of a gross 1,445,548 tons entering and clearing. The total value of the united imports and exports in 1867 was only £14,040,000, as against £52,500,000 in 1900, exclusive of treasure. The imports for 1900 were valued at £28,250,000, and the exports at £24,250,000. The imports from the United Kingdom for 1900 were valued at close upon 3¼ millions. Tin ore to the value of £6,076,760 was exported from the colony during 1900, but none of this is produced in the colony itself, almost the whole of it being brought from the Federated Malay States.

Malacca, the Malay States (Federated)—comprising Pêrak, Sĕlângor, the Nĕgri Sĕmbîlan—and Pahang, Prince of Wales Island or Penang, and Singapore are treated of in separate articles.

The Dindings belonged originally to Pêrak, and was ceded to the British Government under the treaty of Pangkor in 1874. Hopes were entertained that its excellent natural harbour would be utilized, but these have been doomed to disappointment, and the islands, which are sparsely inhabited and altogether unimportant both politically and financially, are now administered by the government of Pêrak.

Province Wellesley, which lies opposite to Penang, was ceded to Great Britain by the sultan of Kĕdah in 1798. It marches with Pêrak on the south. The boundary was rectified by treaty with Siam in 1867. It is administered by a District Officer, who is responsible to the Resident Councillor of Penang. The country consists for the most part of a fertile plain, thickly populated by Malays, and occupied in some parts by sugar-planters employing Tamil and Chinese labour. About an eleventh of the whole area is covered by low hills thickly wooded. Large quantities of rice are grown by the Malay inhabitants. A railway to Bâtu Kâwan, opposite to Penang, is now (1902) in course of construction in conjunction with the line being built through the Federated Malay States, and when completed this will establish communication by rail between Penang and Malacca.

See *Straits Settlements Blue-Books*, *Annual Reports*, 1897 and 1898. Singapore, 1898 and 1899.—*Journal Straits Branch of the Royal Asiatic Society*. Singapore.—Sir Frederick Weld, "Straits Settlements," and Sir William Maxwell, "Straits Settlements," *Journal of Royal Colonial Institute*. London, 1884 and 1892.—Henry Norman. *The Far East*. London, 1894.—*The Straits Directory*. Singapore, 1900.—The annual summaries contained in the issues of the *Straits Times* and *Singapore Free Press*, published on 2nd January of each year.—*Life of Sir Stamford Raffles*. London, 1856.—*Life of Sir Stamford Raffles*. London, 1898. (H. Cl.)

Strakonitz, the chief town of a government district in southern Bohemia, Austria, at the confluence of the Wolinka with the Wottawa river, 33 miles north-west of Budweis. Considerable textile industry, comprising the manufacture of the red Turkish fez, cloth and woollen stuffs, hosiery, hats, soap, perfumes, and soda-water; and trade in corn, pigs, timber, and industrial products. Population (1890), 5419; (1900), 5501, Czech. The adjoining commune of Neu-Strakonitz has 2002 inhabitants, also Czech.

Stralsund, a seaport town of Prussia, in the province of Pomerania, on the west side of Strelasund, the channel which separates Rügen from the mainland, and 139 miles by rail north of Berlin. A steam railway ferry connects it with Rügen. In the town hall, restored in 1882, are preserved the provincial antiquarian museum and the town library (70,000 vols.). There is a fine monument (52 feet high) of the war of 1870–71 (1886), and another (1862) to the local patriot Schill, who was killed here in 1809; also a school of navigation and a deaf and dumb asylum. Population (1885), 28,984; (1900), 31,083.

Strangford, Percy Ellen Frederick William Smythe, 8th Viscount in the peerage of Ireland, and 3rd Baron Penshurst of the United Kingdom (1826–1869), was the youngest son of the 6th Viscount, who served long in the diplomatic service, rising to be ambassador in Russia and Turkey. He was born at St Petersburg, 26th November 1826. During all his earlier years Percy Smythe was nearly blind, in consequence, it was believed, of his mother having suffered very great hardships on a journey up the Baltic in wintry weather shortly before his birth. His health through life was very delicate, but did not prevent his showing quite early most remarkable powers of mind. His education was begun at Harrow, whence he went as a "postmaster" to Merton. From the very first he gave proofs of extraordinary ability as a linguist, and was nominated by the vice-chancellor of Oxford in 1845 a student-attaché at Constantinople. A very interesting account of his colleagues, more especially of Mr Almerick Wood, who was a man of phenomenal capacity, was written by him later in life, and is to be found in the two volumes of his collected essays published by his widow. While at Constantinople, where he served under Lord Stratford de Redcliffe, Percy Smythe gained a mastery not only of Turkish and its dialects, but of almost every form of modern Greek, from the language of the *literati* of Athens to the least Hellenized Romaic. Before he went to the East he had a large knowledge both of Persian and Arabic, but until his duties led him to study the past, present, and future of the sultan's empire he had given no attention to the tongues which he well described as those of the international rubble in and around the Balkan peninsula. He made, while in the East, a careful study of these, and was the first Englishman to see that the Bulgarians were much more likely than the Servians to come to the front as the Ottoman power declined. He avowed himself a Liberal in English politics, and those with whom he chiefly lived were Liberals; but he was not an anti-Turk, as so many Liberals afterwards became. In 1857 the brilliant but erratic 7th Lord Strangford, better known as George Smythe, ended his unfortunate career, and Percy succeeded to the peerage. He did not, however, abandon the East, but lived on at Constantinople for several years, immersed in Oriental studies. At length, however, he returned to England and began to write a great deal, sometimes in the *Saturday Review*, sometimes in the *Quarterly*, and much in the *Pall Mall Gazette*. A rather severe review in the first of these organs of Miss Beaufort's *Egyptian Sepulchres and Syrian Shrines* led to a result not very usual—the marriage of the reviewer and of the authoress. One of the most interesting papers Lord Strangford ever wrote was the last chapter in his wife's book on the *Eastern Shores of the Adriatic*. That chapter was entitled "Chaos," and was the first of his writings which made him widely known amongst careful students of foreign politics. From that time forward everything that he wrote was watched with intense interest, and even when it was anonymous there was not the slightest difficulty in recognizing his style, for it was unlike any other. Many able men were writing for the press during the 'sixties, but Strangford, alike in his knowledge and his way of putting it, was unique. He did not get stronger as his life advanced, and when a slight chill, one January morning, put an end to his fragile existence, he left no one who could guide his countrymen so well as he could through the labyrinth of the twenty different questions of which he used to say that the "Eastern Question" was composed.

A selection from the writings of Viscount Strangford on political, geographical, and social subjects, in two volumes, was edited by the Viscountess Strangford (Bentley, 1868). His letters and papers upon philological and kindred subjects were also edited by the Viscountess Strangford (Trübner, 1878). (M. G. D.)

Stranraer, a royal burgh of Wigtownshire, Scotland, at the head of Loch Ryan, about 50 miles south-south-west of Ayr by rail. There are two large dairy implement factories and creameries. In 1888, 770 vessels of 101,745 tons entered; in 1898, 828 vessels of 183,297 tons. The east pier has been extended, a new station built, and a cottage hospital opened. There is an academy under the school board. Population (1891), 6193; (1901), 6009.

Strasburg (German, *Strassburg*), a town and first-class fortress of Germany, capital of Alsace-Lorraine, stands 2 miles from the left bank of the Rhine, 88 miles by rail north of Basel. It is the see of a Roman Catholic bishop and the headquarters of the 15th German Army Corps, with a garrison of 15,000 men. With the exception of Berlin, there is perhaps no town in Germany which can show so many handsome new public buildings as Strasburg. These are for the most part connected with the resuscitated university of 1872, and are almost entirely in the Renaissance style of architecture. The lecture halls are contained in a building (1877–84) which is adorned by statues, frescoes, &c., by modern German artists, and has near it the chemical, physical, botanical, geological, and zoological institutes, also the observatory, all designed by H. Eggert, and built between 1877 and 1888. On the south of the old town are, further, the various schools, laboratories, and hospitals of the medical faculty, all built since 1877. In the same quarter as the university—namely, on the north-east of the old town—are the imperial palace (1883–89), designed by Eggert in the Florentine Renaissance style, crowned by a cupola 115 feet high, and richly ornamented. The provincial and university library (1889–94) and the hall of the provincial government (*Landesausschuss*), built in 1888–92, both of Pfalzburg white sandstone, in the Italian Renaissance style, occupy the opposite side of the Emperor Square, and behind the latter is the large new post office. A little behind the imperial palace stands the Young St Peter (Roman Catholic) church (1889–93), with a conspicuous cupola. Between the university and the library is the Evangelical garrison church (1892–97), built of reddish sandstone in the early Gothic style. The castle, in the Minster Square, after being used for university purposes from 1871 to 1895, was in 1898 converted into the town art museum (a picture gallery). A new synagogue was completed in 1898. The viceregal palace was entirely rebuilt in 1872–74. In addition, there may be mentioned the new law courts, the Roman Catholic garrison church, the iron bridge across the Rhine to Kehl, built in 1897, the fountain (1895) in the Wine Market, the conservatory of music, industrial art school and museum, botanical garden, seminaries for teachers (both sexes) and for theological students, and a deaf and dumb asylum. In 1900 the university, which has four faculties, was attended by 1145 students and had 129 professors. Since 1870 the trade of the town has grown very considerably, and has been promoted by a new port of 250 acres extent, with quays and wharves on the Rhine, constructed since 1891. Strasburg is not an industrial town of any magnitude. Population (1890), 123,500; (1900), 150,268.

See Dacheux. *Das Münster von Strassburg* (60 plates, 2nd ed.). Strasburg, 1898.—Eheberg. *Verfassungs, &c. Geschichte der Stadt Strassburg bis 1681*. Strasburg, 1899, *et seq.*

Definition.

Strategy.[1]—The exact meaning of the word "strategy" is as generally misunderstood as the study of the art it describes is generally neglected. By civilians it is continually confounded with "tactics" (*q.v.*), and it would seem that even soldiers are not always quite clear as to the essential distinction between the two main branches of their profession. Yet such confusion is not due to the want of definition. Almost every military writer of repute has tried his hand at it, and the only embarrassment is to choose the best. The last perhaps will serve our purpose as well as any other. Strategy, according to the official text-book of the British infantry, is the art of bringing the enemy to battle, while tactics are the methods by which a commander seeks to overwhelm him when battle is joined. It will thus be seen that strategy leads up to the actual fighting—that is, to the tactical decision; but that while the two armies are seeking to destroy each other it remains in abeyance, to spring once more into operation as soon as the issue is decided. It will also be observed that the end of strategy is the pitched battle; and it is hardly necessary to point out that the encounter at which the strategist aims at is one in which every possible advantage of numbers, ground, supplies, and *moral* shall be secured to himself, and which shall end in his enemy's annihilation.

General principle.

The means by which this desirable consummation is attained are many, but the guiding principle is generally the same, and may be summed up in Napoleon's dictum, "*The secret of war lies in the communications.*" The line of supply may be said to be as vital to the existence of an army as the heart to the life of a human being. Just as the duellist who finds his adversary's point menacing him with certain death, and his own guard astray, is compelled to conform to his adversary's movements, and to content himself with warding off his thrusts, so the commander whose communications are suddenly threatened finds himself in a false position, and he will be fortunate if he has not to change all his plans, to split up his force into more or less isolated detachments, and to fight with inferior numbers on ground which he has not had time to prepare, and where defeat will not be an ordinary failure, but will entail the ruin or the surrender of his whole army.

Essential problems.

This great principle is common both to the offensive and the defensive. In the first case, the strategist is generally confronted with the following problem: *The enemy holds a strong position; how is he to be forced out of it?* In the second, the difficulty may be stated thus: *The enemy is advancing in superior numbers; how is he to be checked?* The answers are identical: *By threatening or cutting his line of communications;* and so reducing him to the situation described in the preceding paragraph. It is evident, however, that so vulnerable a point will be most carefully guarded; and, also, that the application of the principle is complicated by the fact that it is two-edged, or, to put it in plainer words, that a general in seeking to reach his adversary's heart may expose his own. In short, to place a force in such a position that it either threatens or severs the enemy's line of supply is not only a difficult but a hazardous operation which, unless the force is overwhelmingly superior, and can push its way through all obstacles by sheer weight of numbers, can never be carried out except by stratagem and manœuvre.

Concentration of superior force.

The scope and nature of such expedients must to a great extent depend upon the circumstances of the particular case. There are certain principles, however, which serve as guides; and it will be seen that they are all accessory to a rule of strategy which is intimately connected with that which bids us strike at the enemy's communications, viz., *the concentration of superior strength, physical and moral, on the field of battle.*

> "How often," says Napier, "have we not heard the genius of Buonaparte slighted, and his victories talked of as destitute of merit, because at the point of attack he was superior in number to his enemies! This very fact, which has so often been converted into a sort of reproach, constitutes his greatest and truest praise. He so directed his attack as at once to divide his enemy and to fall with the mass of his own forces upon a point where their division, or the distribution of their troops, left them unable to resist him. It is not in man to defeat armies by the breath of his mouth; nor is Buonaparte commissioned, like Gideon, to confound and destroy a fort with 300 men. He knew that everything depended ultimately upon physical superiority; his genius is shown in this, that although outnumbered on the whole, he was always superior to his enemies at the decisive point."

Methods of overcoming superior numbers.

We will now take the case of an army superior in numbers, and note down in succession the methods by which those numbers may be reduced by an adversary who is operating against its communications:—(*a*) *If the superior army is not yet concentrated, or is so distributed that the different parts cannot readily support each other, it may be defeated in detail.* (*b*) *If the superior army is concentrated, its commander, by one means or another, may be induced to make detachments, and thus be weak everywhere.*

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[1] This article deals with strategy in the field. For strategy as connected with preparation for war, see the article on War.

To accomplish (*a*) the means are:—1. More rapid mobilization. 2. Surprises, effected by hard marching, secrecy, feints, and the adoption of an unexpected line of operations.

To accomplish (*b*):—1. The skilful use of detached forces, threatening points which the enemy is bound to protect, such as his immediate base of operations, or his line of supply. 2. Concealment, begetting uncertainty and apprehension. 3. Drawing the enemy forward into "a zone of manœuvre" where topographical obstacles, the difficulties of supply, or judicious feints, will compel him to split up his army.

In addition to these shifts of war, which are more or less aimed at the hostile army, there are others which are aimed almost exclusively at the hostile general. The moral equilibrium of the commander is often of even greater importance than the spirit of his troops. If that equilibrium can be upset, or his imagination so played upon that he gives way to recklessness, over-confidence, or despair, victory should be very near. The methods which may be employed are numerous:—

1. Drawing the enemy into a trap by an apparent dispersion of the forces against him.
2. Feigned retreat, inducing the enemy to pursue needlessly, and so commit mistakes.
3. Spreading false information.
4. Changing the base, and adopting a new and unexpected line of operations. This is one of the most effective weapons in the armoury of the strategist, who thereby not only secures great freedom of manœuvre, but may completely baffle his adversary's penetration.

Lastly, there are two great principles which are the foundation and the crown of all strategical methods, and which strike heavily and directly at the *moral* both of the hostile commander and of the troops he commands. They have been defined for us by Stonewall Jackson:—

1. *Always mystify, mislead, and surprise the enemy.*
2. *Never give up the pursuit so long as your men have strength to follow, for an army routed, if hotly pursued, becomes panic-stricken, and can be defeated by half their numbers. To move swiftly, strike vigorously, and secure all the fruits of victory is the secret of successful war.*

Strategical principles not to be pedantically applied.

It will be noted that some of those principles are to a certain extent conflicting. The concentration of the whole army in one body is undoubtedly a rule which is not to be infringed with impunity, and yet the use of detached forces is continually recommended as the surest means of making the enemy disperse his troops or commit other mistakes. The fact is, however, that strategical principles are neither to be rigidly applied nor overscrupulously respected. They are to be obeyed rather in the spirit than the letter; and the strategist, to be successful, must know exactly how far he can go in disregarding or in modifying them, and be ingenious enough to bring those into adjustment which are apparently irreconcilable. For instance, a superior army may derive the greatest advantage from a breach of the rule of concentration. If it divides at the outset into two wings, each approaching the enemy on a different line, and possibly supplied from a different base, it may not only cause the enemy the very greatest embarrassment, but eventually crush him between them, as Napoleon was crushed between the English and the Prussians at Waterloo, or Benedek between the Crown Prince and Prince Frederick Charles at Koniggrätz, or Hooker between Lee and Jackson at Chancellorsville. It is to be observed, however, that the breach of rule is more apparent than real, in that concentration is merely deferred to the field of battle instead of taking place before the troops march against the enemy. Thus, although the letter is infringed, the spirit is respected.

But also not to be safely ignored.

But because a partial application, or even an absolute disregard, of the principles of strategy does not necessarily spell disaster, it is not to be assumed that they are merely theoretical and pedantic formulæ. A general who was an absolute slave to them—who obstinately refused, for example, to make a detachment—would probably fail to achieve decisive success; but a general who acted in defiance of them would, to put it in the mildest form, run enormous risk. This is well shown by the campaign of Waterloo. Wellington and Blucher, at the outset, were not concentrated, and despite the fact that they had 210,000 men against Napoleon's 130,000, they had certainly the worst of it in the opening operations. Two days after their retreat from the line Quatre Bras–Ligny they retrieved the situation at Waterloo, concentrating successfully on the field of battle; but even on 18th June, with all their numerical superiority, there were times when victory hung in the balance. It is thus quite clear that departure from the established principles involves great dangers, and it is therefore impossible to deny that those principles are no dry-as-dust apothegms, but living forces, permeating the whole art of strategy and exerting absolute control over the issue of a campaign.

The difficulties of strategy.

The array of principles, as set out above, is by no means formidable, yet it contains all those that are absolutely essential in the field; and it might be imagined, therefore, that the practice of strategy is exceedingly easy. The exact contrary, however, is the case; and this arises mainly from the fact that the operations of war are carried out in such obscurity, that it is always difficult for a general to see his way to the application of the ruling principles. It is on this point that soldiers have such deep distrust of civilian critics. The latter, as a very general rule, judge after the event. Ignorant of the practical difficulty, not to say the impossibility, of obtaining accurate information, and oblivious of the fact that so long as troops are mobile the military situation may be entirely changed in the course of a few hours, they almost invariably assume that the general, when he made his plans, must have been acquainted with the exact condition of affairs within the hostile lines.

The soldier, on the other hand, is aware that full knowledge on any one point connected with the enemy is very seldom forthcoming; that the data of the problems to be solved are never clear; that the condition of affairs has always to be more or less inferred; and that almost every operation is so involved in uncertainty, from beginning to end, that success is invariably a matter of doubt. "I have fought," said Wellington, "a sufficient number of battles to know that the result is never certain, even with the best arrangements"; and it is within the experience of all those who have had to do with strategy in the field that the density of the "fog of war" is almost appalling. For example, it would surely be imagined that a commander would have no difficulty whatever in ascertaining the direction of his adversary's line of communications. In practice, however, especially where comparatively small forces are concerned, this is exceedingly difficult; and there is always the embarrassing feeling that the enemy may have established a secondary line of supply, to which he may transfer his forces at any given moment. Again, a fortress or extended camp has, in theory, what may be called a fixed value; that is, it may be expected to hold out for a certain definite period. In war, however, the possibilities of accident invariably appear, and often are in reality, so numerous, that calculations which are based on the strength of the garrison and the works lose all their weight; and thus, when a fortified town is beleaguered, operations for its immediate relief become almost imperatively necessary. It is true that operations for this end may often be strategically unsound, and that the general should consider probabilities of the case rather than the possibilities. But human nature asserts itself in war as strongly as elsewhere. It is as constant and as important a factor as the difficulty of procuring information; and it is the recognition of these elemental facts which is the great point of difference between practical and theoretical strategy.

Importance relatively to tactics.

War is assuredly no mechanical art. Broadly speaking, it is a war between the brains and the grit of the two commanders, in which each strives to outwit and outlast the other; a conflict in which accident plays so prominent a part that mistakes, in one form or another, are absolutely unavoidable. It is thus pre-eminently the art of the man who dares take the risk; of the man who thinks deeply and thinks clearly; of the man who when accident intervenes is not thereby cast down, but changes his plans and his dispositions with the readiness of a resolute and reflective mind, which, so far as is possible, has foreseen and provided against mischance. Particularly is this the case with strategy. The tactical errors of a commander have often been redeemed by the skill and courage of his troops, but it is seldom indeed, against a vigilant enemy, that a strategical blunder does not carry its own punishment. Defeat, indeed, is far more often due to bad strategy than to bad tactics. An army may even be almost uniformly victorious in battle, and yet ultimately be compelled to yield. So the Confederates in 1861–65, the Turks in 1877–78, the Boers in 1899–1902, despite their numerous successes, were beaten in the end; but in each case the same strategical faults were conspicuous—the failure to concentrate in sufficient numbers to reap the fruits of victory, the unnecessary dispersion of the troops, and the deliberate disregard of the great end of strategy, viz., the annihilation of the enemy's fighting men, and the destruction of his material resources. To bring a stubborn enemy to his knees the war, like that of Rome against Carthage, "must be carried into Africa."

How to learn and how to teach strategy.

Strategy, then, is an art which almost more than any other is concerned with the fate of nations. Its study should be as assiduous as its practice should be correct; and we now come to the questions, By whom should it be learned, and how should it be taught? It has been the fashion to assert that strategy is the province of the few, tactics of the many; that only those who are destined to or ambitious of high command need trouble about what is perhaps the most important branch of the art of war, and that it is therefore to be taught to staff officers alone. The fallacy of this most preposterous argument, if argument it may be called, is glaring. What soldier can possibly say that he will never be called upon to exercise an important command? Ambitious or not, he can no more foresee the responsibilities a campaign may force upon him than he can make sure, at the critical moment, of having a trained staff officer at his elbow to suggest the right course of action. But there is more to be said than this. If only the few are possessed of a knowledge of strategy, what terribly one-sided creatures must be the remainder! Imagine an officer being asked some question as to Wellington or Napoleon, and being compelled to confess that he knew nothing whatever of their achievements, or of the methods by which they had won so many victories! Could a man who thus admitted that he despised the experience and the teaching of the greatest and most successful masters of his profession by any conceivable stretch of courtesy be rightly called a professional soldier? If so, then a doctrine is applied to the profession of arms that is repudiated by every other profession, by every trade, and by every sport, in the wide world. What would be said of a man without the slightest knowledge of the habits of his quarry, of the importance of wind, of background, of silence, and of invisibility, who started off unaccompanied to shoot red deer in a Scotch forest? He might be a first-rate rifle-shot, but even if he got within sight of the herd it is in the last degree impossible that he would bring back a head. He would be looked upon by the commonest gillie as the most ignorant of novices, and most assuredly he would never be called a sportsman. And yet it is openly asserted that men who may one day become generals need no more knowledge of strategy—the art of approaching the quarry—than the cockney has of forest-craft! Is it possible to hold any other opinion than that this extraordinary doctrine is either a most impudent excuse for idleness, or an abject admission that the more intellectual branch of the art military is utterly beyond the capacity of the ordinary soldier? Yet what can be more humiliating to the great body of officers than the reflection that only a few of their number are considered capable of wielding the weapons of the great captains; and that these few have to be bribed by high pay and good appointments to undergo the necessary study!

Nor is there any truth in the idea that the practice of strategy in the field can be confined to the higher ranks. Every officer in charge of a detached force or flying column, every officer who for the time being has to act independently, every officer in charge of a patrol, is constantly brought face to face with strategical considerations; and success or failure, even where the force is insignificant, will often depend upon his familiarity with strategical principles. The tide of warfare ebbs and flows on an ocean which is studded with strategical objectives. Positions, bridges, road and railway junctions, towns and villages, are always of the utmost importance to the accomplishment of a plan of campaign. Their occupation leads up, as it were by stepping-stones, to the attainment of the ultimate objective, that is, to the destruction of the enemy's army; and a quick recognition of their bearing on the course of operations, perhaps on the part of a very junior officer commanding a small column or conducting a reconnaissance, may go far towards the achievement of a decisive success. We accordingly arrive at the conclusion that every officer of every grade should, if it is deemed necessary that they should be professional soldiers—and it is for this that they are paid—be thoroughly familiar with strategical principles. Let us now consider how that familiarity is to be acquired.

The lessons of experience.

We have not far to go to find the whole case put before us in a nutshell. "*The only right way of learning the science of war is to read and re-read the campaigns of the great captains.*" Such is the opinion of Napoleon; and he is a bold man who dares set himself in opposition to the great Corsican, who if not the finest soldier that ever lived, was at least one of the most sagacious of men. What could be more beneficial to the soldier than that the atmosphere he breathes from the first hour he determines on the profession of arms should be purely military; that the traditions of the army should be constantly before him, the campaigns of great generals the groundwork of his daily study, and famous marches or manœuvres the commonplaces of his ordinary knowledge?

The value of theory.

It has been objected that pure theory can never be a substitute for practice, and that therefore what Napoleon intended to convey was, that the study of military history was a useful supplement to actual experience. It may be remarked, however, that "staff-rides," as exercises on the ground without troops have come to be called, are just as effective a means of teaching strategy as field-days are of teaching tactics; in fact, a better means, for they bear a far closer resemblance to strategical work on a campaign than do the mimic battles of the manœuvre ground. The strategist might perform every one of his functions out of sight and hearing of the battle. The situations, then, in which he would find himself in war, and the problems he would have to solve, may be easily and almost exactly counterfeited in time of peace. The problems of tactics, on the other hand, in which shell and bullet are the predominant factors, can never be more than dimly and lifelessly presented.

But we cannot admit that Napoleon meant anything but what he said. In the first place, it can scarcely be denied that an intimate acquaintance with the processes of war, even though it should be purely theoretical, is as useful to the young officer as a knowledge of common law to the newly-called barrister. In the second place, military history offers a more comprehensive view of those processes than even active service: the platform is loftier, and every phase of warfare, from the marches of great armies to the forays of the guerilla, comes under observation. In the third place, the art of war, as we have already seen, is crystallized in a few great principles; and it is the study of military history alone that makes such principles so familiar that to apply them, or at all events to respect them, becomes a matter of instinct. It is not sufficient, any more than in the study of any other business, merely to place before the tyro a general summary of the maxims by which he is to be guided. He must convince himself of their scope and value by constant reference to apt illustrations. His study of the campaigns of his famous predecessors must be active and not passive; he must put himself in their place, not content with merely reading a lively narrative, but working out every step of the operation with map and compass; investigating the reasons of each movement; tracing cause and effect, ascertaining the relative importance of the moral and the physical, and deducing for himself the principles on which the generals acted. It is probable that he will only discover what has been discovered already. But the value of the discovery will not be in the smallest degree diminished. Far from it, for knowledge that is gained by hard labour and independent effort is of higher worth, and much more likely to be permanently absorbed, than that which comes in by the ear.

Knowledge of military history essential.

Can the truth of this be questioned? In every human transaction the most fruitful cause of failure and of error is the imperfect comprehension or the neglect of principle. He who invariably sees the right course to be pursued is the man of ability, endowed with that clearness of perception which may sometimes be a natural gift, but is more often the product of sound training; he who follows that course, come what may, is the man of high character, of resolution, and of genius. If men fail to do what they ought to do, it is, more often than not, because on their horizon the true principles of conduct do not stand out above the mists of passion and minor issues as beacon lights, for the one reason that the mind's eye has not been trained to see them; or, in other words, that they have not, by study and reflection, realized the paramount importance of these "living oracles."

We may take it that in soldiering there is more to be learned from the history of great campaigns than from the manœuvres of the training-ground. For instance, a man thoroughly penetrated with the spirit of Napoleon's warfare would hardly fail, in all circumstances, to make his enemy's communications his first objective; and if Wellington's tactical methods had become a second nature to him, it would be strange indeed if he were seduced into delivering a purely frontal attack. Moreover, although genius and resolution are no artificial products, there can be no doubt but that a man who is aware that a commander cannot hope for success without running risks, that he must be prepared to act on very meagre information, and that he will often have to decide quickly under most disturbing conditions, is more likely to do well in war than the leader who has no idea of the magnitude of the personal responsibility inseparable from command against the enemy. Again, the study of military history results in the accumulation of a mass of facts. Now the knowledge of facts, however it may be acquired, constitutes experience; and the product of experience is habit, which, as being all-powerful in moments of excitement or danger, plays an even more important part in warfare than in any other phase of human affairs.

Lastly, a knowledge of military history not only supplies a touchstone by which actual experience, whether of peace manœuvres or field service, may be tested, mistakes discovered, and reflection justified, but gives life and vigour to all instruction, and in the long years of peace the chief work of every officer, no matter how low or how high his rank, is the instruction of his subordinates. In every respect, then, it is absolutely clear that a knowledge of military history is an essential ingredient in the making of a really useful soldier; and that any system of military training or education which leaves strategy untouched, except by the few, is not only an insult to the officers of the army, but a danger to the State.

(G. F. R. H.)

Stratford, a city and port of entry of Ontario, Canada, and capital of Perth county, situated 83 miles west-south-west of Toronto by rail, on the Avon river. Railway shops, flour-, saw-, and woollen-mills, engine and agricultural implement works are the principal industries. A large export trade in cheese and other dairy and farm produce is carried on. Exports for the year 1898–99 $1,954,575, and imports $914,722. Population (1881), 8239; (1891), 9501; (1901), 9959.

Stratford-on-Avon, a municipal borough and market town in the Stratford-on-Avon parliamentary division of Warwickshire, England, 110 miles north-west of London by rail. In the church of the Holy Trinity, which has been restored, a memorial window has been placed to the late J. O. Halliwell-Phillipps, the Shakespearean scholar; and another window, illustrating scenes of the Incarnation, and containing figures from English and American history, has been presented by American visitors. Recreation grounds have been laid out. Recent erections are a lecture room opposite the Shakespeare memorial, a drinking fountain with a clock tower, given by an American visitor, the Shakespeare monument (1888), a hospital for infectious diseases, and a new post office. Anne Hathaway's cottage was purchased for the nation in 1892. Area, 4012 acres. Population (1891), 8318; (1901), 8310.

Strathnairn, Hugh Henry Rose, 1st Baron (1801–1885), British field-marshal, third son of the Right Hon. Sir George Henry Rose of Sandhills, Christchurch, Hampshire (Minister Plenipotentiary at the Prussian Court), was born at Berlin on 6th April 1801. He was educated at Berlin, and received military instruction at the Cadet School. He entered the 93rd Sutherland

Highlanders as an ensign on the 8th June 1820, but was transferred to the 19th Foot, then quartered in Ireland, and took part in preserving order during the "Ribbon" outrages. He was promoted rapidly, to a lieutenancy in 1821, a captaincy in 1824, and an unattached majority at the end of 1826. He was brought into the 92nd Highlanders as a regimental major in 1829, and the following year was appointed equerry to H.R.H. the Duke of Cambridge. The 92nd Highlanders were in Ireland, and Rose again found himself employed in maintaining law and order. He rendered important services in suppressing disaffected meetings, but his conduct was so courteous to the ringleaders that he incurred no personal hostility. In 1833 he accompanied his regiment to Gibraltar, and three years later to Malta, where he exerted himself with so much zeal during a serious outbreak of cholera in attending to the sick soldiers that his conduct elicited an official approval from the governor and commander-in-chief. In 1839 he was promoted, by purchase, to an unattached lieutenant-colonelcy. In the following year Rose was selected, with other officers and detachments of Royal Artillery and Royal Engineers, for special service in Syria under the orders of the Foreign Office. They were to co-operate on shore, under Brigadier-General Michell, R.A.—in conjunction with the Turkish troops—with the British fleet on the coast, for the expulsion of Mehemet Ali's Egyptian army from Syria. Sir Stratford Canning sent Rose from Constantinople on a diplomatic mission to Ibrahim Pasha, commanding the Egyptian army in Syria, and after its execution he was attached, as deputy adjutant-general, to the staff of Omar Pasha, who landed at Jaffa with a large Turkish force from the British fleet. Rose distinguished himself in several engagements, and was twice wounded at El Mesden in January 1841. He was mentioned in despatches, and received from the sultan the order of Nishan Iftihar in diamonds, the war medal, and a sabre of honour. The King of Prussia sent him the order of St John, and expressed his pleasure that "an early acquaintance" had so gallantly distinguished himself. Shortly after he succeeded to the command of the British detachment in Syria with the local rank of colonel, and in April 1841 he was appointed British Consul-General for Syria. For seven years, amidst political complications and intrigues, Rose, by his energy and force of character, did much to arrest the horrors of civil war, to prevent the feuds between the Maronites and Druses coming to a head, and to administer justice impartially. In the first year of his appointment his action saved the lives of several hundred Christians at Deir el Khama, in the Lebanon, and his services were warmly recognized by Lord Aberdeen in the House of Lords, and he was made C.B. In 1845, by his promptness and energy, at great personal risk, he rescued 600 Christians belonging to the American mission at Abaye, in the Lebanon, from the hands of the Druses, and brought them to Beyrout. In 1848, during the outbreak of cholera at Beyrout, he was most devoted in his attention to the sick and dying.

At the end of this year he left Syria on leave of absence, and did not return, as Lord Palmerston appointed him secretary of embassy at Constantinople in January 1851. In the following year he was *chargé d'affaires* in the absence of Sir Stratford Canning during the crisis of the question of the "holy places," and he so strengthened the hands of the Porte by his determined action that the Russian attempt to force a secret treaty upon Turkey was foiled. During the war with Russia in 1854–56 Rose was the British commissioner at the headquarters of the French army, with the local rank of brigadier-general. At Varna he succeeded in quenching a fire which threatened the French small-arm ammunition stores, and received the thanks of Marshal St Arnaud, who recommended him for the Legion of Honour. He was present at the battle of the Alma, and was wounded on the following day. At Inkerman he reconnoitred the ground between the British and French armies with great *sang froid* under a withering fire from the Russian pickets, and his horse was shot under him. He distinguished himself on several other occasions in maintaining verbal communication between the allied forces, and by his tact and judgment contributed to the good feeling that existed between the two armies. His services were brought to notice by the commanders-in-chief of both armies, and he received the medal with three clasps and the thanks of Parliament, was promoted to be major-general, and was made K.C.B. and commander of the Legion of Honour. On the outbreak of the Indian Mutiny in 1857 Rose was given command of the Poona division. He arrived in September, and shortly after took command of the Central India force. In January 1858 he marched from Mau, captured Rathgarh after a short siege, and defeated the raja of Banpur near Barodia, in the same month. He then relieved Sagar, captured Garakhot and the fort of Barodia, and early in March defeated the rebels in the Madanpur Pass and captured Madanpur, Narut, Sorai, and Chandairi, when the district was evacuated by the mutineers. He arrived before Jhansi on the 20th March, and during its investment defeated a relieving force under Tantia Topi at the Betwa on 1st April. Jhansi was stormed and the greater part of the city taken on the 3rd, and the rest the following day, and the fort occupied on the 5th. Kunch was captured after severe fighting, in a temperature of 110° Fahr. in the shade, on the 7th May. Rose was only able to hold out by medical treatment, and many casualties occurred from the great heat. Under the same conditions the march was made on Kalpi. The rebels came out in multitudes on 22nd May to attack his small force, exhausted by hard marching and weakened by sickness, and after a severe fight under a burning sun, and in a suffocating hot wind, were utterly routed and Kalpi occupied the following day. Having completed his programme, Rose obtained sick leave, and Sir Robert Napier (*q.v.*) was appointed to succeed him, when news came of the defection of Sindia's troops and the occupation of Gwalior by Tantia Topi. Rose at once resumed command, and moved on Gwalior by forced marches, and on 16th June won the battle of Morar. Leaving Napier there, he attacked Gwalior on the 19th, when the city was captured. The fortress was stormed and won the following day, and Napier gained a signal victory over the flying enemy at Jaora-Alipur on the 22nd. Rose then made over the command to Napier and returned to Poona. For his services he received the medal with clasp, the thanks of both Houses of Parliament, the regimental colonelcy of the 45th Foot, and was creat[illegible] G.C.B. By a legal quibble the Central India fo[illegible] protracted litigation, was not allowed its share[illegible] prize-money, a loss to Rose of £30,000. Rose was promoted lieutenant-general for his "eminent services" in February 1860, and the next month was appointed commander-in-chief of the Bombay army, and on the departure of Lord Clyde from India in the following June he succeeded him as commander-in-chief in India. During his tenure of the commander-in-chief Rose improved the discipline of the army, while his powerful assistance enabled the changes consequent upon the amalgamation of the East India Company's army with the Queen's army to be carried out without friction. He was created K.S.I. in 1861 and G.C.S.I. on the enlargement of the order. On his return home he was made an honorary D.C.L. of Oxford University.

Rose held the Irish command from 1865 until 1870, was raised to the peerage in 1866 as Baron Strathnairn of Strathnairn and Jhansi, transferred to the colonelcy of the 92nd Foot, and appointed president of the Army Transport Committee. By a good organization and disposition of the troops under his command in 1866 and 1867 he enabled the Irish Government to deal successfully with the Fenian conspiracy. He was promoted general in 1867. On relinquishing the Irish command he was made an honorary LL.D. of Trinity College, Dublin. For the rest of his days he lived generally in London. He was gazetted to the colonelcy of the Royal Horse Guards in 1869, and promoted to be field-marshal in June 1877. He died in Paris on the 16th October 1885, and was buried with military honours in the graveyard of the Priory Church, Christchurch, Hampshire. An equestrian bronze statue, by E. Onslow Ford, R.A., was erected to his memory at Knightsbridge, London. He was never married. (R. H. V.)

Strathpeffer, a village and spa of Scotland, in the county of Ross and Cromarty, scattered over the sides of a Highland valley, 5 miles west from Dingwall. It is sheltered on the west and north, and has a relatively dry, warm climate. The waters are sulphurous and chalybeate, the former being of especial strength and the latter effervescent. Here also there is a peat bath, like those of Franzensbad in Bohemia. There are four springs, a pump-room, a pavilion and reading-room, Established and United Free churches, an Episcopalian chapel, and a golf-course. The neighbourhood boasts of a vitrified fort (at Knockfarrel), and an old building known as Castle Leod. Population (1901), 354.

Straus, Ludwig (1835–1899), Austrian violinist, was born at Pressburg, 28th March 1835, and was a pupil at the Vienna Conservatorium from 1843 to 1848, as a pupil of Böhm; made his first appearance in 1850, and five years afterwards made a tour in Italy; in 1857 he became acquainted with his lifelong friend Piatti, and toured with him in Germany and Sweden. From 1860 to 1864 he was concert-meister at Frankfort, and during these years he visited England frequently, in the year 1864 taking up his residence there. He was for many years leader of Hallé's orchestra in Manchester, and a familiar figure at the Popular Concerts in London. He was first violin in the Queen's Band. He retired, owing to ill-health, in 1893, and from that time till his death, 23rd October 1899, lived at Cambridge. His playing, whether of violin or viola, had very great qualities; he was perfect in ensemble, and his power of self-effacement was of a piece with his gentle disposition and with the pure love of art which distinguished him through life. A more lovable nature never existed, and his quiet influence on the art of his time was very great. (J. A. F. M.)

Streator, a city of Lasalle county, Illinois, U.S.A. It is on the Vermilion river, toward the northern part of the state, at an altitude of 625 feet. It is on the river bluffs, has a regular plan, good water supply and sewerage system. It has five railways—the Atchison, Topeka, and Santa Fé; the Chicago, Burlington, and Quincy; the Chicago and Alton; the Indiana, Illinois, and Iowa; and the Wabash, giving it much importance as a railway centre. It is in a coal region, and clay for brick and tile is abundant in its vicinity. Its industries include brickyards, sewer-pipe, and tile factories, glass factories, and flour and planing mills. Population (1880), 5157; (1890), 11,414; (1900), 14,079, of whom 3740 were foreign-born and 100 negroes.

Street Railways. See RAILWAYS.

STRENGTH OF MATERIALS.

Testing machines.

In the article which appeared under this title in the earlier volumes (ninth edition) of this Encyclopædia some account was given of methods usually followed in the testing of materials, and of the general results of such tests. Most of the forms of testing machine which were there shortly described remain typical of the machines in present use. In English practice no form of testing machine is more common than the single-lever machine of Mr Wicksteed, in which the specimen stands in a vertical position, suspended from the short end of a long horizontal lever above it. This lever forms a weigh-beam to measure the force used in the test. Pull is applied to the lower end of the specimen by a hydraulic cylinder beneath it, and the amount of pull is measured by a travelling poise which is run out along the lever to the position necessary to balance the pull. The test is carried out by gradually increasing the pull and at the same time moving the poise out so that the lever is kept from touching either of the stops between which it floats. The general arrangement of a machine of this class for applying pull up to 30 tons was illustrated in the article referred to. More commonly, for purposes of commercial testing, the capacity of the machine is 50 or 100 tons, and supplementary arrangements are provided to allow tests in compression or in bending to be made. For this purpose a small platform is suspended like a stirrup by four rods from the weigh-beam, and hangs below the cross-head, which is pulled down when the hydraulic cylinder is put in action. The arrangement is that of two stirrups linked with one another, so that when the two pull against each other a block of material placed between them becomes compressed. For tests in bending one of the stirrups, namely, the platform which hangs from the weigh-beam, is made some 4 or 5 feet long, and carries two knife-edge supports at its ends on which the ends of the piece that is to be bent rest, while the cross-head presses down upon the middle of the piece. In both cases the force which is exerted is measured by means of the weigh-beam and travelling weight, just as in the tension tests. To apply the force continuously, without shock, and either quickly or slowly at will, a very convenient plan is to use a hydraulic intensifier, consisting of a large hydraulic piston operating a much smaller one. By gradually admitting water to the large piston from any convenient source under moderate pressure, such as the town water mains, a progressively increased pressure is produced in the fluid on which the small piston acts, and this fluid is admitted to the straining cylinder of the machine. One of the advantages of the vertical type of machine, with its single horizontal lever, is the facility with which the correctness of its readings may be verified. The two points to be tested are (1) the distance between the knife-edges, one of which forms the fulcrum of the weigh-beam and from the other of which the shackle holding the upper end of the specimen is hung, and (2) the weight of the travelling poise. The weight of the poise is readily ascertained by using a supplementary known weight to apply a known moment to the beam, and measuring how far the poise has to be moved to restore equilibrium. The distance between the knife-edges is then found by hanging a known heavy weight from the shackle, and again observing how far the poise has to be moved.

When specimens of considerable length have to be dealt with a machine which gives the specimen a horizontal position is generally preferred. In such cases a bell-crank lever is generally used to pass from the horizontal direction in which the pull is applied to the vertical direction in which it is measured by means of a travelling poise. In machines of large power the transmission of the stresses through a lever or system of levers becomes increasingly difficult, and accordingly, in some cases where the forces to be dealt with reach 600 and even 1200 tons, the use of levers has been abandoned and recourse has been had to the simpler plan of estimating the force applied to the specimen from observation of the hydraulic pressure in the straining ram. This process is at the best unsatisfactory, for the friction of the hydraulic packing is uncertain. In such cases the plan might with great advantage be followed of transmitting the stress directly through a steel bar or group of bars, forming a part of the machine, which would be elastically strained, and inferring the stress from measurements of their elastic strain. Such measurements can be readily carried out by means of an extensometer in one of the forms described below. The elastic bars would virtually form springs whose elastic quality could be relied on to remain constant. This method of measuring the forces which act on the specimen on testing machines, though carried out on a small scale by Kennedy,[1] Martens,[2] the present writer, and others, does not appear to have yet been applied to the type of machines for which it is particularly suited, namely, those in which the forces to be measured are so great as to make the use of levers unduly cumbrous and costly.

Extensometers. Much attention has been paid to the design of extensometers, or apparatus for observing the small deformation which a test-piece in tension or compression undergoes before its limit of elasticity is reached. Such observations afford the most direct means of measuring the modulus of longitudinal elasticity of the material, and they serve also to determine the limits within which the material is elastic, a matter not merely of physical interest, but of great practical consequence when alternating loads have to be borne. In such a material as wrought iron the whole amount of elastic extension amounts to only about $\frac{1}{1000}$ of the length under observation; with a length of 8 inches, which is usual in tensile tests, it is desirable to read the extension to, say, $\frac{1}{50000}$ inch if the modulus of elasticity is to be found with fair accuracy, and if the limits of proportionality between strain to stress are under examination. Measurements taken between marks on one side of the bar only are liable to be affected by bending of the piece, and it is essential either to make independent measurements on both sides or to measure the displacement between two pieces which are attached to the bar in such a manner as to share equally the strain on both sides.

In the extensive series of experiments carried out by Bauschinger, independent measurements of the strains on both sides of the bar have been made by using mirror micrometers of the type illustrated diagrammatically in Fig. 1. Two clips a and b clasp the test-piece at the place between which the extension is to be measured. The clip b carries two small rollers d_1 d_2 which are free to rotate on centres fixed in the clip. These rollers press on two plane strips c_1 c_2 attached to the other clip. When the specimen is stretched the rollers consequently turn through angles proportional to the strain, and the amount of turning is read by means of small mirrors g_1 and g_2 fixed to the rollers, which reflect the divisions of a fixed scale f into the reading telescopes e_1 e_2. In Martens's extensometer each of the rollers is replaced by a rhombic piece of steel with sharp edges, one of which bears against the test-piece, while the other rests in a groove formed in the spring projecting parallel to the test-piece from the distant clip. Much excellent work has been done by extensometers of this class, but in point of convenience of manipulation it is of great advantage to have the apparatus self-contained, and patterns having this characteristic have been devised by Unwin and others.[3] The present writer has introduced a microscope extensometer of the self-contained type which has been used in a number of recent researches, and has proved convenient. This instrument is shown in Fig. 2; its action will be seen by reference to the diagram Fig. 3. Two clips B and C are secured on the bar, each by means of a pair of opposed set-screws. Between the two is a rod B′ which is hinged to B and has a blunt pointed upper end which makes a ball-and-socket joint with C and P. Another bar R hangs fro[illegible], and carries a mark which is read by a microscope atta[illegible]. Hence, when the specimen stretches, the length of [illegible] being fixed, the bar R is pulled up relatively to the microscope, and the amount of the movement is measured by a micrometer scale in the eye-piece. A screw at P serves to bring the mark on R into the field of view, and also to calibrate the readings of the micrometer scale. The scale allows readings to be taken to $\frac{1}{50000}$ inch, by estimating tenths of the actual divisions. The arms C P and C Q are equal, and hence the movement of Q represents twice the extension of the bar under test. Fig. 4 shows another form of the instrument, as adapted to the compression of short blocks. In this case the arm C Q is nine times the length of C P, and consequently there is a mechanical magnification of ten besides the magnification afforded by the microscope.

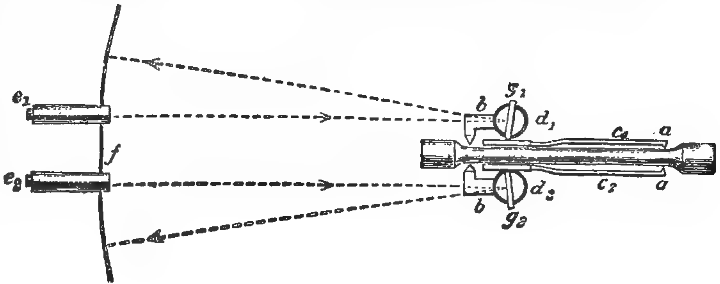

Fig. 1.

(From Unwin's *Testing of Materials.*)

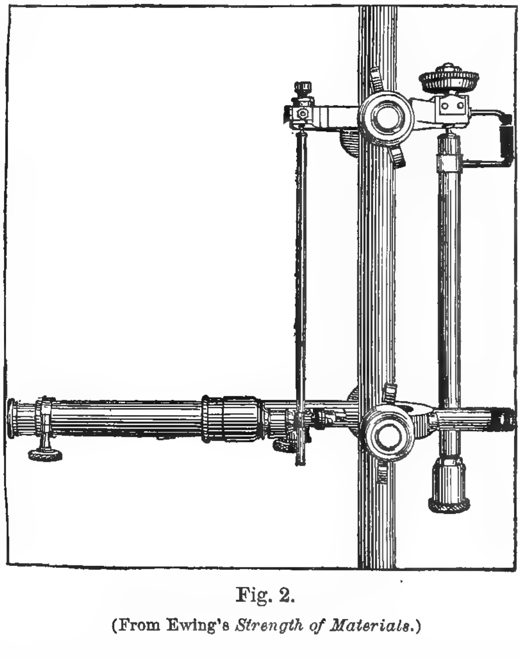

Fig. 2.

(From Ewing's *Strength of Materials.*)

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[1] "The Use and Equipment of Engineering Laboratories," *Proc. Inst. C.E.*, 1886.

[2] *Handbook of Testing Materials*, translated by G. C. Henning. This book should be referred to for detailed accounts of many forms of testing machines.

[3] Descriptions of various forms of extensometer will be found in Martens's book, cited above.

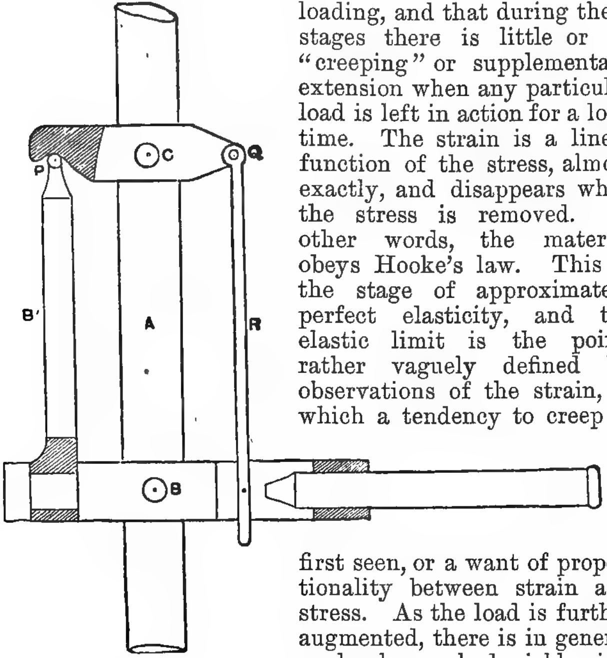

Fig. 3.
(From Ewing's *Strength of Materials.*)

Overstrain.

When the behaviour of specimens of iron, steel, or other materials possessing plasticity, is watched by means of a sensitive extensometer during the progress of a tensile test, it is in general observed that a very close proportionality between the load and the extension holds during the first stages of the loading, and that during these stages there is little or no "creeping" or supplementary extension when any particular load is left in action for a long time. The strain is a linear function of the stress, almost exactly, and disappears when the stress is removed. In other words, the material obeys Hooke's law. This is the stage of approximately perfect elasticity, and the elastic limit is the point, rather vaguely defined by observations of the strain, at which a tendency to creep is first seen, or a want of proportionality between strain and stress. As the load is further augmented, there is in general a clearly marked yield-point, at which a sudden large extension ensues. In metals which have been annealed or in any way brought into a condition which is independent of the effects of earlier applications of stress, this elastic stage is well marked, and the limit of elasticity is as a rule sharply defined. But if the metal has been previously overstrained, without having had its elasticity restored by annealing or other appropriate treatment, a very different behaviour is exhibited. The yield-point may be raised, as, for instance, in wire which has been hardened by stretching, but the elasticity is much impaired, and it is only within very narrow limits, if at all, that proportionality between stress and strained is found. Subsequent prolonged rest gradually restores the elasticity, and after a sufficient number of weeks or months the metal is found to be elastic up to a point which may be much higher than the original elastic limit.[1] It has recently been shown by Mr J. Muir[2] that the rate at which this recovery of elasticity occurs depends on the temperature at which the piece is kept, and that complete recovery may be produced in iron or steel by exposure of the overstrained specimen for a few minutes to the temperature of boiling water. Figs. 5, 6, and 7 illustrate interesting points in Mr Muir's experiments. In these figures the geometrical device is adopted of shearing back the curves which show extension in relation to load by reducing each of the observed extensions by an amount proportional to the load, namely, by one unit of extension for each 4 tons per square inch of load. The effect is to contract the width of the diagrams, and to make any want of straightness in the curves more evident than it would otherwise be. To escape confusion, curves showing successive operations are drawn from separate origins. In the experiment of Figs. 5 and 6 the material under test was a medium steel, containing about 0·4 per cent. of carbon, which when tested in the usual way showed a breaking strength of 39 tons per square inch, with a well-marked elastic limit at about 22 tons. In Fig. 5 the line A relates to a test of this material in its primitive condition; the loading was raised to 35 tons so as to produce a condition of severe overstrain. The load was then removed, and in a few minutes it was reapplied. The line B exhibits the effect of this application. Its curved form shows plainly that all approach to perfect elasticity has disappeared, as a consequence of the overstraining. There is now no elastic limit, no range of stress within which Hooke's law applies. With the lapse of

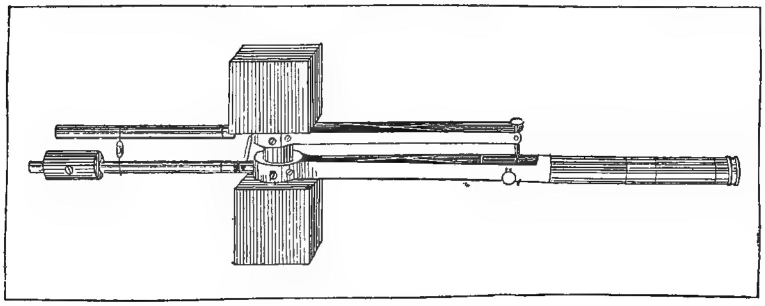

Fig. 4.
(From Ewing's *Strength of Materials.*)

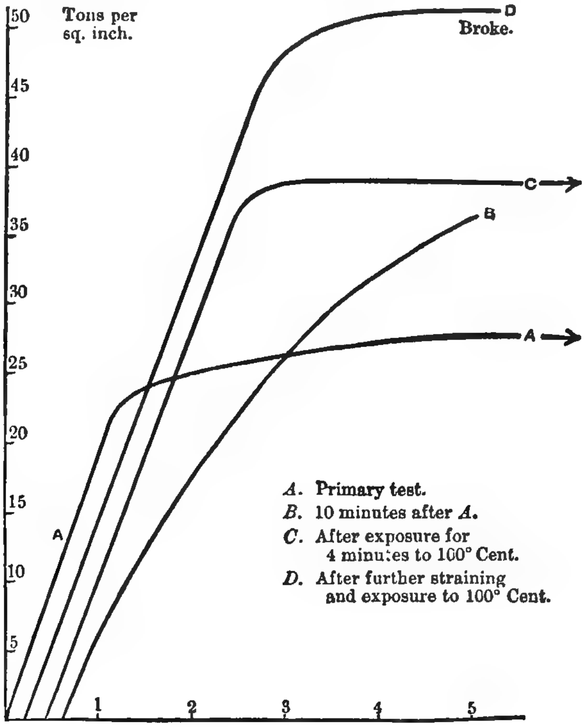

Fig. 5.
(From Ewing's *Strength of Materials.*)

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[1] See experiments by Bauschinger, *Mitth. aus dem mech-tech. Lab. in München*, 1886, and by the writer, *Proc. Roy. Soc.*, vol. xlviii., 1895. A summary of Bauschinger's conclusions will be found in Martens's book, cited above, and in Unwin's *Testing of Materials.*

[2] Muir, "On the Recovery of Iron from Overstrain," *Phil. Trans. Roy. Soc.*, A, vol. 193, 1900.

time the curve gradually recovers its straightness, and the material, if kept at ordinary atmospheric temperature, would show almost complete recovery in a month or two. But in this instance the recovery was hastened by immersing the piece for four minutes in boiling water, and line C shows that this treatment restored practically perfect elasticity up to a limit as high as the load by which the previous overstraining had been effected. The loading in C was continued past a new yield-point; this made the elasticity again disappear, but it was restored in the same way as before, namely, by a few minutes' exposure to 100° C., and the line D shows the final test, in which the elastic limit has been raised in this manner to 45 tons. Other tests have shown that a temperature of even 50° C. has a considerable influence in hastening the recovery of elasticity after overstrain.

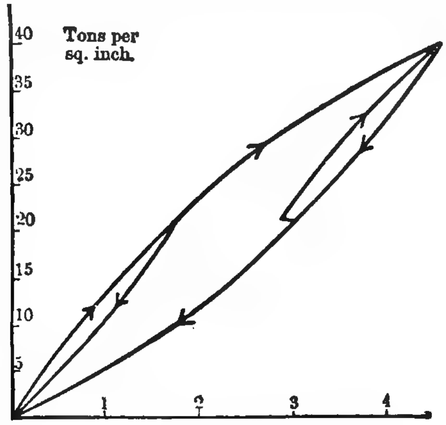


Fig. 6.

(From Ewing's *Strength of Materials.*)

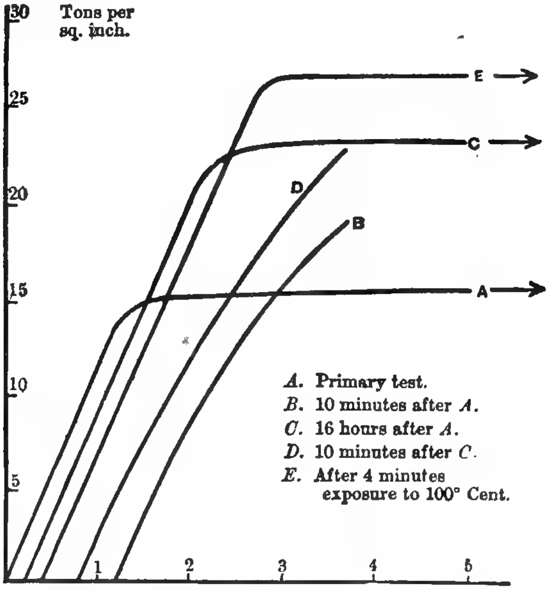


Fig. 7.

(From Ewing's *Strength of Materials.*)

In the non-elastic condition which follows immediately on overstrain the metal shows much hysteresis in the relation of strain to stress during any cyclic repetition of a process of loading. This is illustrated in Fig. 6, where the arrows indicate the sequence of the operations. Fig. 7 relates to tests of wrought iron, a material in which the recovery through lapse of time is more rapid than it is in steel. There the first overstraining A brings about the non-elastic condition B, but a rest during sixteen hours suffices to restore nearly perfect elasticity, with the result that the next loading gives line C with a raised elastic limit. This loading was carried far enough to overstrain the piece a second time, and line D then shows that a non-elastic condition has reappeared. Finally line E shows the recovery which is brought about by immersion in boiling water.

When a piece of iron or steel which has been overstrained in tension is submitted to compression, it shows, as might be expected, no approach to conformity with Hooke's law until recovery has been brought about either by prolonged rest at ordinary temperature or by exposure for a short time to some higher temperature. After recovery has taken place the elastic limit in compression is found to have been lowered; that is to say, it occurs at a lower load than in a normal piece of the same metal. But it appears from Mr Muir's experiments that the amount of this lowering is not at all equal to the amount by which the elastic limit has been raised in tension. In other words, the general effect of hardening by overstrain, followed by recovery of elasticity, is to widen the range within which a practically complete proportionality between strain and stress holds good.

Of all recent aids to a knowledge of the structure of metals, and of their behaviour under stress, perhaps the most important is microscopic examination. The microscopic study of metals was initiated by Sorby as early as 1864 (see *Brit. Assoc. Report* for that year). After a period of neglect, it has been pursued with much energy by a large number of observers, and has yielded results which are of fundamental importance in relation to the strength of materials. For the purpose of microscopic examination it is usually necessary to bring a small piece of the metal to a state of high surface polish, the final stage of which is performed by rubbing on a surface of wash-leather charged with a thin paste of rouge and water. The specimen is then lightly etched in dilute acid or treated with a staining medium, such as liquorice or cocoa, to make the structure visible. When the surface is examined under a lens of suitable power it is seen to be made up of irregular areas with well-defined boundaries. A characteristic example is given in Fig. 9 (see Plate), which is a microphotograph of wrought iron under a magnification of 200, normally illuminated by light which is condensed on the field by means of the objective itself. The areas into which the surface is divided differ in apparent texture, and when illuminated obliquely it is found that some of them shine out brightly while others are dark; by changing the direction of the incident light other areas become bright and those previously bright become dark. These areas are the sections of crystalline grains which constitute the mass of the metal. Each grain is a crystal, the elementary portions of which are all oriented one way, but the orientation changes as we pass from grain to grain. The irregular boundaries are the chance surfaces in which one grain meets another during the progress of its crystalline growth. Etching a polished surface develops a multitude of facets which have the same orientation over any one grain, and therefore give it a uniform texture and a uniform brightness in reflecting light of any particular incidence. The size of the grains depends very much upon the previous thermal treatment to which the metal has been subjected. Sudden cooling from a high temperature tends to make the grains small, slow cooling tends to keep them large; and protracted exposure to moderately high temperature has been observed in some cases to favour the growth of very large grains.

Crystalline structure of metals.

When the metal is strained in any manner beyond its

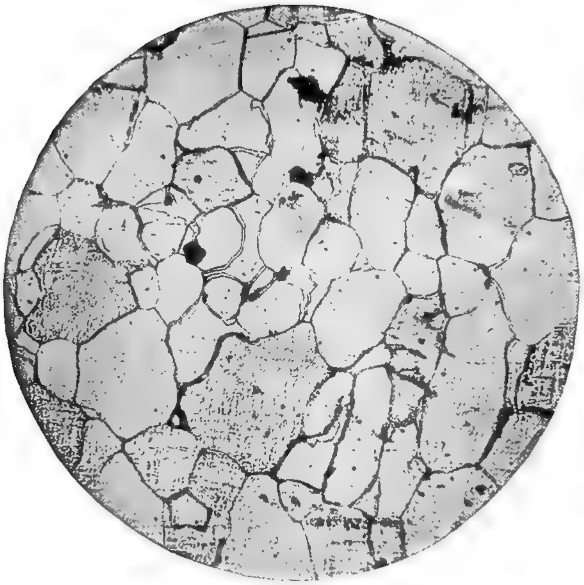


Fig. 9.

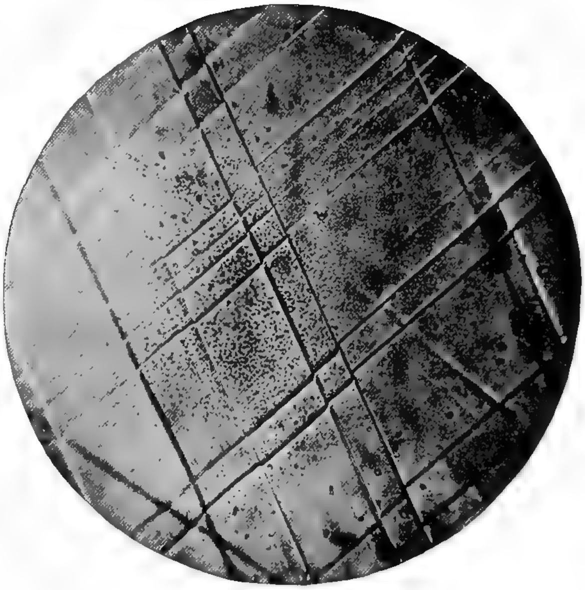


Fig. 11.

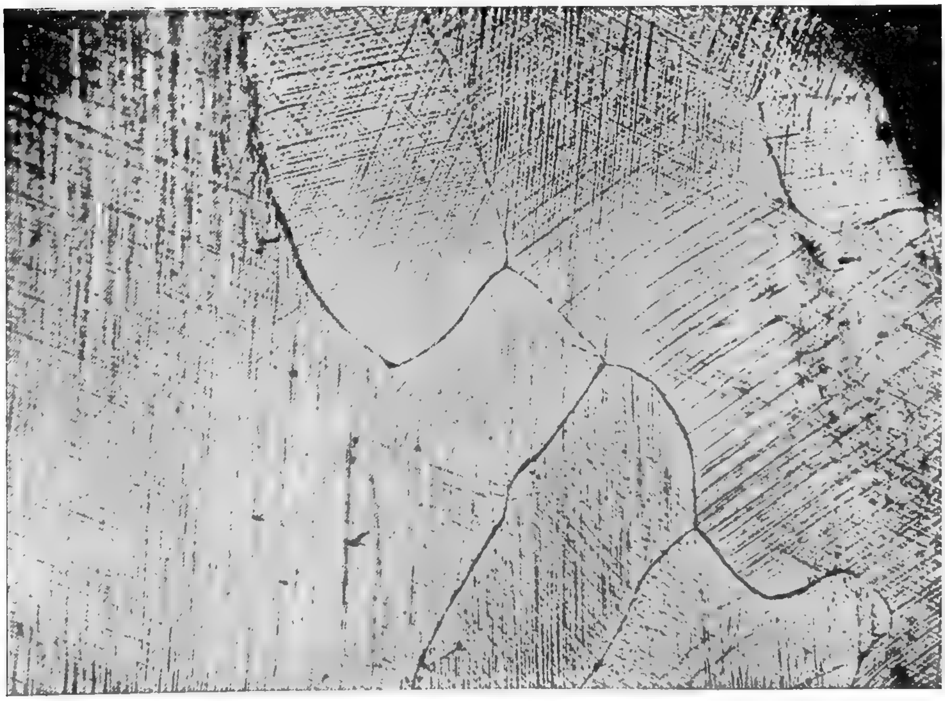
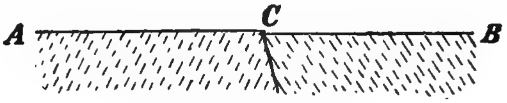


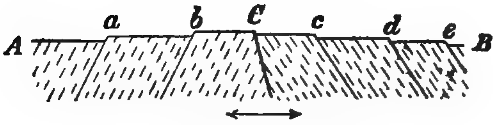
Fig. 10.

(*From "Phil. Trans. Roy. Soc.," A, vol.* 193.)

limit of elasticity the grains are found to have altered their shape, becoming lengthened in the direction in which stretch has occurred. Subsequent exposure to a temperature which is high enough to remove the mechanical hardness produced by overstraining is found to bring about a reconstruction of the grains; the original pattern is not reproduced, but the reformed grains show no direction of predominating length. Researches by Mr W. Rosenhain and the present writer have been directed to examining the manner in which the grains change their shape during straining, and also the changes in structure which subsequently take place. (See "The Crystalline Structure of Metals" (two papers), *Phil. Trans.*, 1900.) These researches have shown that metals retain their crystalline character even when so severely strained as to exhibit qualities of plasticity which are at first sight inconsistent with the idea of crystalline structure. The manner in which a metal yields under severe strain is by slips which occur in the cleavage or "gliding" planes of the individual crystals. These slips are seen under the microscope as sharply defined lines which appear on the polished surface of each grain as soon as the yield-point in any process of straining has been reached. Seen under normal illumination the lines are dark; seen under oblique illumination they may be made to appear as bright lines on a dark ground. The appearance of each line shows that it is a narrow step produced by the slipping of one part of the crystalline grain over another part. The diagram Fig. 8 represents a section between two contiguous surface grains, having cleavage or gliding planes as indicated by the dotted lines, A B being a part of the polished surface. When straining beyond the elastic limit takes place, as by a pull in the direction of the arrows, yielding occurs by finite amounts of slip at a limited number of places, as at *a, b, c, d, e*. This exposes short steps, which are portions of cleavage surfaces, and which, when viewed under normally incident light, appear black because they return no light to the microscope. They consequently appear as dark lines or narrow bands extending over the polished surface in directions which depend on the intersection of that surface with the planes of slip. Many such lines appear as the process of straining goes on; they are spaced at more or less regular intervals, and in general three systems of them may be observed intersecting one another. The general appearance of these slip-lines is illustrated in Fig. 10 (see Plate), which is a comparatively low-power microphotograph of the surface of several grains in a piece of strained lead. Fig. 11 (see Plate), which is part of the same surface under a much higher power, shows the intersections of slips along three or four different planes. With three independent systems of slips it is clear that the grain may take any shape in the process of straining; in many cases four systems of slips are seen. In this way severe deformations occur without affecting the crystalline character of the structure, although the shape of each crystal undergoes much change. A bar of iron which has been rolled cold from a large to a small section shows, when it is polished and etched, a structure in which each grain has all the characteristics of a crystal, although the grains have been distorted into forms very different from those which are found in bars which are rolled at a red heat or are annealed after rolling. It is clear that the process of straining has occurred through movements which preserve the parallelism of all the portions of each individual grain so long as continuity of the parts of the grain is preserved. In many metals, however, a further effect of severe strain is to develop twin crystals, and this implies a rotation of one group of elements through a definite angle with respect to the other elements of the same grain. Excessively severe straining, as, for instance, the squeezing of a block of lead into a thin flat plate, is found to produce a crystalline structure in which the grains have a greatly reduced size; the slips have in that case gone so far as to cause divisions and interpenetrations of the crystals.



Before straining.



After straining.

Fig. 8.
(From *Phil. Trans. Roy. Soc.*, A, vol. 193.)

Growth of crystals.

Microscopic examination further shows that after severe straining the structure of a metal is far from stable, a fact which connects itself with what is observed in respect to mechanical quality. In some metals at least, and notably in lead, severe straining is followed, even at atmospheric temperatures, by a protracted crystalline growth which results in the formation of crystals which are relatively very large. A piece of ordinary sheet lead shows the effects of this growth well; it will be found, when etched, to consist in general of crystals enormously larger than any that could have survived the process of manufacture by rolling. A similar growth may readily be traced from day to day or week to week in a piece of lead which is kept under observation after being severely strained. The process of growth is greatly accelerated by raising the temperature. That some process more or less analogous to this goes on in iron and steel during the change which occurs when elastic recovery takes place after overstraining may be conjectured, though there is as yet no direct evidence on the point. The growth of large crystals which is seen to occur in lead at very moderate temperatures has perhaps a more direct relation to the changes which occur in iron at temperatures high enough to produce annealing. In the second of the two papers referred to above a theory of the growth of crystals in solid metal is suggested, according to which the film of eutectic alloy, which forms a cement between one crystal grain and another, acts as a solvent on one grain and deposits metal on the neighbouring grain, by a process which is probably electrolytic. Most specimens of metal may be expected to contain enough impurity to furnish material for an intergranular cement.

It is impossible in a short article to give any account of what has been done, largely by microscopic examination, in studying the constitution and properties of alloys. Reference should be made to the researches of Heycock and Neville (*Phil. Trans.*, 1900), and to the valuable reports of the Alloys Research Committee made by Sir W. Roberts-Austen to the Institution of Mechanical Engineers (*Proc. Inst. Mech. Eng.*, 1891, 1893, 1895, 1897, 1899), which not only contain much original work, but give a useful summary of the researches of others. The structure of steel in particular has attracted much attention, notably at the hands of Osmond (*Journ. Iron and Steel Inst.*, 1890) and Arnold (*Proc. Inst. C. E.* vol. cxxiii.). Microscopic examination of the low or medium carbon steel used for structural purposes shows it to consist of grains of iron (ferrite), interspersed with grains which have in general a laminated structure and are composed of alternate bands of two constituents, namely, iron and carbide of iron (Fe_3C). To these laminated grains the name of pearlite has been given. In steel such as is used for rails, containing about 0·4 or 0·5 per cent. of carbon, the grains of pearlite occupy about as large a volume of the specimen as the grains of unlaminated ferrite; but when the proportion of carbon is increased to about 0·9 per cent. the whole is a mass of pearlite having an exceedingly intimate mixture of the two constituents. This appears to be a eutectic alloy, and the same intimately blended structure is characteristic of eutectic alloys generally. Important variations in the visible structure result from quenching, annealing, and other varieties of thermal treatment, as well as from the presence of other constituents in the steel. The microscope may be said to serve the part of a detective in determining whether the treatment has been normal or has involved features which would prejudice the quality of the finished product.

Influence of foreign matter.

It is a well-known characteristic of metals that small quantities of foreign matter may produce an altogether disproportionately large influence on their mechanical and other properties. The effect of small quantities of carbon in iron, of nickel in iron, of aluminium in copper, are important practical instances where a highly beneficial effect, in respect of strength and ductility, is produced. The wide and varied range of qualities possessed in steel from pure iron at one end to tool-steel at the other is due to quantities of carbon which lie, for the most part, under 1 per cent. The addition of about 3 per cent. of nickel to mild steel has given an important new structural material possessing increased strength and increased capacity for plastic strain. The presence of manganese in small quantities is known to be an essential condition of strength in mild steel. By adding nickel or manganese in large quantities various interesting products are obtained, one of which has the remarkable property of being almost destitute of magnetic quality (see papers by Mr R. A. Hadfield, *Journ. Iron and Steel Inst.*, 1888, 1889, 1890, 1892, 1894; *Proc. Inst. C. E.*, vols. ciii. and cxxxviii.). The microscope goes far to make intelligible such instances of large effects following on apparently small causes. It also throws light on the important practical question of the influence of certain impurities in causing weakness. It has long been known that sulphur, for example, is a dangerous constituent of iron or steel, its presence even in small quantities being apt to cause brittleness. Under the microscope it may be seen that sulphur tends to segregate into pockets or webs between the crystalline grains of the metal. The cohesion is destroyed, or greatly weakened, where these incipient flaws occur, and a state of stress which would be uniform in homogeneous metal becomes far from uniform in the immediate neighbourhood of the flaw. An alternating stress, for example, which would be well within the elastic limit if it were uniformly distributed may much exceed that limit locally round the edges of the flaw. Hence the material there may be periodically overstrained, and may give way much as a rod gives way when it is bent backwards and forwards beyond its elastic limits, with the result that the flaw gradually spreads and the mischief becomes more and more serious until the piece as a whole breaks. It is not unlikely that many of the sudden failures of propeller-shafts and rails are due to some such cause. The experiments of Wöhler, showing that repeated stresses can produce fracture, although the load is kept within limits which are apparently narrow enough to avoid producing cumulative plastic strains, are difficult to understand in relation to a strictly homogeneous material. They become more readily intelligible when it is recognized that the metals with which the engineer has to deal are far from homogeneous, but consist of aggregates of granules, each of which is a crystal, united by films of cementing material whose properties are not only different from those of the granules themselves, but probably not constant from place to place throughout the substance of the piece. (J. A. E.)

STRIKES AND LOCK-OUTS.

A STRIKE is a stoppage of work by common agreement on the part of a body of work-people for the purpose of obtaining or resisting a change in the conditions of employment. The body of work-people may be large or small, and the cessation of work may be simultaneous or gradual; *e.g.*, if the notices to cease work happen to expire at different dates, the cessation may nevertheless be a strike, provided it takes place as the result of a common agreement. It will be seen from the above definition that a strike, though the immediate result of an agreement, formal or tacit, on the part of work-people to withhold their labour, may originate in a demand on the part of the employer as well as on the part of the employés. In the former case the stoppage is often (though loosely) termed a "lock-out." It is obvious, however, that to distinguish stoppages as strikes or lock-outs according to the source of the original demand for a change of conditions would lead to a very arbitrary and misleading classification. Frequently it is not easy to say which side made the original demand to which the dispute is to be attributed, and frequently a stoppage is the result of a break-down of negotiations in the course of which demands have been made by both sides. Moreover, in so far as the distinction can be drawn, it would lead to the result that in almost all cases a dispute in times of improving trade would be termed a strike, and in times of declining trade a lock-out. It is not possible to frame an entirely satisfactory definition of a lock-out which shall enable it always to be discriminated from a strike. It may be noticed that the attempt to make this distinction has been abandoned in the Board of Trade statistics since 1894, both kinds of stoppages being now included under the comprehensive title of "trade disputes."

The only basis of distinction between a "strike" and a "lock-out," which is sufficiently definite for precise or statistical purposes, is the source from which the actual notice to cease work emanates, cessations resulting from notices given by the employers being termed "lock-outs," while those which either result from notices given by the men, or from their withdrawal from work without notice, would be termed "strikes." But whether the term "lock-out" be restricted as above, or applied, as in the popular use of the term, to any dispute in which the employers appear to be the aggressors, the distinction does not afford a sound basis for the statistical classification of disputes. The source of the actual notices to leave work is often quite an unimportant matter; while, on the other hand, if the ordinary current use of the terms be followed, there will be many disputes which, according to the workmen's view, should be termed lock-outs, and, according to the employers, should be termed strikes—a difficulty which was well illustrated in the controversy as to whether the

"Strike Clauses" in Admiralty contracts could be invoked in the case of work stopped through the engineering dispute of 1897 described below (p. 24). In the present article, therefore, no distinction is drawn for statistical purposes between a strike and a lock-out.

Another distinction, perhaps of greater importance than the above, but which in practice it is sometimes difficult to draw, is between a stoppage in pursuance of a trade dispute, and a stoppage due to a *bonâ fide* dismissal or change of employment arising from the intention of an employer to cease to employ a particular set of men, or of a group of workmen to cease to work for a particular employer. Generally speaking, a stoppage may rightly be termed a trade dispute if there be an intention on the part of both parties (at least at the beginning) to resume the relations of employer and employed on the satisfaction of certain specified conditions. Where the willingness to resume this relation exists on one side only the question is more difficult, and accordingly it is not uncommon for an employer to deny the existence of a trade dispute, although the men formerly in his employ may be actually drawing "strike pay" from their unions, and "picketing" his works to prevent their places being filled. Such cases sometimes arise when the workmen consider that the dismissal of some of their colleagues is due not to personal faults or slackness of employment, but to some collective action which they have taken, or to their membership of some organization. Broadly speaking, however, the distinction is that a trade dispute is a temporary stoppage entered into to obtain or to resist a change of conditions of employment.

The essence of a strike or lock-out is a refusal on the part of a number of workmen collectively or of an employer to renew contracts of employment except on certain changed conditions. This simple situation may be complicated by actual breaches of contract, as when a body of work-people leave work without notice, or by attempts on their part to prevent other persons from entering into contracts of service, or to persuade other persons to terminate or break their contracts. But such features as these, though common to many strikes, are not essential. The question of the legal position of strikes, and of the methods adopted for the conduct of strikes, is discussed below. Here it is only necessary to point out that strikes, as such, are incidents arising out of the modern relationship of free contract as between employers and workmen, and have little real analogy with the revolts of servile or semi-servile labour in ancient or mediæval times.

Trade Disputes in the United Kingdom.

Since 1888 the Board of Trade have kept a record of strikes and lock-outs in the United Kingdom, and the following table, based on the official returns published by that department for the last ten years, shows the number and importance of these stoppages in the United Kingdom:—

Year.	Number of Disputes.	Number of Work-people affected.			Aggregate Duration in Working Days.
		Directly.	Indirectly.	Total.	
1891	906	203,571	63,889	267,460	6,809,371
1892	700	316,136	40,663	356,799	17,381,936
1893	783	598,534	37,852	636,386	31,205,062
1894	929	257,314	67,934	325,248	9,529,010
1895	745	207,239	55,884	263,123	5,724,670
1896	926	147,950	50,240	198,190	3,746,368
1897	864	167,453	62,814	230,267	10,345,523
1898	711	200,769	53,138	253,907	15,289,478
1899	719	138,058	42,159	180,217	2,516,416
1900	648	135,145	53,393	188,538	3,152,694

A comparison of the figures for particular years is subject to some qualifications, owing on the one hand to the increasing completeness of the Board of Trade returns, and on the other hand to the fact that from 1894 very small disputes have been excluded. There have also been some changes in the method of computing "aggregate duration." On these points reference should be made to the reports themselves. The figures stated above give, however, a fair idea of the magnitude and fluctuations of trade disputes in recent years. It should be noted that by "indirectly affected" are meant the work-people employed in the same establishments as those on strike, who are thrown out of employment owing to the strike, but are not themselves engaged in it. The Board of Trade statistics do not take into account the persons employed in kindred trades who are indirectly affected.

The most important thing to note about the above statistics is that in most years they are dominated by one or two large disputes. This is seen most clearly from the following table:—

Year.	Principal Disputes of the Year.			All other Disputes.		
	Trade and Locality.	Number of Work-people affected.	Aggregate Duration in Working Days.	Number of Disputes.	Number of Work-people affected.	Aggregate Duration in Working Days.
1891	(No very large dispute)	...	...	906	267,460	6,809,371
1892	Coal Miners (Durham)	75,000	4,275,000	698	231,799	7,156,936
	Textile Operatives (Lancashire and Cheshire)	50,000	5,950,000			
1893	Coal Miners (Federated Districts)	300,000	23,700,000	781	246,386	5,165,062
	Coal Miners (South Wales)	90,000	2,340,000			
1894	Coal Miners (Scotland)	70,000	5,600,000	928	255,248	3,929,010
1895	Boot and Shoe Operatives	46,000	1,564,000	744	217,123	4,160,670
1896	(No very large dispute)	...	...	926	198,190	3,746,368
1897	Engineers	47,500	5,731,000	863	182,767	4,614,523
1898	Engineers—*continued*		1,118,000	710	153,907	2,521,478
	Coal Miners (South Wales)	100,000	11,650,000			
1899	(No very large dispute)	...	...	719	180,217	2,516,416
1900	(No very large dispute)	...	...	648	188,538	3,152,694

From the above figures it appears that of the 7931 disputes recorded in the past decade, nearly 60 per cent. of the total magnitude as measured by aggregate duration in working days was accounted for by eight large disputes. The great majority of the disputes were very trivial affairs. Thus in 1900, 488 of the recorded disputes (or about three-quarters of the whole number) accounted for only 9 per cent. of the total time lost, and this, it is to be remembered, is after the very small disputes have been excluded.

By "aggregate duration" or "time lost" is meant the product of the number affected multiplied by the duration of the dispute in working days, with (in recent years) some allowance for those who have found work elsewhere or been replaced by others. Though this figure is the best general index of the importance of the disputes of each year, it is but a rough approximation to the time actually lost through disputes.

For example, if a strike cause a postponement or accumulation of work, the extra demand for labour, and the overtime worked after its conclusion, may partially compensate for the stoppage. On the other hand, if a dispute should drive away trade or cause the closing of works, it may lessen the field of employment for a long period after its termination, and such lost time cannot be taken into account in the estimates of "aggregate duration."

For these reasons all estimates of wages lost through disputes are somewhat fallacious. The real importance of strikes lies less in the value of the actual time consumed by their duration, than in their indirect effects on the organization and effectiveness of the industry, and on the relations of employer to employed, and also in their reaction on the conditions of allied trades. The comparative insignificance of the actual loss to production owing to the mere loss of time caused by strikes will be seen from the fact that the total duration of strikes during the past seven years, if spread over the entire adult male working population, would be equivalent to less than the loss of one day per head per annum. As a matter of fact, however, the loss owing to strikes is very unequally distributed over the industrial population. In large groups of industries, *e.g.*, agriculture, strikes are of rare occurrence. In others, such as the building trades, they are frequent, but mostly small and local; while in mining they are not only frequent and often prolonged, but in many cases they involve large numbers of persons and extend over wide areas. Thus on an average of the seven years 1894–1900 there were 169 disputes annually in the building trades, and 156 in mining and quarrying, but the latter disputes have involved more than five times as many persons, and had an aggregate duration nearly six times as great. Intermediate between these groups of trades is the metal, engineering, and shipbuilding group, in which, more perhaps than in any other group, the importance of disputes varies according to the state of trade.

The principal facts relating to the distribution of trade disputes among the more important groups of trades are given in the following table for the mean of the seven years 1894–1900:—

Groups of Trades.	Number of Disputes.	Number of Work-people affected (directly and indirectly).	Aggregate Duration in Working Days.	Percentage of Total Number employed who were affected by Disputes.	Percentage of Aggregate Working Time occupied by Disputes.
Building . . .	169	19,688	590,639	2·4	0·24
Mining and Quarrying .	156	102,408	3,445,124	12·2	1·37
Metal, Engineering, and Shipbuilding .	174	40,294	1,826,869	3·7	0·55
Textile . . .	126	40,778	608,588	3·3	0·16
Clothing . . .	48	10,658	326,988	1·9	0·19
Transport (Dock, Harbour, Railway, &c.) .	88	10,102	116,858	1·0	0·04
Miscellaneous . .	74	9,716	267,994	0·4	0·03
Employés of Public Authorities	7	574	3,748	0·5	0·01
All Trades, except Agricultural Labourers, Seamen, Fishermen, and Domestic Service		234,218	7,186,808	2·8	0·29

It is not easy from the statistics available to trace a definite relation between the prevalence of trade disputes and the general state of employment, both because of the comparatively short period over which the records extend, and of the dominating effect of a few gigantic stoppages. If, however, these great labour wars be excluded, it will be found that the statistics of the remaining disputes show a certain degree of stability, the annual numbers affected varying roughly in the years 1890–1900 from 150,000 to 260,000. The range of variation of the aggregate duration has been greater, viz., from about 2½ to 7 million working days a year, the average being about half a day for each adult workman belonging to the classes who are affected by strikes. This is the measure of the time actually consumed by trade disputes other than the great conflicts which attract public attention. It would be natural to expect that these trade disputes would be most prevalent at or just after a turn in the tide of employment, when there is most room for *bonâ fide* disagreement as to the conditions of the labour market. These are undoubtedly the most critical times in the relations of employers and employed, but the disturbing influence of accidental causes is too great to enable any regular law of variations in disputes to be established by statistical evidence. It is to be remembered that in recent years there has been a great development in the means available for avoiding stoppages by conciliatory action (see ARBITRATION AND CONCILIATION), and this of itself would greatly complicate the task of tracing any correspondence between the prevalence of actual stoppages and the state of employment. Broadly it may be said that the great majority of upward and downward changes of wages are settled nowadays without strikes, and in many trades actual stoppages, instead of being a normal feature in the relations between employer and employed, are rather to be looked on as cases of accidental breakdown of the recognized machinery of negotiation.

Causes.

The causes of disputes are of course very varied, embracing all the matters relating to conditions of employment on which differences may arise between employers and employed. Experience shows, however, that the great bulk of disputes relate to questions of wages, a much smaller proportion to hours of labour, and the balance to a large number of miscellaneous questions, of which perhaps the most frequently occurring is the employment of persons or classes obnoxious to the strikers on the ground that they do not belong to their union, or have worked against its interests, or because they are held to have no "right" to the particular occupation on which they are employed, either on account of not having gone through the recognized training or of belonging to another trade. Among this class of strikes are to be included the so-called "demarcation" disputes between two bodies of workmen as to the limits of their trades, which frequently cause suspension of work by both groups, to the great inconvenience of the employer. Strikes are also not uncommon on the question of trade-unionism pure and simple—*i.e.*, to obtain or defend freedom to belong to a union, or to act through its agency in negotiations with employers. This question enters more or less as a factor into a large number of disputes, most usually, however, as a secondary cause or object, so that it hardly appears so prominently as it deserves in the tabulation of causes in the Board of Trade statistics, which is based on principal causes only. Thus the formulated demands of the strikers are usually for improved conditions of work, the question of "recognition" of the trade union only arising incidentally when the parties attempt to negotiate as to these demands. The following table, showing the principal causes of disputes for the past five years, is based on the official statistics:—

Principal Cause.	Percentage of Work-people directly affected by Disputes in					Mean of 5 Years.
	1896.	1897.	1898.	1899.	1900.	
Questions of wages	64·9	44·1	87·9	68·6	61·4	65·4
Questions of hours	1·6	23·4	0·4	2·8	0·5	5·7
Employment of particular classes or persons	15·4	8·9	4·6	5·9	7·7	8·5
"Trade unionism" (see above)	3·6	3·8	1·1	3·7	14·5	5·3
Other causes	14·5	19·8	6·0	19·0	15·9	15·1

Results.

The results of trade disputes are as varied as their causes. Sometimes a strike goes on until the employer is ruined or retires from business, and is only ended by the permanent closing of the works; sometimes, especially when trade is slack, the places of the men are almost immediately filled, and the only economic result of the strike is to replace one body of men by another without perceptible interruption of business. There have been frequent cases of this kind in strikes of unskilled labourers. Sometimes, on the other hand, the demand for labour is so active that the whole of the strikers immediately find work elsewhere, and the only economic result is to transfer a body of men from one set of employers to another with little or no interruption of their employment. Of late years the building trades have afforded several examples of this issue of a trade dispute. In other cases, after a more or less prolonged stoppage, the disputes end by the permanent "blocking" of an employer's establishment by a union, or the permanent refusal of the employer to take back any of his former employés. All these, however, are extreme, and on the whole exceptional cases. The vast majority of trade disputes are settled by mutual arrangement, and whether such arrangement is wholly in favour of one or other party, or involves a compromise, its terms provide that the whole or part of the body of work-people whose labour was withheld or excluded shall return on agreed conditions to their former employment. Thus in 1900, of 188,538 persons involved in 648 disputes, only 8895, involved in 45 disputes, returned to work on their employers' terms without negotiation of any kind, while 71 disputes, involving 4918 persons, were ended by replacement of men; 4, involving 300, by the closing of works, and 9, involving 3689 work-people, were settled by indefinite means, or remained unsettled. All the remaining disputes, 519 in number, involving 170,736 persons, were concluded by negotiation, either with, or more usually without, the aid of an outside mediator or arbitrator.

The following figures show the comparative results of trade disputes. The percentages refer to the proportion of work-people involved in disputes which resulted in the manner indicated. (From 1896 onward only the work-people directly affected are included.)

Year.	In favour of Work-people.	In favour of Employers.	Compromised.	Indefinite.	Total.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1891	25·6	34·8	36·7	2·9	100·0
1892	27·5	19·9	51·4	1·2	100·0
1893	62·9	12·1	24·7	0·3	100·0
1894	22·1	42·1	34·2	1·6	100·0
1895	24·1	27·9	47·1	0·9	100·0
1896	43·5	28·0	28·3	0·2	100·0
1897	24·2	40·7	34·0	1·1	100·0
1898	22·6	60·1	17·2	0·1	100·0
1899	26·7	43·7	29·1	0·5	100·0
1900	30·1	24·8	41·7	3·4	100·0
Decennial Average	30·9	33·4	34·5	1·2	100·0

As regards the results of disputes in different groups of trades, it is to be observed that in recent years workmen in the building trades have had more than the average degree of success, while in the textile trades the balance has been in favour of the employers.

It is, of course, to be understood that the figures in the above table only relate to the *immediate* results, as determined by the relative extent to which one or other of the parties succeed in enforcing their demands. The question of the ultimate effect of the stoppages on the welfare of the parties or of the community generally, is an entirely different question (see below, p. 20).

Organization of Strikes and Lock-Outs.

Influence of trade unions.

In the great majority of cases strikes are organized and controlled by trade unions. It does not, however, follow from this that the growth of trade unionism has always fostered and encouraged strikes, there being evidence that in many trades the strengthening of organization has had the effect not only of restraining ill-considered, partial stoppages, but also of preventing more serious dislocations of industry by providing a channel for the expression of grievances and a recognized means of negotiating with employers. Much of the evidence given before the Royal Commission on Labour (1891–94) tended to show that the growth of trade unions has the effect on the whole of lessening the frequency though of widening the area of disputes. The Commission, moreover, laid down that the stage of industry in which disputes are likely to be most frequent and bitter is that in which it is emerging from the "patriarchal" condition, in which each employer governs his establishment and deals with his own men with no outside interference, but has not fully entered into that other condition in which transactions take place between strong associations fully recognizing each other. In this state of industrial organization bitterness is often caused by the insistence of the work-people on the "recognition" of their unions, and by the treatment of these unions by the employers as outside parties interfering and causing estrangement between them and the work-people actually in their employ.

Probably next to the patriarchal stage, in which each factory is a happy family, the industrial conditions most favourable to peace are when a powerful trade union is face to face with a representative employers' association—both under the guidance of strong but moderate leaders, and neither feeling it beneath its dignity to treat on equal terms with the other. When, on the other hand, some or all of these conditions are absent, the growth of combinations may tend to war rather than peace.

Whether, however, trade unionism tends generally to encourage or to restrain strikes, the organization and policy of all trade unions, as at present constituted, are based on the possibility of a collective withdrawal from work in the last resort. Dispute pay is consequently the one universal form of trade union benefit. Though, however, in most of the disputes recorded the strikers are financially supported by some trade union, this is by no means universally the case. Many strikes have been entirely carried out without the instrumentality of a permanent combination, the work-people affected belonging to no union, and merely improvising a more or less representative strike committee to control the movement. It is not uncommon, however, for a permanent union to originate in a strike of non-unionists. In other cases (*e.g.*, in the London dock strike of 1889) an insignificant trade union may initiate a strike movement involving several thousands of labourers outside its membership. In the case quoted the membership of the Dockers' Union rose during the few weeks of strike from

800 to over 20,000. The most conspicuous recent case of a widespread strike of workmen not belonging to a trade union was the South Wales coal-miners' dispute of 1898. Of the 100,000 men affected, probably not more than 12,000 belonged at the time to any trade union, but the workmen's representatives on the committee of the sliding scale (against which the movement was directed) formed the nucleus of a strike committee, and one result of the strike was the formation of the "South Wales Miners' Federation," affiliated to the Miners' Federation, and numbering at the end of 1900 no less than 128,000 members. In the case of strikes of non-unionists, the strikers, of course, have to depend for their maintenance on their own resources or on the proceeds of public subscriptions. Frequently grants are made in their aid by sympathetic trade unions, and in the case of the South Wales dispute above referred to, several boards of guardians gave out-door relief to strikers who had exhausted their resources. This action, however, has been held to be illegal.

The majority of strikers, however, belong to trade unions and receive "dispute benefit," which usually consists of a weekly payment of from 10s. to 15s. In 1900 the sum expended by 100 of the principal trade unions in support of men engaged in disputes was £150,283. In some recent years it has largely exceeded this sum. Thus in 1897, the year of the great engineering dispute, the amount so expended by trade unions was no less than £633,347.

Although most strikes are controlled by trade unions, cases are comparatively rare in this country in which the central committee of a trade union takes the initiative and directs its members to cease work. More usually a local strike movement is initiated by the local workmen, and the central committee is generally empowered by the rules to refuse its sanction to a strike and to close it at its discretion, but has no authority to order it. In many unions a ballot is taken of the members of the districts affected before a strike is authorized, and a two-thirds (or even greater) majority, either of members or of branches, in favour of a stoppage may be required before the sanction of the central executive is granted. Some unions in their rules draw a distinction between strikes to enforce new conditions (*e.g.*, a rise of wages, a restriction of hours or of overtime) and strikes to oppose the introduction of new conditions by the employers, greater freedom being allowed to the local members in the case of "defensive" than of "offensive" strikes.

Sometimes also the executive committee, while refusing their official sanction to a strike, and declining to allow the funds of the society to be used to support the strikers, may tacitly permit a local committee to take what action it pleases and to collect funds for the purpose. Some strong unions, however, especially those which have entered into general agreements with employers' associations, not only refuse financial support to an unauthorized strike, but even expel from their society strikers who refuse to obey their order to return to work. The Boilermakers' and Iron Shipbuilders' Union has more than once taken drastic action of this kind, even to the extent of fining or superseding recalcitrant members and officials. In 1899 the National Union of Boot and Shoe Operatives, which is a party to an agreement with the Employers' Federation (known as the "Terms of Settlement") was fined £300 by the umpire under that agreement for failing to expel or to induce to return to work certain of their members who took part in a strike contrary to the provisions of the agreement. It sometimes happens, however, that the central committee of a trade union is not strong enough to withhold financial support even from an unauthorized strike.

When a strike has been authorized by the executive, the conduct of it is frequently entrusted to a "strike committee," appointed *ad hoc*, one reason being that a strike of any considerable dimensions often affects members of several unions, so that the common action necessary in a conflict with employers can only be attained by a committee representing all the societies involved. Thus the great engineering dispute of 1897 began with a purely London movement for an eight hours' day, and was conducted by a committee representing the London districts of several societies. A strike committee has often no power to draw on the funds of the unions represented, each of which pays dispute pay in accordance with its rules to its own members, the financial power of the strike committee being limited to the support of non-unionists out of any funds available for the purpose, or the collection and administration of funds in case of the exhaustion of the resources of any of the unions represented.

The financial support of a local or sectional strike imposes but little strain on the resources of a large society, but where a considerable proportion of the members are affected it is usual for a union to replenish its funds by imposing a "levy" or special contribution on members remaining at work. During the engineering dispute of 1897–98 the levies imposed by the Amalgamated Society of Engineers rose to 2s. 6d. per week, and one of the main objects of the federated employers was to diminish the revenue obtained from this source by enlarging the area of the dispute.

When there is no regular provision for the financial support of strikers, or when this provision is exhausted, the strike leaders have a much more difficult task in preventing the return to work of some of their followers; and it is in these cases that intimidation and violence are most to be apprehended. In all strikes, however, except in the few cases in which the whole of the workmen in the trade are in the union, and the skill required is such that no new labour can enter the trade during the dispute, there is the possibility of the strikers being replaced by other labour, and the efforts of the strike organizers are largely directed to the prevention of this by all means in their power. The chief method employed has generally been that known as "picketing," viz., the placing of members of the union to watch the approaches to the works or factories affected, to give information as to the strike to any workmen who attempt to enter, and to endeavour to dissuade them from accepting employment. The state of the law as regards picketing is described on the next page. In practice the line between giving information and peacefully persuading, or again between peacefully persuading and intimidating, is often so fine that the most divergent views may be taken, especially in the excitement of a contest as to what has really occurred in any given case. Other methods of preventing workmen from taking the place of strikers may also be adopted or attempted, ranging from the publication of information in leaflets or otherwise as to the existence of a dispute, or appeals to workmen to avoid the works affected, to systematic annoyance or intimidation of workmen who take or retain employment during a stoppage by threats or by actual violence and outrage.

The methods adopted by strikers and strike organizers naturally suggest the counter measures adopted by employers. To break down the resistance of a body of work-people supplied with a weekly strike allowance by a powerful trade union employers sometimes have recourse to some method of mutual indemnification by which the financially weaker of their number are temporarily subsidized by the stronger, whether through the machinery of a permanent employers' association or of an emergency committee. Employers' associations being usually composed of much smaller numbers than trade unions, are, as a rule, able to act in concert with greater secrecy and less formality than is possible in a workmen's union. Apart from any financial support which employers may guarantee their colleagues when attacked by a trade union, they have in some cases formed or aided organizations for the systematic provision of a reserve of "free labourers" available to replace men on strike. By "free labourers" is meant not necessarily non-unionists, but labourers pledged to work amicably with others whether members of a union or not. The Shipping Federation, an organization of shipowners and shipowners' associations which was formed in 1890 to combat the strikes then prevalent among seamen, arranged a system of shipping offices at which seamen could be engaged who were prepared to give a pledge that they would work with non-unionists. They also opened similar offices for shore labourers in some ports. Other independent agencies exist for supplying employers with labour during a dispute. It is not uncommon, in disputes in which there is any apprehension of intimidation or violence, for employers to board and lodge the imported work-people. Another method on which employers have recently shown an increased tendency to rely is the institution of legal proceedings to restrain individual strikers or the union to which they belong from taking wrongful action injurious to their business. There has, however, been no attempt to induce the courts to restrain bodies of work-people from striking by injunction, as has been frequently done in American strikes affecting interstate commerce. In many disputes the attitude of public opinion is of some importance in determining the results, and accordingly both sides frequently issue statements or manifestoes giving their versions of the difference, and in other ways (*e.g.*, by an offer of arbitration) one party or the other endeavours to enlist public opinion on its side.

Free labour.

Public Action with regard to Strikes and Lock-Outs.

Though the majority of labour disputes have little importance for third parties, stoppages of this kind sometimes acquire a special interest for the general public either by reason of the large number of labourers whose livelihood is affected, or of their indirect effects on employment in kindred trades, or of the danger and inconvenience that may be caused to the public, or of the fear that industry may be diverted abroad, or that a breach of the peace may be caused by attempts on the part of the strikers to coerce persons outside their combinations. For these and other reasons, strikes and lock-outs are usually regarded as a class of disputes in which legislative interference has more justification than in the case of other kinds of industrial and commercial differences.

Legislative action, with the view of providing alternative methods of adjusting labour difficulties, is discussed in the article ARBITRATION AND CONCILIATION. It is there shown that only in New Zealand and New South Wales have these alternative methods been made compulsory, and there are indications that the great majority of employers and workmen in Great Britain would not be prepared for such a measure, involving as it would the legal fixing of wages and conditions of employment, and the surrender by those directly concerned of their freedom to arrange these matters by voluntary agreement or by a trial of strength. Without the provision of some alternative by the State, it would be impossible in a free country to prohibit altogether the termination of labour contracts by collective agreement among work-people or employers.

The law, however, may and does restrict or prohibit the use of some of the methods of promoting or carrying on strikes which interfere with the liberty of other labourers, or inflict a wrong on employers, or injuriously affect the public interest.

Law of the United Kingdom dealing with strikes.

The present relation of the law in the United Kingdom to strikes and lock-outs is briefly as follows. Since the legislation of 1871 and 1875 there has been no question of the legality of a strike as such, viz., of a combined abstention from work in order to influence the conditions of employment, but the method in which the strike is carried out may subject the strikers either to criminal or civil liabilities. In this connexion the chief questions of interest relate to the limits within which strikers may lawfully act for the purpose of inducing other persons not to take their places, and for the purpose of bringing indirect pressure to bear upon the employer by influencing others not to work for or deal with him; and, on the other hand, the limits within which employers may act in inducing other employers to abstain from employing workmen or members of a trade union with whom they have a dispute.

Strikers are necessarily liable to the general criminal law, but the Conspiracy and Protection of Property Act, 1875, enacted that an agreement or combination by two or more persons to do, or procure to be done, any act in contemplation or furtherance of a trade dispute between employers and workmen shall not be indictable as a conspiracy if such act if committed by one person would not be punishable as a crime, namely, on indictment or on summary conviction with the statutory liability of imprisonment either absolutely or alternatively for some other punishment. The Act does not affect any conspiracy punishable by statute nor the law relating to riot, unlawful assembly, breach of the peace, or sedition, or any offence against the State or sovereign. The Act also does not apply to seamen, or to apprentices to the sea service.

Sudden breach of contract of service in gas and water undertakings, or under circumstances likely to endanger human life or cause serious bodily injury, or expose valuable property to destruction or serious injury, are made punishable offences by special sections, but the miscellaneous provisions of the Act are the most important in trade disputes. These provisions subject to a penalty of fine or imprisonment every person who, with a view to compel any other person to abstain from doing, or to do any act which such other person has a legal right to do or abstain from doing, wrongfully and without legal authority.

(1) Uses violence to or intimidates such other person, or his wife, or children, or injures his property; or

(2) Persistently follows such other person about from place to place; or

(3) Hides any tools, clothes, or other property owned or used by such other person, or deprives him of or hinders him in the use thereof; or

(4) Watches or besets the house or other place where such person resides, or works, or carries on business, or happens to be, or the approach to such house or place; or

(5) Follows such other person with two or more other persons in a disorderly manner in or through any street or road.

Attending at or near the house or place where a person resides, or works, or carries on business, or happens to be, or the approach to such house or place, in order merely to obtain or communicate information, shall not be deemed a watching or besetting within the meaning of the Act.

As interpreted by the courts in recent years, in a series of cases, of which Lyons *v.* Wilkins (1896 and 1899) is the most important, the above provisions render illegal all picketing except such as is merely for the purpose of giving or obtaining information. Attending in order to persuade was held not to be within the exemption, and it was pointed out that the Act applies to all the King's subjects, and did not legalize acts in themselves unlawful at common law. Until these cases, it was generally supposed that picketing for the purpose of peaceably, and without threats or intimidation, persuading persons not to work or to cease work for an employer was lawful. But it is now clear that this is not the law. It has been held that the compulsion aimed at is not limited to direct coercion, but includes such compulsion as is exercised upon an employer by inducing others not to work for him, that the place beset is not limited to the works of the employer, but extends to any place where men who do or may work for him happen to be, and that the besetting need not be persistent, but may be on a single occasion. To beset any place where men happen to be who do or may work for the employer in order to persuade them not to work, if it be done with the view of compelling the employer to concede the strikers' demands, is within the section.

For damages flowing from any of these criminal acts, as from any actionable wrong not amounting to a crime, the strikers guilty of them will be civilly liable at the suit of the employer or other person injured. And employers have in recent years frequently had recourse to injunction as a ready remedy to restrain strikers, especially in order to stop illegal picketing. The extent to which strikers may render themselves liable to an action for damages by conduct aimed at bringing indirect pressure to bear upon the employer has been the subject of judicial consideration in several recent cases, and the law cannot yet be regarded as settled in any very definite manner. Picketing, except for the very limited purpose allowed by the Act of 1875, and the other acts aimed at by that Act are means of such pressure which clearly give a cause of action to the party wronged. But apart from the statute, there are many forms of coercion which are actionable because a wrongful infringement of the liberty of others. The general principle is that every one, employer or workman, has a right to deal with other persons who are willing to deal with him, and that no one may interfere with that right by any form of *coercion*. What is coercion must depend upon the circumstances, but, when many men are acting in concert, conduct may be coercive in them all which would not be coercive in one. Picketing is thus, apart from the statute, an actionable wrong. The publication of black lists is the same. To call out men who are willing to work for an employer is an infringement of the right of the employer and of the men. If the members of a trade union, in order to bring pressure to bear upon employer A, threaten employer B that unless he ceases to deal with A the union will call out B's men, it is a wrongful infringement of the right of A and B to deal with one another. All such forms of coercion, if they directly cause damage, will amount to actionable wrongs. An illustration may be seen in the case of Quinn *v.* Leathem in 1901. At one time the case of Allen *v.* Flood in the House of Lords (1898) seemed to place some important limitations on the civil liability of strikers. But the only general principle decided by that case was that an act lawful in itself is not converted by a malicious or bad motive into an unlawful act so as to make the doer of the act liable to a civil action. The question to be determined in every case will be not whether the strikers acted out of spite, but whether they infringed any legal right of the party complaining of their action. Wherever a legal right is infringed and damage follows, the motive of the act is immaterial except in so far as it may help to show that the damage caused was the natural result of the act done, and therefore not too remote to be actionable.

Until recently it was supposed that for wrongs committed in strikes only the individual wrongdoers could be made responsible. But the decision of the House of Lords in the Taff Vale Railway case (1901) has shown that a trade union can be sued in tort for acts done by its agents within the scope of their authority, and may be sued in its collective capacity, and execution of any damages recovered may be enforced against its general funds (see TRADE UNIONS).

Economic Effects.

The question of the effectiveness or otherwise of strikes and lock-outs for the purpose of influencing the conditions of employment is part of the wider question of the economic effect of combinations, the strike or lock-out being only one of many methods adopted by combinations of workmen or employers to enforce their demands. (This matter is discussed in the article TRADE UNIONS.) Apart, however, from the question of the extent of the immediate advantage, if any, which one party or the other is able to obtain from a stoppage, we have to consider generally the economic effects of strikes and lock-outs to the community as a whole. Stoppages of work are in their nature wasteful. Time, which might be employed in work yielding wages to the work-people and profits to the employers, is lost never to be recovered, while many forms of fixed capital deteriorate during idleness. In attempting, however, to estimate the utility or disadvantage of strikes and lock-outs, whether to the parties themselves or to the industrial community as a whole, it is insufficient to take into account the value of the wages and profits foregone during the stoppage, and to balance these against the gains made by one party or the other. Attempts have often been made to measure the loss or gain due to strikes in this way, but even as applied to particular stoppages, looked at purely from the point of view of one or other of the parties involved, the method is unsatisfactory. On the one hand, the time and work apparently lost may be afterwards partially recouped by overtime, or some of the strikers may be replaced by others, or may themselves find work elsewhere, so that the actual interruption of production may be less than would appear from the magnitude of the dispute. On the other hand, the total loss due to the stoppage may be augmented by the diversion of trade for a longer or shorter period after the resumption of work. Again, the ultimate effect of the forced concession of excessive demands may be damaging instead of advantageous to the nominal victors, by contracting the field of employment or by lowering the efficiency of the labour. If, however, the arithmetical computation of the value of the time lost compared with the value of the terms gained is an unsatisfactory test of the benefit or disadvantage of a particular strike to the parties concerned, it is wholly fallacious as a method of estimating the social utility or otherwise of strikes and lock-outs as instruments for effecting changes in the condition of employment. For any satisfactory consideration of this wider question we must look not merely to the actual strike, but to the whole process of free bargaining between employers and organized bodies of work-people, of which, as already shown, the strike may be regarded as merely an untoward incident. The actual cessation of work is a symptom that for the time there is a deadlock, and frequency of such cessations in any trade is a sign of the imperfection of means of negotiation. In many trades in which both employers and workmen are strongly organized various forms of machinery have been brought into existence for the purpose of minimizing the chance of stoppages (see ARBITRATION AND CONCILIATION). But wherever there is free combined negotiation, there is always in the background the possibility of combined stoppage. This being understood, the question of the utility of strikes as an industrial method resolves itself into the questions: (1) Whether the process of settling the terms of employment by agreements affecting considerable bodies of work-people and employers is superior to the method of individual settlements of labour contracts, or, at least, whether its advantages are sufficient to outweigh the cost of strikes and lock-outs; (2) whether free collective negotiation could be replaced with advantage by any other method of settling the conditions of employment of bodies of work-people, which would dispense with the necessity of testing the labour market by a suspension of work.

(1) The first of these questions is virtually the question of the advantages and disadvantages to the community of combinations of workmen and employers, which is discussed at length in the article TRADE UNIONS. As regards the question of the direct cost of strikes and lock-outs, it is proper to remember that individual bargaining does not do away with stoppages; in fact, the aggregate amount of time lost in the process of adjusting ten thousand separate labour contracts may be considerable—possibly not less than that consumed on an average in effecting a single agreement involving the whole body, even if the chance of a collective stoppage of work occurring during the process of combined bargaining be taken into account.

While, then, the strikes and lock-outs which accompany the system of combined bargaining are rightly to be described as wasteful, this is not so much because of the excessive amount of working time which they consume, as because of the disturbance and damage done to industry by the violent breach of continuity—a breach which may dislocate trade to an extent quite disproportionate to the actual loss of time involved, and the fear of which undoubtedly affects the minds of possible customers, and hampers enterprise on the part of employers. The extent of the injury directly inflicted on the consuming public by a strike varies greatly in different cases, being at its maximum in the case of industries having the total or partial monopoly of supplying some commodity or service of prime necessity, *e.g.*, gas-works, water-works, railway or tramway service; and least in the case of a local stoppage in some widely-spread manufacturing or constructive industry open to active competition from other districts.

In speaking above of the loss occasioned by strikes and lock-outs attention has only been paid to the effects of the actual stoppage as such, and not to the particular methods adopted by the strikers to make the stoppage effective. The evils arising from the practice of intimidation or violence towards other workmen, or from the increase of class-hatred and bitterness engendered by the strife between employer and employed, are patent to all, though they cannot be estimated from an economic point of view.

(2) As to the second question, viz., the possibility of maintaining combined negotiation, but of substituting some better method than strikes of resolving a deadlock, it is hardly necessary to say that so far as such substitution can be voluntarily carried out with the assent of both parties, whether by the establishment of wages boards or joint-committees, or by agreements to refer differences to third parties, the result is an economic as well as a moral advantage.

But the increasing adoption of these voluntary expedients for diminishing the chance of industrial friction lends no countenance to the expectation that a satisfactory universal substitute for strikes and lock-outs can be devised except at the price of economic liberty. Compulsory reference of disputes to a State tribunal cannot be reconciled with freedom of voluntary negotiations.

Unless, then, we are prepared for a scheme of compulsory regulation of industry by the State, strikes and lock-outs must be accepted as necessary evils, but their frequency may be greatly diminished with the improvement of means of information as to the true condition of the labour market, and the influences by which it is determined. Many disputes arising purely from mismanagement and misunderstanding are wholly avoidable. While there is no warrant for expecting the total abolition of strikes and lock-outs, it is not unreasonable to hope that the spread of education and the means of rapidly obtaining information, the improvement of class relations, and the adoption, where practicable, of conciliatory methods, may gradually tend to confine actual stoppages to the comparatively few cases in which there is a genuine and serious difference of principle between the parties.

Important Strikes and Lock-Outs.

Some of the more important labour disputes which have occurred in various groups of trades in the United Kingdom are noted briefly below. With regard to the statistics given, it may here be noted that although for the sake of brevity it is stated in some places that a certain number of men were idle for a specified number of days, it must not be supposed that in all cases the whole number affected were idle for the whole number of days.

Coal Mining is an industry which has always been more convulsed by labour disputes than any other, probably owing to the violent oscillations of prices and wages, and to the varied and ever-changing conditions under which work is carried on. Several of the earliest recorded disputes among coal-miners, however, referred to the term of engagement rather than the rate of wages. In 1765 the Northumberland miners struck for several weeks unsuccessfully against the system of a yearly bond of service, which was then prevalent. In 1810 a strike of seven weeks in the same district against a variation of the yearly bond ended in a compromise. Turbulent strikes in Northumberland and Durham are also recorded in 1831 and 1832, the former, in which the men were successful, for a general removal of grievances, and the latter, in which they were defeated, for the maintenance of the union. These strikes were attended with violence and destruction of property. In 1844 still another prolonged strike took place in the north of England to enforce alterations in the terms of the yearly bond. From 30,000 to 40,000 men were out for 18 weeks. New men, however, were obtained, and there were many evictions. In 1864 widespread strikes took place in South Yorkshire and South Staffordshire, the one for an advance and the other against a reduction of wages. The Yorkshire strike is said to have affected 37,000 men, and the Staffordshire strike 20,000. The latter lasted over four months.

The rapid fall in the price of coal after the abnormal inflation in 1871–72 produced a series of obstinate strikes and lock-outs arising out of reductions of wages, in which the men were usually defeated. The South Wales miners, to the number of 70,000, were out for eleven weeks in 1873 and for 19 weeks in 1875, the latter dispute being a combined strike and lock-out, and leading to the formation of the first of the series of sliding scales under which the industry in South Wales has since been regulated. In 1877 the West Lancashire miners (30,000) were out for 6 weeks, and the Northumberland men (14,000) for 8 weeks. The last-mentioned dispute was terminated by an arbitration award in the miners' favour. In 1879, 70,000 Durham men were out for 6 weeks, the dispute being terminated by an arbitration award giving half the reduction claimed by the coal-owners. The introduction of sliding scales in Durham and Northumberland in 1877 and 1879 did something to preserve peace in those districts, though the Durham scale did not prevent the dispute of 1879 mentioned above. Both scales, however, were terminated by the men in 1889 and 1887 respectively. In 1880–81 the Lancashire coal-mining industry was stopped for 7 weeks by a strike of 50,000 to 60,000 men against "contracting out" of the Employers' Liability Act of 1880.

The fall of prices after 1890 led to a renewal of disputes. In 1892 there was a prolonged stoppage in the Durham coalfield, 75,000 men being out for about 11 weeks.

In 1893 the greatest dispute took place that has ever been recorded in the coal-mining industry, a body of miners, which at its maximum reached the huge total of 300,000 men in Yorkshire, Lancashire, and the Midlands, being out for 16 weeks against a proposed reduction of 25 per cent. on the "standard" rate of wages. This dispute is described in detail on page 23. The conference at the Foreign Office at which it was adjusted led to the formation of a Conciliation Board, which, with some interruption, has since regulated the rate of wages and prevented general stoppages in these districts. During the summer of 1893 there was also a strike of about 90,000 men in South Wales, which lasted nearly a month. The next year, 1894, saw a prolonged dispute in the Scottish coal-mining industry, the men vainly attempting to resist the fall of wages which followed the fall of coal prices from the abnormal level to which they had risen during the English stoppage of the previous year; 70,000 men were out from 15 to 16 weeks. In 1898 there was a stoppage lasting 25 weeks in South Wales and Monmouth affecting 100,000 men, for the abolition or amendment of the sliding scale agreement, in which the men were unsuccessful.

The record of strikes and lock-outs in the *Cotton Trade* goes back to a time before the repeal of the Combination Laws. Thus the year 1810 was marked by lock-outs of spinners in Lancashire and Glasgow, the former caused by a strike in the Stalybridge district to enforce Manchester rates of wages, and the latter having for its object the break-up of the men's union. In both cases the employers were successful. Two years later there was a stoppage of 40,000 looms in Scotland for some weeks, arising out of a wages dispute, in which the men were beaten, their union broken up, and their leaders imprisoned. Another unsuccessful strike attended with imprisonment of the men's leaders took place among the Manchester spinners in 1818, when 20,000 to 30,000 men were out for three or four months to obtain an advance of wages and reduction of hours. In 1830 there was a strike of spinners in Ashton and Stalybridge. The year 1853 was one of great disturbance in the Lancashire cotton-spinning trade. For seven months 20,000 to 30,000 spinners in the Preston district were engaged in an unsuccessful strike for an advance of wages, and in the same year there was a stoppage of 65,000 spinners in Lancashire generally. The period of bad trade culminating in 1879 was marked by bitter disputes in the cotton trade generally, the men vainly trying to resist the reductions of wages which marked that period. Partial disputes at Bolton in 1877 (10,000 to 12,000 persons for 8 weeks), and Oldham in 1878 (6000 persons for 5 weeks) were followed in the latter year by a general stoppage in North and North-east Lancashire affecting 70,000 persons for 9 weeks. The general dispute was attended with violent riots, and 68 persons were tried and convicted. The next important dispute was a strike of 18,000 weavers in North-east Lancashire in 1884 against a reduction of wages, which ended after 8 weeks in a compromise. Next year there was a strike at Oldham against a reduction of wages affecting 24,000 persons in the spinning and weaving branches. The dispute ended in a compromise, half the proposed reduction of 10 per cent. being agreed to. In 1892–93 the last great dispute in the cotton-spinning trade took place, 50,000 persons in the Oldham and surrounding districts being out for 20 weeks against a proposed reduction of 5 per cent. The dispute was ended by the so-called "Brooklands Agreement," which provided for a reduction of about 3 per cent., and also contained rules for the settlement of future disputes by conciliatory methods.

The *Building Trades* have in most years been characterized by a large number of local and sectional disputes sometimes affecting comparatively small bodies of men. Often, however, all branches of building trades in a given district have been stopped simultaneously, but few of the building trade stoppages have affected a sufficiently large body of men to be noticed here as important disputes except in London. The years 1810 and 1816 were marked by strikes on the part of the London carpenters, the first being a successful attempt to obtain a rise in wages, the second an unsuccessful resistance to a fall. In 1833 an important dispute laid idle the building trades of Liverpool and Manchester. The dispute arose out of the objection of the men to the contract system, and led to a general lock-out to compel the men to leave their unions, in which the employers were generally successful. In 1859–60 a partial strike in London against the discharge of a delegate led to a lock-out of 25,000 building operatives for 7 months, and in 1861–62 a renewed strike for a reduction of hours resulted in a compromise. In 1872 there was a successful strike of 10,000 London building operatives for a rise of wages, a shortening of hours being also obtained. In 1891 there was an unsuccessful strike of carpenters in London for a rise in wages, affecting 9000 men and lasting 24 weeks.

Engineering, Shipbuilding, and Metal Trades.—Among the most noteworthy disputes in the engineering trade was that in 1852, soon after the formation of the Amalgamated Society of Engineers by the fusion of a number of local and sectional societies. The dispute originated in Lancashire, and turned on demands from the men for the abolition of piecework and overtime, the dispute being further complicated by questions relating to the employment of labourers in working machines. The men ceased working overtime, and were locked out to the number of over 13,000 for periods ranging from three to nine months. The men were completely beaten, and many engineering shops required the men to leave the union before resuming work. In 1871 a strike of 8000 to 9000 men in the North of England for a reduction of hours from 59 to 54 was successful after a stoppage of 20 weeks, and led to the general introduction of the nine hours' day throughout the country. In 1897–98 there was a widespread and prolonged dispute turning on questions of hours and of freedom of management of works, which lasted 29 weeks and affected 47,500 men. This dispute, which resulted in the defeat of the men, is described in detail below (p. 24).

In 1866 a strike of 3000 shipwrights on the Clyde led to a general lock-out of shipbuilders in the district. In 1877, 25,000 iron shipbuilders on the Clyde struck for 23 weeks for an advance of wages, the dispute being settled by arbitration.

In 1891 a prolonged dispute took place between the plumbers and engineers engaged in shipyards on the Tyne as to "demarcation"; 2460 men were idle from 7 to 8 weeks, the result being the drawing up of an elaborate list of apportionment applicable to the Tyne and Wear. The shipbuilding trades have from early times been marked by numerous "demarcation" disputes, mostly of a local character, as to the limits of the work of the various bodies of work-people—*e.g.*, between shipwrights and boatbuilders; shipwrights and joiners; shipwrights and boilermakers; joiners and cabinetmakers; boilermakers and engineers; engineers and plumbers; engineers and brassfinishers. Some of these matters are now dealt with by joint trade boards (see ARBITRATION AND CONCILIATION).

Among the more important disputes in the iron trade are to be mentioned a strike and lock-out of 30,000 ironworkers in Staffordshire in 1865, in which the men were beaten after a costly stoppage of 18 weeks; an unsuccessful strike of 12,000 ironworkers in Middlesbrough for 18 weeks in 1866; and an unsuccessful strike of 20,000 ironworkers in Staffordshire for 4 weeks in 1883 against a reduction of wages, attended by rioting and destruction of plant.

The nailmakers in the Dudley district were engaged in widespread disputes in 1840, 1881, and 1887, the first being an unsuccessful strike of 20,000 men attended by rioting, to resist a reduction; and the two last being strikes for advance of wages; resulting, the first wholly and the second partially, in favour of the work-people.

Other Trades.—Among other noteworthy disputes are to be mentioned—

(1) A successful strike of 14,000 persons in the Leicester hosiery trade in 1819 for an advance in wages.

(2) An unsuccessful strike of 13,000 or more tailors

in London in 1834 for a rise of wages and reduction of hours, lasting several months.

(3) A dispute among the pottery workmen in the Midlands in 1836 against the terms of yearly hiring, leading to a general lock-out of over 15,000 men for 10 weeks, which ended in the defeat of the men.

(4) A series of disputes among agricultural labourers in 1872–74 for increases of wages and other improvements in the conditions of employment, in which the men were mostly successful. These disputes, which are almost the only widespread disputes recorded in agriculture, evoked much public interest.

(5) In 1889 there was a prolonged strike of dock and waterside labourers in London for a rise in wages and other alterations in conditions of employment, which was successful, mainly through the financial support received from the Australian trade unions and from the general public (see below).

(6) The organization of labour at the principal ports which followed this dispute led to a series of struggles between the new unions and the shipowners, who formed an organization called the Shipping Federation Limited, and successfully established their right to employ "free labour" in opposition to the unions of seamen and other bodies of labourers. The last of these disputes on a large scale occurred at Hull in 1893, and ended in the defeat of the dock labourers after a stoppage affecting 11,000 men for 6 weeks.

(7) In 1895 a general stoppage of 46,000 boot and shoe operatives was terminated, after a stoppage of 6 weeks, by a settlement effected through the Board of Trade. The issues of this dispute were of interest as involving the scope and limits of the functions of trade union action and of arbitration in relation to the management of business. The terms of settlement, which were of an elaborate character, are still in operation.

(8) Two prolonged disputes at Lord Penrhyn's slate quarries in North Wales in 1896 and 1900 attracted public notice from the obstinacy with which the contests were conducted on both sides. About 2500 work-people were affected, and the questions at issue were the recognition of the men's combination and the remedy of a number of alleged grievances, including the abolition of the contract system. After 48 weeks' stoppage, during which the Board of Trade vainly tried to mediate, the first dispute was ended by a compromise; but in 1900 another struggle began which, after more than a year's continuance, is still persisted in by many of the men, though a considerable body of workmen are now (March 1902) at work.

Historic Strikes of Recent Years.

A few of the strikes referred to above appear to deserve a more detailed account.

London dock strike, 1889.

The London dock strike of 1889 was notable, both as the most noteworthy example of a widespread and determined strike of unskilled and previously unorganized labourers, and for the amount of public sympathy shown for the men, and for the financial aid rendered by their Australian sympathizers. It began on 13th August with a small local dispute at the West India Docks about the wages earned for discharging a certain cargo, but spread rapidly among all classes of dock labourers in the port, who took the opportunity of demanding an increase in the rate of pay for time work from 5d. to 6d., the abolition of contract and piecework, and the remedy of other grievances. They were joined by the stevedores and lightermen, who came out "in sympathy," though the latter class of men soon formulated a set of demands of their own. Employment was brisk, the weather fine, and the public sympathetic, and in a few days' time not less than 16,000 men were idle. For the most part they were unconnected with trade unions which could give them strike pay, but during the month that the strike lasted the public at home and abroad subscribed nearly £50,000 in support of the strikers. Of this total over £30,000 came from Australia, where from 29th August onwards a series of meetings were held for the purpose of raising funds to assist the London labourers. The Australian subscriptions practically decided the issue of the contest. On the very day on which the first Australian meeting was held at Brisbane the leaders of the strike attempted by means of a "no-work manifesto" to widen the area of the dispute and cause a general stoppage of industry. Though this attempt was soon abandoned, it caused considerable alarm and threatened to alienate public sympathy from the men. Early in September many of the wharfingers made separate settlements with the strikers, and the shipowners attempted to put pressure on the dock companies to allow them to employ labour direct within the docks. The apprehensions of the public led to the formation of a Conciliation Committee at the Mansion House, including the Lord Mayor, the Bishop of London, Cardinal Manning, Sir John Lubbock (now Lord Avebury), and others, who mediated between the strikers and the dock directors, with the result that after one abortive attempt at a settlement, the terms of which were rejected by the men, an agreement was arrived at on 14th September, under which the dock labourers obtained the greater part of their demands. From 4th November the rate of hourly wages for time work was raised to 6d., with 8d. overtime; contract work was converted into piecework, with a minimum rate of 6d., and other points in dispute were settled. Though during the strike cases of intimidation and violence on the part of pickets were by no means absent, the police court charges arising out of the dispute were remarkably few. By the end of the year the Dock Labourers' Union (which had previously been known as the Tea Operatives and General Labourers' Union, and at the beginning of the dispute numbered about 800 members) had increased its membership in London to over 20,000—a number which was afterwards further increased by the formation of provincial branches. In London, however, the membership rapidly declined during the following years of depression of trade. The stevedores, who, as above remarked, came out "in sympathy" with the dock labourers, returned to work as soon as the latter were satisfied, but the lightermen's demands were adjusted by an award of Lord Brassey before they returned to work.

Coal-miners' dispute, 1893.

The coal-miners' dispute of 1893, whether measured by the number of men involved or by its aggregate duration in working days, was the greatest labour dispute yet recorded in this country. Both prices and wages in the coal-mining industry are subject to rapid fluctuations, according to the general state of trade, and in most districts the principle has been explicitly or tacitly recognized that wages ought to follow the course of prices. In some districts an automatic connexion between wages and prices has been established by a "sliding scale," and in other districts where there is no sliding scale the average prices of coal have usually practically determined the rates of wages. The period 1879–87 was one of low prices and wages, but the revival of prices in 1888–90 led to a rapid rise of miners' wages, which in the latter year stood generally 40 per cent. higher than in 1888 throughout the principal districts embraced by the Miners' Federation, viz., Yorkshire, Lancashire and Cheshire, and the Midlands. During the years 1891 and 1892 prices again fell, and most of the districts outside the above area submitted to reductions of wages varying from 15 per cent. off the standard in Durham, to 42½ per cent. in South Wales and 50 per cent. in Scotland, where the previous rise had been greatest. The Miners' Federation, however, refused to recognize the principle that wages should follow prices, and put forward instead the theory that a minimum or "living wage" should be fixed, and prices left to adjust themselves to this rate. They declined altogether to agree to any reduction, and so strong was their combination that the coal-owners deferred any definite action until the middle of 1893, when they considered that some reduction was absolutely necessary to enable the trade to be carried on. On 30th June they passed a resolution, after a conference with the men, demanding a reduction of 25 per cent. off the "standard" (equivalent to about 18 per cent. off current rates of wages), and offered arbitration as an alternative; but the Federation absolutely refused any reduction, and the contest began. Shortly before the beginning of the dispute Northumberland and Durham had become affiliated to the Federation, but these districts were not threatened by a reduction, and they seceded from the Federation sooner than strike, as demanded by that body to obtain the return of the reductions sustained since 1891. These districts consequently remained at work throughout the dispute, as well as Scotland and (except for a part of August and September) South Wales, reaping the advantage of the increased prices and wages resulting from the restriction of production due to the stoppage. Within the Federation districts proper there were some localities in which no notices of reduction were posted, but the policy of the Miners' Federation was to make the stoppage as universal as possible, and all its members were required to leave work. The Cumberland miners, however, though members of the Federation, were for special reasons permitted to continue at work. By the middle of August nearly 300,000 men were idle, or nearly half the total number of coal-miners in the United Kingdom. The early stages of the dispute were uneventful, but as the funds of the unions affiliated to the Federation became exhausted, and the pinch of distress was felt, feeling ran high, and in some districts deplorable acts of violence were committed. At Featherstone, in Yorkshire, an attack was made on a colliery, in the course of which the military fired on the rioters, two of whom were killed.

The decision of the Federation requiring all its members to leave work, whether under notice of reduction or not, had from the beginning met with considerable opposition in certain districts, and this opposition naturally grew stronger as the distress caused by the stoppage increased. At the end of August a ballot on the question showed a small majority still in favour of a universal stoppage, but the experience of another month led to a formal reversal of policy in this respect, a meeting of the Federation at Chesterfield on 29th September deciding to allow all men to return to work who could do so at the old rates of pay, such men to pay a levy of 1s. a day in aid of those still on strike. Up to October no step was taken towards a settlement beyond an offer on the part of the miners on the 22nd August to pledge themselves not to ask for an advance until prices reached the 1890 level, and also to assist the employers to prevent underselling—an offer which was rejected by the coal-owners. On 9th October a meeting of the representatives of the parties was held at Sheffield, at the invitation of the mayors of six important towns affected, but without definite result, beyond leading to an amended proposal on the part of the coal-owners for an immediate 15 per cent. reduction, and the regulation of future changes in wages by a Conciliation Board. The men, however, still refused all reduction, and during October a number of coal-owners, especially in the Midlands, threw open their pits at the old rate of wages.

A further advance towards a compromise was made by the owners on 25th October, when they offered that the proposed 15 per cent. reduction should be returned to the men in the event of the Conciliation Board (with an independent chairman) deciding in their favour. In consequence of this offer a meeting was held between the representatives of the owners and the men in London on 3rd and 4th November, but without arriving at a settlement. Matters had now reached a deadlock, and accordingly, on 13th November, the Government addressed an invitation to both parties to be represented at a conference under the presidency (without a casting vote) of Lord Rosebery, who was then Foreign Secretary. The conference took place at the Foreign Office on 17th November, and resulted in a settlement, the men to resume work at once at the old rate of wages, to be continued until 1st February 1894, from which date wages were to be regulated by a Conciliation Board, consisting of fourteen representatives of the coal-owners' and miners' federations respectively, with a chairman mutually elected, or in default nominated by the Speaker of the House of Commons, the chairman to have a casting vote.

This agreement terminated the dispute. The Speaker appointed Lord Shand as Chairman of the Board. In the middle of the following year, by mutual arrangement, the constitution of the Conciliation Board was modified so as to provide for limits below and above which wages should not move during a definite period. These limits have since been modified from time to time, but (with a gap from July 1896 to January 1899) the Conciliation Board has continued to regulate miners' wages in the federated districts up to the present, and its formation has been followed by the institution of Conciliation Boards in most of the other important centres of the mining industry, except in South Wales.

Engineering dispute. 1897-98.

The engineering dispute of 1897–98 was in some respects the most remarkable dispute of recent times, both on account of the nature and importance of the issues involved and of the tenacity with which the contest was conducted. The immediate occasion of the stoppage was a demand on the part of the men for an eight hour day in London workshops, but this issue was soon overshadowed in importance by other questions relating to the freedom of employers from interference by the unions in the management of their business, especially in such matters as piecework, overtime, selection and training of workmen to work machines, employment of unionists and non-unionists, and other matters affecting the relations of employer and employed generally throughout the United Kingdom. For some time previous to the general dispute there had been a growing dissatisfaction on the part of the employers with the encroachments of the Amalgamated Society of Engineers and other societies in kindred trades on matters affecting the management of business, which the employers considered to be outside the legitimate functions of trade unions. In the absence of any general combination of employers, the unions were able to bring their whole force to bear on employers in particular localities, with the result that the stringency of the conditions and restrictions enforced varied very greatly in different districts, according to the comparative strength of the unions in those districts. Employers complained of being subject to vexatious restrictions not imposed on their competitors, and they declared that they were severely handicapped as compared with America and other countries, where engineering employers had much more complete control over the management of their business. In 1895 was formed the Federation of Engineering Employers by the coalition of the local associations on the Clyde and in Belfast, and this Federation gradually spread to other districts until it finally embraced the United Kingdom generally. The policy of the Federation was to defeat the attempts of the unions to put pressure on particular individuals or localities, by the counter threat of a general lock-out of trade unionists over a wide area in support of the employers thus attacked. The lock-out notices were framed in such a way that 25 per cent. of the trade unionists employed were to be discharged at the end of each week until the whole were locked out. Lock-out notices of this kind were twice posted—in August of 1896 and in the spring of 1897—before the general dispute, but in each case the dispute was tided over before the notices took effect. But the conferences which took place in April 1897 between the representatives of employers and unions led to no agreement except on comparatively unimportant points. When, therefore, in June 1897 the London employers, threatened with a strike for an eight hour day, put their case in the hands of the Employers' Federation, and the Federation determined to support them by a general lock-out, it was understood that this lock-out was enforced, not only in order to resist the reduction of hours in London, but to obtain a settlement of all the important questions at issue between the Federation and the unions as a whole.

The engineers replied to the notices of a gradual lock-out by withdrawing the whole of their members from work in federated workshops. At first the lock-out affected some 25,000 men employed in 250 establishments, but by the close of the dispute the number of employers involved had risen to 702, and of work-people to 47,500.

Until November no meeting between the parties took place, but on 24th November and following days a conference was held in pursuance of negotiations with the parties by the Board of Trade, each side having its own chairman. The main point for which the employers contended was freedom on the part of each employer to introduce into his workshop any condition of labour under which any members of the trade unions were working in any of the federated workshops at the beginning of the dispute, except as regards rates of wages and hours of labour. Arising out of this general principle of freedom of management, a number of special points were discussed, and subsequently embodied in separate articles of the provisional agreement, and a system of local and general conferences for the settlement and avoidance of future disputes was also included therein. The employers absolutely declined to grant any reduction of hours of labour. The negotiations dragged on for a considerable time, and were at one time broken off owing to the refusal of the men to ratify the provisional agreement. By the end of the year, however, it was evident that the position of the men was very much weakened owing to the depletion of their funds, while that of the employers was stronger than ever. On 13th January the London demand for an eight hours' day was formally withdrawn, and after some further negotiation, and the embodiment in the agreement of the notes and explanations published by the employers, a settlement was arrived at and ratified by more than a two-thirds majority of the men, the final agreement being signed on 28th January.

The victory of the employers was complete, but the use since made of it has been moderate, and the relations between employers and workmen in the engineering trades seem, on the whole, to have been improved, all matters likely to cause dispute being now amicably discussed between the representatives of the respective associations.

COUNTRIES OTHER THAN THE UNITED KINGDOM.

It is not possible within the limits of this article to give a detailed account of the strikes and lock-outs in all the principal foreign countries. Strikes in the United States are dealt with in a separate section. Below is given a brief account of the most recent strike statistics and of some of the chief recent disputes in France and Germany, together with notices of a few of the most important recent labour disputes in other Continental countries.

France.—Detailed statistics of strikes and lock-outs in France have been published annually since 1890 by the French Office du Travail. The figures show great variations from year to year, as appears from the following summary for eight years:—

Year.	Number of Disputes.	Number of Work-people directly affected.	Aggregate Duration in Working Days.
1893	634	170,123	3,174,000
1894	391	54,576	1,062,480
1895	406	45,809	617,669
1896	476	49,851	644,168
1897	356	68,875	780,944
1898	368	82,065	1,216,306
1899	744	177,081	3,550,734
1900	903	222,769	3,761,227
Average of eight years	535	108,894	1,850,941

These figures show that the importance of strikes in France, both as regards numbers involved and duration, is in ordinary years much less than in the United Kingdom, but in exceptional years (*e.g.*, 1893, 1899, and 1900) the figures approach those of an average year in the latter country. In two of the eight years (1899 and 1900) more time was lost through disputes in France than in the United Kingdom. In five out of the eight years (1894, -5, -6, -9, and 1900) the trades most largely affected were the textile group. This was especially the case in 1899 and 1900, when this group accounted for about half the total time lost. In 1893 half the total time lost was accounted for by mining disputes, and in 1897 and 1898 the building trades held the first place.

In the French statistics of causes of disputes, a dispute due to several causes is entered several times, and not merely under its principal cause, as in the United Kingdom. In 1900, when 222,769 persons were affected, 178,912 were involved in strikes for advance of wages, and about 40,920 in disputes as to other wages questions. Strikes for decrease of hours affected 78,512, those relating to employment of particular classes or persons 44,192, and those relating to working arrangements 57,226. As regards results, the percentages of work-people involved in disputes resulting in various ways are as follows (average of eight years): in favour of work-people, 19; in favour of employers, 35; compromised, 46.

Some of the most notable of the French strikes in recent years have taken place in the coal-mining industry, namely in the Nord and Pas-de-Calais departments.

Coal.

In 1884 the miners of Anzin and the neighbouring district struck against certain proposed alterations in the working conditions, including the letting of the work by contract to the gang making the lowest tender. After a stoppage of fifty-six days work was resumed, substantially on the company's conditions, on 17th April. The number affected is stated to have been about 30,000. In 1889 a strike affecting 15,000 men, for an increase of wages, resulted in an increase of 10 per cent. after a short stoppage, and in the autumn of 1891 a strike in the same districts, involving nearly 40,000 men, for a more equitable distribution of wages and the reorganization of benefit funds, was settled by arbitration, the result being a compromise. In the following year a prolonged dispute took place among the miners at Carmaux, in the Tarn department, which, though not involving a very large body of workmen, attracted great public attention, and was marked by violence and disturbance. The cause of the strike was the dismissal of a miner who had been elected mayor. The strike broke out on 15th August, and on 26th October M. Loubet, as arbitrator, decided that the mayor should be reinstated, but given leave of absence during his mayoralty. He also decided that there was no ground for the removal of the director to whom the men objected. The men rejected the award because it did not provide for the reinstatement of the men convicted of violence, and ultimately the Government remitted the penalty of those convicted on condition that the miners resumed work. The men accepted these terms, and the director resigned.

The year 1890 in France, as in England, was marked by a widespread agitation for an eight hours' day, which led to numerous strikes in different trades and districts.

In 1893 a general strike took place among the miners of the Pas-de-Calais and Nord departments for a 10 per cent. increase of wages and other demands, about 42,000 men being affected. The Anzin miners, however, held aloof. An invitation to both sides to submit the dispute to arbitration, under the law of 1892, met with no response from either party, and during October, in the course of which month the number of strikers gradually diminished, the strike was attended with a good deal of disorder. The strike gradually crumbled away, and early in November those who remained out decided to resume work.

On 25th October 1900 a strike for increased wages and other demands took place among the Pas-de-Calais miners, 20,000 men being affected. A compromise, however, was arrived at after a fortnight's stoppage, through the intervention of a member of the Chamber of Deputies.

At the end of 1900 and beginning of 1901 a series of strikes took place among the miners in the Saône-et-Loire department, the most important being a dispute affecting 12,000 miners at Monteceau-les-Mines, the matters in dispute including wages and the reinstatement of men dismissed on account of a previous strike. Eventually the men resumed work without securing their demands.

Textiles.

Among the more important textile trade disputes in recent years was a strike of spinners, weavers, and dyers in the Roubaix district in 1890, the number affected being about 22,000. The demands were for a reduction of hours and rise of wages, but the work-people were all unsuccessful. In 1893 a number of disputes took place as the result of the application of the law of 1892 regulating the hours of women and children in factories, the employers endeavouring to compensate themselves for the reduction of hours by a proportionate decrease of wages. For example, at Lille in the textile factories, where men and women work side by side, the reduction of hours necessarily affected men as well as women, and the employers attempted to reduce the wages of both by one hour's pay. A strike of men and women ensued, which resulted in the restoration of the old rate of pay on condition that the hands should stand by the frames without interruption during the whole time that the machinery was in motion. Other strikes arising out of the application of the law took place at Paris, Marseilles, Rheims, and elsewhere. Similarly in 1900, the application of the law of 30th March 1900, regulating the hours of women and children, led to a strike of 12,000 laundry workers in Paris against a threatened reduction of wages. After a week the dispute ended in a compromise. On 12th November 1900 a strike of lace and tulle workers at Calais took place in opposition to the enforcement of the system of work by quarter days. The strikers demanded also an increase of 20 per cent. in wages. Though only between one and two thousand persons were on strike, 14,000 or 15,000 women, youths, and girls were thrown out work. The dispute was complicated by a discussion as to the interpretation of the Factory Law of 1900. A good deal of assistance was given to the strikers by English trade unions, but, after lasting till February 1901, the strike ended in the defeat of the operatives.

Waterside labour.

The summer of 1900 was marked by a general outbreak of strikes among seamen and various classes of waterside labourers at several French ports. The strikes resulted in the first instance from a difference as to the interpretation of the agreement under which the seamen worked in the port of Havre. In the course of a strike of coalies the crew of a ship were ordered to take the coal on board. They refused, contending that this unusual work could be asked from them only during a voyage. The Tribunal Maritime decided that the men were in the wrong, and condemned 51 of them to 15 days' imprisonment. A strike followed, and the work-people belonging to the various maritime trades at once demanded an increase of wages, which they obtained after eight days. The strike movement then spread rapidly to the chief ports of the Channel, Atlantic, and Mediterranean coasts; from Dunkirk to Bayonne, from Port-Vendres to Nice, and from Oran to Bône. After the seamen and dock labourers had struck the dispute spread to many other trades. In most cases the labourers, aided by the active state of employment at the time, secured a complete or partial victory. At Marseilles, where the strikes affected 8000 labourers of various classes during August, the strikes of stokers, coal-heavers, and sailors were ended by the concession of considerable advances of wages by the shipowners on the mediation of Admiral Besson. Other classes of labourers remained out until they could secure satisfactory concessions; and the strike movement also spread to various classes of non-maritime labour, *e.g.*, engineering works, oil-mills, bakers, &c. The agreement arrived at through Admiral Besson's intervention did not prevent a fresh strike at the end of February 1901, the dock labourers demanding an eight hours' day for six francs. The strike, however, ended on 9th April in the defeat of the men.

Germany.—Before 1899 there were no official statistics of strikes and lock-outs throughout the German Empire, but certain figures were collected and published by the committee of the "Gewerkschaften" or Social Democratic trade unions in their *Correspondenzblatt.* These figures, however, were admittedly incomplete. For 1899 and 1900, however, statistics have been published by the German

Imperial Statistical Office for strikes and lock-outs other than in agriculture. The figures for 1900 show that 1468 disputes occurred (or rather were terminated) in that year, involving 141,121 persons, of whom 131,888 were directly and 9233 indirectly affected. A large proportion of the work-people (40,044) were in the building trades, 23,431 in wood-working trades, 15,366 in mining and smelting industries, and the rest in various miscellaneous industries. It is noteworthy that in the printing and allied trades, which (see TRADE UNIONS) are the most effectively organized as regards trade unions, only 324 persons were affected by strikes in this year. In 1899, 1311 disputes were recorded involving 116,486 work-people. No fewer than 1166 of the disputes in 1900 were due to demands for advances of wages. A considerable number (444) were for decreased hours of labour. (In the German statistics of causes a dispute arising from more than one class of cause is counted under more than one head.) About 19 per cent. of the disputes were settled in favour of the work-people (compared with 26 per cent. in 1899), 45 per cent. in favour of the employers (compared with 41 per cent.), and 36 per cent. were compromised (compared with 33 per cent.).

Coal.

The most extensive dispute among German coal-miners in recent years was the great strike of 1889. The dispute began on 3rd May as a local strike at a single colliery in Gelsenkirchen, Westphalia, but rapidly spread throughout the mining districts of Westphalia, Rhine Provinces, Lorraine, the Palatinate, Upper and Lower Silesia, and Saxony. Altogether about 144,000 miners were involved. The demands were for a rise of 15 per cent. in wages, an eight hours' shift from bank to bank, the payment of wages twice a month, and other concessions. On 18th May the Coal Association at Essen agreed to an eight hours' day "at the face," with certain exceptions, and made other concessions as to minor matters, the settlement being partly due to the action of the Emperor, who received a deputation from the men on 14th May and from the employers two days later. Owing to some misunderstanding, however, work was not generally resumed until the end of the month.

On 29th December 1892 a strike broke out among the men employed in the State mines in the Saar district against the introduction of a new code of regulations under the Prussian Mining Law of 1892. Many other miners came out in sympathy, including 13,000 Westphalian miners, so that by the middle of January 34,000 men were affected. At the end of January the miners had to give way, and a large number of dismissals followed.

Printing.

In 1891 a general strike took place in the German printing trade, 10,000 men being affected. The object was to secure a nine hours' working day and an advance of 10 per cent. in the wages scale. Most parts of Germany were affected. Before a stoppage took place the dispute was submitted to the Wages Board at Leipzig, but employers would only agree to a 7½ per cent. advance. The strike began on 24th October, and lasted until the middle of January 1892, when the men resumed on the old conditions. In Stettin and Breslau, however, the stoppage had terminated at an earlier date on the exhaustion of the strikers' funds. The collapse of the strike was hastened by the action of the Prussian and Würtemberg Governments in preventing support being given to the strikers out of certain benefit funds in possession of the union.

Tailoring.

In the spring of 1896 a widespread strike took place in the German tailoring trade, mainly affecting women. The work-people's demands included the recognition of price lists, erection of suitable workshops, weekly payment of wages, and appointment of a joint-committee to deal with disputes. In Berlin, where, as in several other districts, the strike began on 10th February, 20,000 to 30,000 persons were affected. The dispute was a three-cornered one, affecting the interests alike of the manufacturers and the contractors as well as the work-people.

In Berlin a speedy resumption of work took place, terms of settlement being arranged on 19th February, partly through the Berlin Industrial Court, by which various increases of wages were conceded, and a Conciliation Board was empowered to arrange a minimum price list. Wages were to be paid weekly, but the demand for workshops was withdrawn. Partial concessions were also secured by the strikers in the chief provincial centres, and the strike came to an end. Friction, however, subsequently occurred between the manufacturers and contractors, and when the minimum price list was fixed in July it met with approval from none of the parties.

Waterside labour.

In the winter of 1896 a stoppage took place among the stevedores, dock labourers, and other waterside labourers at the port of Hamburg, the men demanding a rise in wages, with higher rates for overtime, night, and Sunday work. The strike began among the stevedores on 21st November, and spread until at least 15,000 men were affected. The shipowners refused to submit the dispute to the Industrial Court. The Senate promised an inquiry into the conditions of labour at the docks if the men would resume work, but this they refused to do. On 16th January a meeting between representatives of the parties took place at the Chamber of Commerce, but broke down over the men's demand for the dismissal of labourers who had been engaged during the dispute. Ultimately on 6th February the men resolved to return to work unconditionally.

Cabinet-makers.

On 19th February 1900 the Berlin cabinetmakers struck to the number of 6000 to obtain uniform piece wages and a minimum of 24s. per week. The dispute extended until a considerably larger number were affected. The dispute was settled by the intervention of the Berlin Industrial Court acting as a board of conciliation, a minimum of 24s. being guaranteed to workmen of average efficiency. The strike ended on 27th March.

Among the more important labour disputes of recent date in other Continental countries are the following:—

Austrian Coal Miners (1900).—The greatest strike recorded in Austria took place early in 1900, in the coal-mining industry. Originating in a strike on a small scale, for an increase of wages, at certain pits on the borders of Moravia and Silesia, it spread until 90,000 miners out of a total of 110,000 in Austria were involved. The men's demands, in their final shape, included an eight-hours' day from bank to bank, a minimum wage, weekly wages settlements, free light, and an increase of wages. The Boards of Conciliation constituted under the law of 1896 failed to effect a settlement, and the endeavour of the Government to induce the strikers to return to work on the promise of introducing a Bill for the reduction of hours in coal mines was also of no avail, the men pointing out that there was no guarantee of such a Bill passing. The strike gave rise to debates in the Reichsrath, and the whole question of miners' hours was referred to a committee, which prepared a draft Bill. It became evident, however, by the middle of March that no legislation could be introduced until after the Easter recess, on which the miners of northern and western Bohemia, followed gradually by those in other districts, resumed work with concessions (offered five weeks before) as regards wages, free light and fuel, and the regular settlement of wage accounts, but without securing an eight-hours' day or minimum wage. The whole stoppage lasted eleven weeks.

Danish Building Trades (1899).—The most important labour dispute recorded in Denmark was the lock-out in the building and kindred trades in 1899. The dispute began with a demand from 300 joiners in Jutland for an advance of wages. At a conference between the central unions of employers and employed at Copenhagen it was agreed that the men should remain at work for a month on certain terms, while an endeavour should be made to arrange a compromise. The local unions rejected these terms, whereupon the employers gave notice of a lock-out; and on the men offering to accept the terms previously rejected, the employers declared that they were withdrawn, and that a general lock-out would take place throughout the building trades of Denmark unless the men resumed work on the old conditions. The lock-out which followed on 24th May threw 30,000 men idle, and the number was subsequently increased to 50,000 by the adhesion of employers in the wood-working, metal, and other trades, including the tailors and paviors, with a view of cutting off the support given to the men by members of these industries. The employers also contrived to stop the supply of building materials, so as to prevent the locked-out men from setting up business for themselves. The struggle mainly turned on the freedom of the employers to manage their business, and on the enforcement of the responsibility of the central trade union for the acts of the local affiliated unions. The dispute was eventually terminated by an agreement between the "Danish Employers' and Masters' Association" and the "Associated Trade Unions," which laid down in detail the conditions under which alone strikes and lock-outs might be declared, or supported, and explicitly recognized the freedom of employers in the organization of their business, and the responsibilities of the central organization for the fulfilment of agreements by their members and branches. (A translation of the full text is published in the *Labour Gazette* for October 1899.)

Italian Straw-plaiters (1896 and 1897).—Among the more important of recent disputes in Italy were two strikes of the women straw-plaiters in 1896 and 1897. The women affected were employed in the villages to the south and east of Florence. The object of the dispute in 1896 was to obtain a rise of wages which were extremely low, owing, among other causes, to the competition of Chinese and Japanese straw-plait. The number affected was 40,950 and the dispute lasted ten days, during which serious riots and conflicts with the soldiers took place. On 27th May the strike was settled in favour of the work-people through the mediation of the local Chamber of Commerce and Labour Chamber. In 1897 another outbreak, stated to affect 41,550 persons, took place, and was ended by a compromise.

Belgian Coal-Miners (1899).—A widespread stoppage of Belgian coal-miners took place in the spring of 1899, arising from a demand for a 20 per cent. rise of wages put forward by a meeting of the National Federation of Belgian Miners at Charleroi on 17th April. The number affected rose to 60,000; but from 3rd May the number fell off. As soon as the strike began the Government convened the coal-mining sections of all the Councils of Industry and Labour to meet on 23rd April and inquire into the wages of coal-miners. Adjourned meetings were also summoned to enable the workmen to submit data rebutting the figures produced by the employers to show that wages had risen with the price of coal. On 15th May the committee of the Miners' Federation declared the suspension of the strike, to be resumed if the employers failed to raise wages. This was at once followed by a general resumption of work.

THE BRITISH COLONIES.

Australian strikes, 1890-92.

The only labour disputes in the British colonies which require special mention are the series of widespread conflicts which took place in various parts of Australia during the years 1890–92. These disputes were remarkable in many ways. They turned to a large extent on the attempt of labour unions to secure a monopoly of employment; they all ended in the defeat of the work-people, and led to a weakening of trade unionism; and in the course of them intimidation and violence were carried to a point rarely known in the history of strikes and lock-outs, some of the conflicts almost resembling armed insurrections rather than peaceful differences between employers and employed.

The great dispute of 1890 originated in a difference between the pastoralists and shearers, which caused a deadlock between the Pastoralists' Association and the Shearers' Union, and the consequent engagement of a number of non-union shearers for the season. Thereupon the Wharf Labourers' Union refused to handle wool shorn by non-unionists, and a strike was announced for 18th August. Independently of the shearers' dispute, the maritime labourers were ready for a strike, owing to the refusal in June of the employers to confer with the marine officers with regard to their grievances unless they broke off all connexion with the Trades Councils of Melbourne and Sydney. This requirement was stated to be necessary in the interests of discipline; but the officers and labourers alike regarded it as an attack on their organizations; and in August the marine officers, wharf labourers, seamen, and other bodies of men ceased work. The strike began in Victoria, but spread to New South Wales, Queensland, and even New Zealand. The Newcastle coal-miners refused to hew coal intended for employers involved in the dispute, and were locked out; and in September the shearers also ceased work. In Queensland the shearers resumed work after a week, the Labour Federation ordering the execution of existing contracts; but in New South Wales and Victoria the struggle was of an obstinate kind, and paralysed industry from August to October. Extensive picketing was resorted to, and assaults were made on gangs of non-unionists engaged in loading and unloading cargoes, or in carting wool through the streets. The disorders culminated in an attack on 19th September on nine trolleys which were being escorted from the Darling Harbour yards by mounted troopers and police, and this necessitated the reading of the Riot Act and the dispersal of the crowd by armed force. After this incident the disturbances gradually ceased, and the strike collapsed in October through the replacement of the strikers by non-union labour.

The difficulties, however, between the shearers and the pastoralists were not ended by this dispute, and at the beginning of the following year an agreement drawn up by the newly-formed Federation of Pastoralists' Unions was rejected by the shearers' unions. This caused a prolonged stoppage of work in Queensland; and in June the shearers of New South Wales (where the season is later) resolved to cease work on the refusal of the pastoralists to dispense with free labour. Victoria and South Australia were unaffected. The Queensland shearers formed camps in the bush; incendiarism was advocated and practised; and violent measures of various kinds were adopted to prevent the importation of non-unionists. Volunteers were called out, and troops drafted into the disturbed districts, shearing being meanwhile carried on by free labour, until on 15th June, the strikers' funds being exhausted, the dispute was declared at an end. The strikers in New South Wales were also defeated by the employment of non-union labour.

In July 1892 a strike took place among the silver-miners at Broken Hill in New South Wales, caused by the attempt of the management to substitute a contract system for day payments. An extensive system of picketing was resorted to, and the directors refused to meet the strike leaders until the pickets were withdrawn. After some weeks the company began to import labour under a strong police escort. The first contingent, which arrived from Adelaide by special train on 11th September, was attacked with stones, and a few shots were fired. Subsequent contingents, however, were unmolested, and by November the strike had entirely collapsed. During the strike six of the leaders were tried and sentenced to various terms of imprisonment for inciting to riot; and a night attack by the miners on non-unionists and the police, which followed the news of the sentences, led to more arrests. The men were completely defeated, and a large number were left out of employment at the end of the dispute.

In the above disputes the employers were greatly strengthened by the presence of a large and increasing reserve of unemployed labour, owing to the depression of trade, which was gradually becoming more intense throughout Australia.

AUTHORITIES.—The following are among the more important official publications on strikes and lock-outs: Reports of the Chief Labour Correspondent of the Board of Trade on Strikes and Lock-Outs (annually from 1888).—*Labour Gazette* (Board of Trade, monthly, from May 1893).—Reports of Royal Commission on Labour (1891–94).—Second Abstract of Foreign Labour Statistics (Board of Trade, 1901—section on trade disputes).—*Statistique des Grèves*, &c. (French Labour Department, annually from 1890). —*Streiks und Aussperrungen* (German Imperial Statistical Office, annually from 1899). See also list of authorities on TRADE UNIONS and ARBITRATION AND CONCILIATION. (X.)

UNITED STATES.

The first recourse to a strike in the United States occurred in 1740 or 1741, when a combined strike of journeymen bakers occurred in New York City. An information was filed in 1741 against the strikers for conspiracy not to bake until their wages were raised. On this they were tried and convicted, but it does not appear that any sentence was ever passed. In May 1796 an association of journeymen shoemakers in Philadelphia ordered a "turn-out" or strike to secure an increase of wages, and again in 1798, for the same purpose, both strikes being successful. In 1799 the shoemakers of Philadelphia struck against a reduction of wages, the strike lasting about 10 weeks, and being only partially successful. These four are the only strikes to which any reference can be found that occurred in the United States prior to the 19th century. The condition of industry generally during the colonial days was not conducive to strikes. The factory system had not taken deep root, masters and men worked together, and so there was no opportunity for concerted action.

Notable early strikes.

The first notable American strike occurred in November 1803, in the city of New York, and is commonly known as the "sailors' strike." The sailors in New York had been receiving $10 per month. They demanded an increase to $14. In carrying out their purpose they formed in a body, marched through the city, and compelled other seamen who were employed at the old rates to leave their ships and join the strike. The strikers were pursued and dispersed by the constables, who arrested their leader and lodged him in gaol, the strike thus terminating unsuccessfully. In 1805 the Journeymen Shoemakers' Association of Philadelphia again turned out for an increase of wages. The demands ranged from 25 to 75 cents per pair increase. This strike lasted six or seven weeks, and was unsuccessful. The strikers were tried for conspiracy, the result of the trial being published in a pamphlet which appeared in 1806. An account of this trial may be found in the United States Supreme Court Library. In November 1809 a strike among the cordwainers occurred in the city of New York. The proprietors quietly took their work to other shops, and by this stratagem defeated the strikers; but the action being discovered, a general turn-out was ordered by the Journeymen Cordwainers' Association against all the master workmen of the city, nearly 200 men being engaged in the strike. At that time a stoppage of work in one shop by the journeymen was called a "strike"; a general stoppage in all shops in a trade was known as a "general turn-out." A member of a journeymen's association who did not keep his obligations to the organization was denominated a "scab."

In 1815 some of the journeymen cordwainers of Pittsburg, Pa., were tried for conspiracy on account of their connexion with a strike, and were convicted. In 1817 a peculiar labour difficulty occurred at Medford, Mass. Thacher Magoun, a shipbuilder of that town, determined to abolish the grog privilege customary at that time. Mr Magoun gave notice to his people that no liquor should be used in his shipyard, and the words "No rum!" "No rum!" were written on the clapboards of the workshop and on the timbers in the yard. Some of Mr Magoun's men refused to work; but they finally surrendered, and a ship was built without the use of liquor in any form.

The period from 1821 to 1834 witnessed several strikes, but rarely more than one or two in each year. These strikes occurred among the compositors, hatters, ship carpenters and caulkers, journeymen tailors, labourers on the Chesapeake and Ohio canal, the building trades, factory workers, shoemakers, and others. One of the most notable of these, for its influence upon succeeding labour movements, occurred in 1834, in the city of Lynn, Mass. During the latter part of the preceding year the female shoebinders of that town began to agitate the question of an increase of wages. The women engaged in this work usually took the materials to their homes. The manufacturers were unwilling to increase the prices paid, so a meeting for consultation was held by more than one thousand binders. This was on 1st January 1834. The binders resolved to take out no more work unless the increase was granted. The employers, however, steadily refused to accede to the demands, as they found no difficulty in having their work done in neighbouring towns at their own prices. The strike, after three or four weeks, came to an unsuccessful termination. In February of the same year a disturbance of short duration occurred at Lowell, Mass., among the female factory operatives. Their strike was to prevent a reduction of wages. During the year 1835 there was a large number of strikes throughout the country, instigated by both men and women. The number of strikes by dissatisfied employés had at this time become so numerous as to call forth protests from the public press, the *New York Daily Advertiser* of 6th June 1835 declaring that "strikes are all the fashion," and suggesting that it was "an excellent time for the journeymen to come from the country to the city."

Investigations.

The United States Government, through the Census Office and the Department of Labour, has investigated the question of strikes, the result being a fairly continuous record from 1880 to 31st December 1900 inclusive. In 1880, according to the tenth census, there were 610 strikes, but the number of establishments involved in them was not reported; the record must therefore commence with 1881, and since then the facts have been continuously and uniformly reported by the Department of Labour. This record, so far as numbers are concerned, is shown in the following table:—

Year.	Strikes.			Lock-outs.	
	Number of Strikes.	Establishments involved.	Employés thrown out of Employment.	Establishments involved.	Employés thrown out of Employment.
1881	471	2,928	129,521	9	655
1882	454	2,105	154,671	42	4,131
1883	478	2,759	149,763	117	20,512
1884	443	2,367	147,054	354	18,121
1885	645	2,284	242,705	183	15,424
1886	1,432	10,053	508,044	1509	101,980
1887	1,436	6,589	379,676	1281	59,630
1888	906	3,506	147,704	180	15,176
1889	1,075	3,786	249,559	132	10,731
1890	1,833	9,424	351,944	324	21,555
1891	1,717	8,116	298,939	546	31,014
1892	1,298	5,540	206,671	716	32,014
1893	1,305	4,555	265,914	305	21,842
1894	1,349	8,196	660,425	875	29,619
1895	1,215	6,973	392,403	370	14,785
1896	1,026	5,462	241,170	51	7,668
1897	1,078	8,492	408,391	171	7,763
1898	1,056	3,809	249,002	164	14,217
1899	1,797	11,317	417,072	323	14,817
1900	1,779	9,248	505,066	2281	62,653
Total	22,793	117,509	6,105,694	9933	504,307

Statistics of Strikes.—Out of the total of 117,509 establishments at which strikes took place during the period named, 41,910 were in building trades, 14,575 in coal and coke, 6153 in tobacco, 19,695 in clothing, 5126 in food preparations, 4652 in metals and metallic goods, 3436 in transportation, 3583 in stone quarrying and cutting, 1264 in boots and shoes, 1108 in furniture, 1193 in brick-making, 1723 in printing and publishing, and 891 in cooperage. These thirteen industries supplied 105,309, or 89·61 per cent. of the whole number of establishments in which strikes occurred during the twenty years. In the lock-outs occurring during the same time six industries bore a very large proportion of the burden, involving 8754, or 88·13 per cent. of the whole number of establishments, which was 9933. The industries affected were—building trades, 5001; clothing, 2034; stone quarrying and cutting, 516; boots and shoes, 292; tobacco, 339; metals and metallic goods, 272. The whole number of persons thrown out of employment by strikes was 6,105,694, of whom 90 per cent. were males and 10 per cent. were females; and the total number thrown out of employment by lock-outs during the same period was 504,307, of whom 80·24 per cent. were males and 19·76 per cent. were females. About 64 per cent. of the whole number of strikes were ordered by labour organizations; and of the number so ordered (14,457) 52·86 per cent. succeeded, 13·60 per cent. succeeded partly, and 33·54 per cent. failed. Of the whole number of strikes, 50·77 per cent. succeeded, 13·04 per cent. succeeded partly, and 36·19 per cent. failed. Of the lock-outs, 50·79 per cent. succeeded, 6·28 per cent. succeeded partly, and 42·93 per cent. failed. The average duration of the strikes for the whole period was 23·8 days, and of the lock-outs 97·1 days. Strikes are principally undertaken on account of wages, either for an increase or against a reduction, or in relation to the hours of labour. These leading causes covered 76·86 per cent. of the strikes occurring in the period from 1st January 1881 to 31st December 1900.

Losses from strikes.

It is difficult to ascertain exactly the losses of employés and employers resulting from strikes and lock-outs. Differences may counterbalance each other, so that the following results, taken from the report of the United States Government, may be considered as fairly accurate:—

Year.	Strikes.			Lock-Outs.		
	To Date when Strikers were re-employed or employed elsewhere.		Loss of Employers.	To Date when Employés locked out were re-employed or employed elsewhere.		Loss of Employers.
	Wage-loss of Employés.	Assistance to Employés by Labour Organizations.		Wage-loss of Employés.	Assistance to Employés by Labour Organizations.	
1881 . . .	$3,372,578	$287,999	$1,919,483	$18,519	$3,150	$6,960
1882 . . .	9,864,228	734,339	4,269,094	466,345	47,668	112,382
1883 . . .	6,274,480	461,233	4,696,027	1,069,212	102,253	297,097
1884 . . .	7,666,717	407,871	3,393,073	1,421,410	314,027	640,847
1885 . . .	10,663,248	465,827	4,388,893	901,173	89,488	455,477
1886 . . .	14,992,453	1,122,130	12,357,808	4,281,058	549,452	1,949,498
1887 . . .	16,560,534	1,121,554	6,698,495	4,233,700	155,846	2,819,736
1888 . . .	6,377,749	1,752,668	6,509,017	1,100,057	85,931	1,217,199
1889 . . .	10,409,686	592,017	2,936,752	1,379,722	115,389	307,125
1890 . . .	13,875,338	910,285	5,135,404	957,966	77,210	486,258
1891 . . .	14,801,505	1,132,557	6,176,688	883,709	50,195	616,888
1892 . . .	10,772,622	833,874	5,145,691	2,856,013	537,684	1,695,080
1893 . . .	9,938,048	563,183	3,406,195	6,659,401	364,268	1,034,420
1894 . . .	37,145,532	931,052	18,982,129	2,022,769	160,244	982,584
1895 . . .	13,044,830	559,165	5,072,282	791,703	67,701	584,155
1896 . . .	11,098,207	462,165	5,304,235	690,945	61,355	357,535
1897 . . .	17,468,904	721,164	4,868,687	583,606	47,326	298,044
1898 . . .	10,037,284	585,228	4,596,462	880,461	47,098	239,403
1899 . . .	15,157,965	1,096,030	7,443,407	1,485,174	126,957	379,365
1900 . . .	18,341,570	1,434,452	9,431,299	16,136,802	448,219	5,447,930
Total . .	257,863,478	16,174,793	122,731,121	48,819,745	3,451,461	19,927,983

The total loss to employés and employers alike in the establishments in which strikes and lock-outs occurred, for the period of twenty years, was thus $468,968,581. The number of establishments involved in strikes during this period was 117,509, making an average wage-loss of $2194 to employés in each establishment in which strikes occurred. The number of persons thrown out of employment by reason of strikes was 6,105,694, making an average loss of $42 to each person involved. The number of establishments involved in lock-outs was 9933, making an average loss of $4915 to employés in each establishment in which lock-outs occurred, while the number of employés thrown out was 504,307, making an average loss of $97 to each person involved. Combining the figures for strikes and lock-outs, it is seen that the number of establishments involved was 127,442, while 6,610,001 persons were thrown out of employment. These figures show an average wage-loss of $2406 to the employés in each establishment, and an average loss of $46 to each person involved. The assistance given to strikers by labour organizations during the period was $16,174,793; to those involved in lock-outs, $3,451,461, or a total of $19,626,254. This sum represents but 6·40 per cent. of the total wage-loss incurred in strikes and lock-outs, and is probably too low. Much assistance was also furnished by outside sympathizers, the amount of which cannot be readily ascertained. The total loss to the establishments or firms involved in strikes and lock-outs during this period was $142,659,104.

The states of Illinois, Massachusetts, New York, Ohio, and Pennsylvania, being the leading manufacturing states, necessarily experienced the largest number of strikes. Out of 117,509 establishments having strikes during the period named, 87,878, or 74·78 per cent. of the whole, were in these five states; and out of 9933 establishments having lock-outs, 8424, or 84·81 per cent., were in these states. In 1900 these states contained 45·02 per cent. of all the manufacturing establishments in the United States, and employed 55·15 per cent. of the entire capital invested in mechanical industries.

The figures given relate to all strikes, of whatever magnitude, occurring in the United States from 1881 to 31st December 1900 inclusive. Among them have occurred what may be called historic strikes, the first of which was in 1877, though of course many very severe strikes had taken place prior to that year. The great railway strikes of 1877 began on the Baltimore and Ohio railroad at Martinsburg, W. Va., the immediate cause of the first strike being a 10 per cent. reduction of wages of all employés. This, however, was but one of many grievances. There was irregular employment. Men with families were permitted to work only three or four days per week, the remainder of the time being forced to spend away from home at their own expense, leaving them but little money for domestic use. Wages, payable monthly, were often retained several months. The tonnage of trains was increased, and the men were paid only for the number of miles run, irrespective of the time consumed. So there were many alleged causes for the great strikes of 1877. Riot, destruction of property, and loss of life occurred at Martinsburg, Baltimore, and various places in Pennsylvania. The state militia at Martinsburg and Pittsburg sympathized with the strikers, affiliated with them, and refused to fire upon them. United States troops were ordered from Eastern garrisons, and they dispersed the mobs. In Cincinnati, Toledo, and St Louis mobs of roughs and tramps collected, and succeeded in closing most of the shops, factories, and rolling-mills in those cities. There were also formidable demonstrations in Chicago, as well as in Syracuse, Buffalo, West Albany, and Hornellsville, New York, where mobs were dispersed by the state militia without violence or destruction of property.

Historic strikes.

The Pennsylvania railroad also had a memorable strike, accompanied by riots and much violence and destruction of property, during the same year, the strike being ordered on account of a general reduction in wages and some other causes which came in to create the difficulty. The complete story of this strike is too long to relate here, but from the beginning the strikers had the active sympathy of a large proportion of the people of Pittsburg, where the chief movements occurred. The actual loss of the Pennsylvania Company, not including freight, has been estimated at $2,000,000, while the loss of property and loss of business at Pittsburg amounted to $5,000,000. Claims were presented before the courts in Allegheny county to the amount of over $3,500,000, while the actual amount paid by compromise and judgments was over $2,750,000.

The next great strike was that of the telegraphists, which occurred in the year 1883. This strike was inaugurated to secure the abolition of Sunday work without extra pay, the reduction of day turns to eight hours, and the equalization of pay between the sexes for the same kind of work. Universal increase of wages was also demanded. The strike commenced 19th July and ended 23rd August 1883, although it was declared off on the 17th of the latter month. It was unsuccessful, the employés losing $250,000 and expending $62,000 in assistance to destitute fellow-operators. The employers lost nearly $1,000,000.

Another historic strike was that on the South-Western or Gould system of railways in the years 1885–86, but the most prominent labour controversies in the 19th century were those at Homestead, Pa., in July 1892, and at Chicago in 1894, concerning which a more detailed account is given below. Other great labour convulsions have occurred which help to identify the decade beginning

1890 with the great strike era of the century. Among them may be named the Lehigh Valley railroad strike in December 1893, the American Railway Union strike on the Great Northern railway in April 1894; the great coal strike, which occurred in the same month; the difficulties at Lattimer, Pa.; and those in the Cœur d'Alene district of Idaho.

Homestead strike or riot.

In July 1892 there occurred a most serious affair between the Carnegie Steel Company and its employés at what is known as the Homestead Works, near Pittsburg, growing out of a disagreement in the previous month in regard to wages. The parties were unable to come to an agreement, and the company closed its works on the 30th of June and discharged its men. Only a small portion of the men were affected by the proposed adjustment of wages. The larger portion of them, who were members of the Amalgamated Association of Iron and Steel Workers, were not affected at all, nor was the large force of employés, some three thousand in number, who were not members of that association. The company refused to recognize the association as an organization, or to hold any conference with its representatives. Upon the failure to arrive at an adjustment of the wage difficulty, the company proposed to operate its works by the employment of non-union men. The men, who could not secure recognition, refused to accept the reduced rates of wages, and also came to the determination that they would resist the company in every attempt to secure non-union workers.

The history of the events at Homestead shows that the lodges composing the Amalgamated Association proceeded to organize what was styled an "advisory committee" to take charge of affairs for the strikers. All employés of the company were directed to break their contracts and to refuse to work until the Amalgamated Association was recognized and its terms agreed to. The works were shut down two days prior to the time provided by the contract under which the men were working, and, as alleged, because the workmen had seen fit to hang the president of the company in effigy. On 4th July the officers of the company asked the sheriff of the county to appoint deputies to protect the works while they carried out their intention of making repairs. The employés, on their part, organized themselves to defend the works against what they called encroachments or demands to enter; in fact, they took possession of the Homestead Steel Works. When the sheriff's men approached, the workmen, who were assembled in force, notified them to leave the place, as they did not intend to create any disorder, and would not allow any damage to be done to the property of the company. They further offered to act as deputies, an offer which was declined. The advisory committee, which had been able to preserve the peace thus far, dissolved on the rejection of their offer to serve as deputies and conservators of the peace, and all of their records were destroyed. The immediate cause of the fighting which subsequently took place at Homestead was the approach of a body of Pinkerton's detectives, who were gathered in two barges on the Ohio river, some miles below the works. When the Pinkertons arrived the workmen broke through the mill fence, entrenching themselves behind the steel billets, and made all preparations to resist the approach of the Pinkerton barges; and they resisted all attempts to land, the result being a fierce battle, brought on by a heavy volley of shots from the strikers. The Pinkertons were armed with Winchesters, but they were obliged to land and ascend the embankment single file, and so were soon driven back to the boats, suffering severely from the fire of the strikers. Many efforts were made to land, but the position of the men they were attacking, behind their breastworks of steel rails and billets, was very strong, and from this place of safe refuge the detectives were subjected to a galling fire. This opening battle took place on the 5th of July, about four o'clock in the morning, and was continued in a desultory way during the day. It was renewed the following day. A brass ten-pound cannon had been secured by the strikers, and planted so as to command the barges moored at the banks of the river. Another force of one thousand men had taken up a position on the opposite side of the river, where they protected themselves and a cannon which they had obtained by a breastwork of railway ties. A little before nine o'clock a bombardment commenced, the cannon being turned on the boats, and the firing was kept up for several hours. The boats were protected by heavy steel plates inside, so efforts were made to fire them. Hose was procured and oil sprayed on the decks and sides, and at the same time many barrels of oil were emptied into the river above the mooring place, the purpose being to ignite it and then allow it to float against the boats. Under these combined movements the Pinkertons were obliged to throw out a flag of truce, but it was not recognized by the strikers. The officers of the Amalgamated Association, however, interfered, and a surrender of the detectives was arranged. It was agreed that they should be safely guarded, under condition that they left their arms and ammunition; and having no alternative, they accepted the terms. Seven had been killed and twenty or thirty wounded. On the 10th of July, after several days' correspondence with the state authorities, the governor sent the entire force of the militia of the state to Homestead. On the 12th the troops arrived, the town was placed under martial law, and order was restored. There had been much looting, clubbing, and stoning, and as the detectives, after surrender, passed through the streets they were treated with great abuse. Eleven workmen and spectators were killed in the fights.

Congress made an investigation of this strike, but no legislative action was ever taken. Some indictments were made and lawsuits ensued. The mills were gradually supplied with new people, but the strike was not declared off until 20th November 1892. The Homestead strike must be considered as the bitterest labour war in the United States prior to the Chicago strike in 1894.

The Chicago or Pullman strike.

Probably the most expensive and far-reaching labour controversy which can properly be classed among the historic controversies of this generation was the Chicago strike of June and July 1894. Beginning with a private strike at the works of Pullman's Palace Car Company at Pullman, a suburb of Chicago, it ended with a practical insurrection of the labour employed on the principal railways radiating from Chicago and some of their affiliated lines, paralysing internal commerce, putting the public to great inconvenience, delaying the mails, and in general demoralizing business. Its influences were felt all over the country, to a greater or less extent, according to the lines of traffic and the courses of trade. The contest was not limited to the parties with whom it originated, for soon there were brought into it two other factors or forces. The original strike grew out of a demand of certain employés of the Pullman Company in May 1894 for a restoration of the wages paid during the previous year. The company claimed that the reduction in the volume of business, owing to business depression, did not warrant the payment of the old wages. On account of the increased production of rolling-stock to meet the traffic incident to the World's Fair in 1893, orders for building cars were not easily obtainable, a large portion of the business of the Pullman Company being contract business in the way of building cars for railway companies generally. This state of affairs resulted in a partial cessation of car-building everywhere in the country, the Pullman Company suffering with all others. The demand of the employés therefore was not acceded to, and on 11th May 1894 a strike was ordered. Several minor grievances were claimed to have existed and to have led to the action of the strikers, who had joined the American Railway Union, an association of railway employés which had achieved a partial success in a contest with the Great Northern railway a few weeks previous to the Pullman strike. The Railway Union espoused the cause of the Pullman employés on the ground that they were members thereof. This union was said to number about 150,000 members. It undertook to force the Pullman Company to accede to the demands of its employés by boycotting Pullman cars; that is to say, they declared that they would not handle Pullman cars on the railways unless the Pullman Company would accede to the demands made upon it. The immediate antagonist of the Pullman Company in the extended controversy was therefore the American Railway Union.

Another force was soon involved in the strike, which was, very naturally, an ally of the Pullman Company. This was the General Managers' Association, a body of railway men representing all the roads, twenty-four in number, radiating from Chicago, and it was said to be the necessity of protecting the traffic of its lines that brought about its struggle with the American Railway Union. These roads represented a combined capital of more than $2,000,000,000, and they employed more than one-fourth of all the railway employés in the United States. These three great forces, therefore, were engaged in a battle for supremacy, and that rivalry alone, without reference to the conditions and circumstances attending the strike or accompanying it, makes this one of the historic strikes of the period.

According to the testimony of the officials of the railways involved, they lost in property destroyed, hire of United States deputy marshals, and other incidental expenses, at least $685,308. The loss of earnings of these roads on account of the strike is estimated at nearly $5,000,000. About 3100 employés at Pullman lost in wages, as estimated, probably $350,000. About 100,000 employés upon the twenty-four railways radiating from Chicago, all of which were more or less involved in the strike, lost in wages, as estimated, nearly $1,400,000. Beyond these amounts very great losses, widely distributed, were suffered incidentally throughout the country. The suspension of transportation at Chicago paralysed a vast distributive centre, and imposed many hardships and much loss upon the great number of people whose manufacturing and business operations, employment, travel, and necessary supplies depend upon and demand regular transportation to, from, and through Chicago. The losses to the country at large are estimated by Bradstreets to be in the vicinity of $80,000,000. Whatever they are, whether more or less, they teach the necessity of preventing such disasters, and the strike illustrates how a small local disturbance, arising from the complaints of a few people, can affect a whole country. When the American Railway Union took up the cudgels for the Pullman strikers and declared their boycott against Pullman cars, and the General Managers' Association took every means to protect their interests and prevent the stoppage of transportation, the sympathies and antagonisms of the whole country were aroused. An unsuccessful attempt was made to induce all trades in Chicago to join in a great sympathetic strike.

The inevitable accompaniments of a great strike were brought into play at Chicago. Riots, intimidations, assaults, murder, arson, and burglary, with lesser crimes, attended the strike. In this, as in some of the other historic strikes, troops were engaged. The city police, the county sheriffs, the state militia, United States deputy marshals, and regulars from the United States army were all brought into the controversy. The United States troops were sent to Chicago to protect Federal property and to prevent obstruction in the carrying of the mails, to prevent interference with inter-state commerce, and to enforce the decrees and mandates of the Federal courts. They took no part in any attempt to suppress the strike, nor could they, as such matters belong to the city and state authorities. The police of the city were used to suppress riots and protect the property of citizens, and the state militia was called in for the same service. The total of these forces employed during the strike was 14,186.

Many indictments and law-suits originated in the difficulties occurring in Chicago. But all the attending circumstances of the strike point to one conclusion—that a share of the responsibility for bringing it on belongs in some degree to each and every party involved. The strike generated a vast deal of bitter feeling—so bitter that neither party was ready to consider the rights of the other. The attacking parties claimed that their grievances warranted them in adopting any means in their power to force concessions. This is the attitude of all strikers. The other parties, on the other hand, claimed that they were justified in adopting any means in their power to resist the demands of the attacking party. The probability is that neither recognized the rights of the public to such an extent as to induce them to forbear bringing inconvenience and disturbance to it. It was the most suggestive strike that has ever occurred in the United States, and if it only proves a lesson sufficiently severe to teach the public its rights in such matters, and to teach it to adopt measures to preserve these rights, it will be worth all it cost.

The steel strike, 1901.

The so-called steel strike of the year 1901 was a contest between the Amalgamated Association of Iron, Steel, and Tin Workers and the United States Steel Corporation. It began on the first day of July, and lasted until 15th September 1901, when work was resumed in accordance with an adjustment agreed to on the 13th of the latter month. The difficulty grew out of an attempt to adjust a sliding scale of wages with some of the constituent companies of the United States Steel Corporation, a new company having $1,404,000,000 capitalization. This corporation was perfected after the difficulties really began, so the Amalgamated Association ultimately had to confront the new powerful corporation. The real nut of the difficulty was not a question of wages, hours of labour, or rules or conditions of work, but a contest for recognition of the right of the association to demand the unionizing of mills, a demand, of course, which was positively refused by the United States Steel Corporation. There were no grievances, as intimated; it was clearly and solely a conflict on the demand for recognition in the trade-union sense, and it was the first great struggle in the United States that was conducted solely on this issue. This issue has been contested many times, but usually in conjunction with some grievance or complicated with some demand as to wages or other economic conditions. The result was that the Amalgamated Association did not secure the terms demanded; and it lost further, because some of the mills which were subject to the union's rules were taken out and made non-union mills. The strike was conducted without any of the dramatic and tragic circumstances which attended the Homestead affair in 1892, in which the Amalgamated Association was one of the parties. In the contest of 1901 the association did not have the hearty endorsement of a large number of workmen, as it was not a movement to redress any grievance. It was fought for a principle, but the movers did not consider the power against which they were obliged to contend. Officers of the Amalgamated Association estimated that the number of men out of employment during the strike averaged 30,000 per day. At a conservative estimate there must have been a loss of more than $4,000,000 in wages. The steel company through its officers claimed that it experienced no great loss as the result of the strike.

Coal strike, 1902.

A strike affecting more individual interests than any preceding it was the anthracite coal strike of 1902, which formally began on 12th May. It was ordered at a convention held at Hazleton, Pennsylvania, 15th May, by a vote of 461 to 349. The leaders of the miners, with one or two exceptions, opposed the strike. It was therefore a strike of the workers themselves. Grievances had existed in the anthracite coal region for many years, but more especially since the strike of 1900. An attempt was made in 1901 to secure some concessions, but the operating railways declined even to enter into a conference. This, of course, caused irritation, and constant appeals were made to the officers of the union to make new demands, and failing to secure concessions, to organize a strike. The demands of the miners were as follows: (1) An increase of 20 per cent. to those miners who are paid by the ton; (2) a reduction of 20 per cent. in the time of per diem employés; (3) that 2240 ℔ constitute the ton on which payment is made for coal mined by weight. No grievances were presented. The powder question was practically settled in 1900. The miners' demands being rejected by the operators, the demands were subsequently reduced one-half; *i.e.*, 10 per cent. increase per ton where mining is paid by the ton, and 10 per cent. decrease in the working day. The miners also voted to leave the whole matter to arbitration and investigation, and to accept the results. They were willing to make a three years' contract on the terms proposed. The fundamental difficulty on the part of the operators related to efforts to secure and preserve discipline. They claimed that every concession already made had defeated this. The strike involved nearly 150,000 employés, and affected the consumers of anthracite coal throughout the Eastern states.

Authorities.—U.S. Department of Labour, Sixteenth Annual Report, 1902; reports of various State Bureaus of Labour Statistics; Pennsylvania Bureau of Industrial Statistics, Twentieth Annual Report, 1892; U.S. House of Representatives, "Employment of Pinkerton Detectives at Homestead, Pa.," Report No. 2447, 52nd Congress, 2nd Session, 1892; United States Strike Commission, Report on Chicago Strike, Senate Ex. Doc. No. 7, 53rd Congress, 3rd Session, 1894; "The Amalgamated Association of Iron and Steel Workers," *Quarterly Report of Economics* for November 1901.

(C. D. W.)

Strood. See Rochester.

Strossmayer, Joseph George (1815- ——), Roman Catholic theologian, was born at Essek, in Slavonia, 4th February 1815. He studied theology at Pesth. After his ordination to the priesthood in 1838 he became a professor in the seminary at Diakovár. He next was made chaplain to the emperor of Austria, and at a later period director of the Augustinian body at Rome. In 1849 he was consecrated bishop of Bosnia. From that time he became, by his ability, force of character, and strong national sentiments, a recognized leader of the Slavonians of eastern Austria. He created a national party in Austrian Slavonia, and stimulated Slavonic national feeling by establishing national schools and by publishing collections of Croatian songs and "Volksbücher." He eagerly advocated the use of the vernacular in the Roman Catholic services, so as to bring over the Slavonians of the Greek Church to the Roman obedience. His fervid advocacy of the Slav cause drew upon him the displeasure of the emperor. But he still persevered in his efforts to fan the flame of Slav national feeling. Among other steps in this direction, and in that of Romanizing the Slavs, he founded a seminary in Austria for the Slavs of Bosnia. With the assistance of Theiner, the librarian at the Vatican, he compiled his *Vetera Monumenta Meridionalium Slavorum historiam illustrantia*, which was published at Rome in 1863. When the Infallibility question arose in 1870, he was one of the most energetic and outspoken opponents of the decrees, and for years he refused to send in his submission to them. But the difficulty was finally surmounted by an informal submission, and in 1881 and 1888 he headed a pilgrimage of Slavs to Rome. In spite of his opposition to the decrees of the Vatican Council, he succeeded in obtaining from the Pope the concession he had so long advocated, that the vernacular should be retained in the South Slavonian liturgy. Strossmayer retired from active political life in consequence of a rebuke administered to him by the emperor of Austria, as king of Hungary, who charged him with stirring up strife between Croats and Hungarians. In consequence of this reproof, and of his advancing age, little was heard in late years of a man who once wielded an altogether exceptional influence in southern Slavonia.

Stroud, a parish and market town in the Stroud parliamentary division of Gloucestershire, England, on the Frome, 10 miles south of Gloucester by rail. Recent erections are a free library and a school of art. There are foundries, and umbrella and walking-stick factories. Area of urban district, 1169 acres. Population (1891), 9818; (1901), 9188.

Stryj, or STRY, a town in Galicia, Austria, 40 miles S. by W. of Lemberg. Population (1890), 16,515; (1900), estimated at 23,673 (70 per cent. Polish, 26 per cent. Ruthenian, 4 per cent. German; 40 per cent. Jewish, 30 per cent. Catholic, 27 per cent. Greek Catholic, and 3 per cent. Protestant). Its chief industries are tanning and the manufacture of lucifer matches, but it is also an important cattle market. Iron ore is mined in the adjoining district.

Stubbs, William (1825–1901), English historian and bishop of Oxford, son of William Morley Stubbs, solicitor, of Knaresborough, Yorkshire, was born on 21st June 1825, and was educated at the Ripon grammar school and Christ Church, Oxford, where he graduated in 1848, obtaining a first-class in classics and a third in mathematics. He was elected a fellow of Trinity College, and held the college living of Navestock, Essex, from 1850 to 1866. He was librarian at Lambeth, and in 1863 was an unsuccessful candidate for the regius professorship of ecclesiastical history at Oxford. In 1866 he was appointed regius professor of modern history at Oxford, and held the chair until 1884. His lectures were thinly attended, and he found them grievous interruptions to his historical work. Some of his statutory lectures are published in his *Lectures on Mediœval and Modern History.* He was rector of Cholderton, Wiltshire, from 1875 to 1879, when he was appointed a canon of St Paul's. He served on the Ecclesiastical Courts Commission of 1881–83, and wrote the weighty appendices to the report. On 25th April 1884 he was consecrated bishop of Chester, and in 1889 was translated to the see of Oxford.

Until Bishop Stubbs found it necessary to devote all his time to his episcopal duties, he pursued historical study with unremitting diligence. He rejected the theory of the unity and continuity of history so far as it would obliterate distinctions between ancient and modern history, holding that, though work on ancient history is a useful preparation for the study of modern history, either may advantageously be studied apart. He urged that history is not to be treated as an exact science, and that the effects of individual character and the operations of the human will necessarily render generalizations vague and consequently useless. While pointing out that history has a utility as a mental discipline and a part of a liberal education, he recommended its study chiefly for its own sake, for the truth's sake, and for the pleasure which it brings. It was in this spirit that he worked; and his intellectual character was peculiarly fitted for his work, for he was largely endowed with the faculty of judgment and with a genius for minute and critical investigation. He was eminent alike in ecclesiastical history, as an editor of texts, and as the historian of the English constitution. His right to be held as an authority on ecclesiastical history was proved in 1858 by his *Registrum Sacrum Anglicanum,* which sets forth episcopal succession in England, by many other later works, and particularly by his share in *Councils and Ecclesiastical Documents,* edited in co-operation with the Rev. A. W. Haddan, for the third volume of which he was specially responsible. His place as a master in critical scholarship and historical exposition is decided beyond debate by the nineteen volumes which he edited for the Rolls series of *Chronicles and Memorials.* It is, however, by his *Constitutional History of England* that he is most widely known as a historian. The appearance of this book, which traces the development of the English constitution from the Teutonic invasions of Britain till 1485, marks a distinct step in the advance of English historical learning. Specialists may here and there improve on a statement or a theory, but it will always remain a great authority, a monument of patient and exhaustive research, of intellectual power, and of ripe and disciplined judgment. Its companion volume of *Select Charters and other Illustrations of English Constitutional History,* admirable in itself, has a special importance in that its plan has been imitated with good results both in England and the United States.

Bishop Stubbs belongs to the front rank of historical scholars both as an author and a critic. Among Englishmen at least he excels all others as a master of every department of the historian's work, from the discovery of materials to the elaboration of well-founded theories and literary production. He was a good palæographer, and excelled in textual criticism, in examination of authorship, and other such matters, while his vast erudition and retentive memory made him second to none in interpretation and exposition. His carefulness was exemplary, and his references are always exact. His merits as an author are often judged solely by his *Constitutional History.* The learning and insight which this book displays are unquestionable: it is well planned, and its contents are well arranged; but constitutional history is not a lively subject, and, in spite of the skill with which Stubbs handled it and the genius displayed in his narrative chapters, the book does not afford an adequate idea of his place as a writer of history. What that is cannot be determined without taking into account the prefaces to some of the volumes which he edited for the Rolls series. Several of them contain monographs on parts, or the whole, of the author's work, written with remarkable literary skill. In these his language is vigorous and dignified: he states the results of his labour and thought with freshness and lucidity; tells numberless stories in a most delightful manner, and exhibits a wonderful talent for the representation of personal character; the many portraits of historic persons of all orders which he draws in these prefaces are as brilliant in execution as they are exact and convincing. Among the most notable examples of his work for the Rolls series are the prefaces to Roger of Hoveden, the *Gesta Regum* of William of Malmesbury, the *Gesta Henrici II.,* and the *Memorials of St Dunstan.* Both in England and America Bishop Stubbs was universally acknowledged as the head of all English historical scholars, and no English historian of his time was held in equal honour in European countries. Among his many distinctions he was an hon. D.C.L. of Oxford, LL.D. of Cambridge, Edinburgh, and Dublin, and hon. Doctor *in utroque jure* of Heidelberg; an hon. member of the University of Kief, and of the Prussian, Bavarian, and Danish Academies; he received the Prussian order *Pour le mérite,* and was corresponding member of the *Académie des Sciences Morales et Politiques* of the French Institute.

Stubbs was a High Churchman whose doctrines and practice were grounded on learning and a veneration for antiquity. His opinions were received with marked respect by his brother prelates, and he acted as an assessor to the archbishop in the trial of the bishop of Lincoln. Much of his work as bishop must have been uncongenial to him, for his tastes were those of a student, and he did not disguise his dislike of public functions and the constant little journeys which take up so much of a bishop's time. Nevertheless he fulfilled all his episcopal duties with diligence, and threw all his heart into the performance of those of a specially spiritual nature, such as his addresses at confirmations and to those on whom he conferred orders. As a ruler of the Church he showed wisdom and courage, and contemptuously disregarded any effort to influence his policy by clamour. In personal character he was modest, kind, and sympathetic, ever ready to help and encourage serious students, generous in his judgment of the works of others, a most cheery companion, full of wit and humour. His wit was often used as a weapon of defence against those who annoyed or bored him, for he did not suffer fools gladly. An attack of illness in November 1900 seriously impaired his health. He was able, however, to attend the funeral of Queen Victoria on 2nd February 1901, and preached a remarkable sermon before the King and the German Emperor on the following day. His illness became critical on 20th April, and he died on the 22nd. In 1859 he had married Catherine, daughter of John Dollar of Navestock, and had a numerous family.

(W. HU.)

Stuttgart, the capital of Würtemberg, Germany, stands in a basin surrounded by vine-clad hills, 1½ miles from the left bank of the Neckar. The beauty of the situation and the educational advantages attract several foreign residents, more particularly British and Americans. The more important of the recent erections are the Queen Olga Buildings, in the Renaissance style, put up in 1893–95, on the north side of the Castle Square; the National Industrial Museum (1890–96), in the Late Renaissance style, flanked by a couple of cupola-crowned corner towers, and richly decorated with medallions of famous Swabians, &c.; the Liederhalle, with one of the largest halls in Germany; the new town hall; the Peace church (1893), the Roman Catholic church of St Nicholas (1896), three other churches, large swimming baths (1888–89), a new railway viaduct across the valley of the Neckar, 738 yards long; a bronze statue of Duke Christopher (1889) in the principal square; a monument to the Emperor William I. (1898) near the old castle; an equestrian statue of King William I. (1884), by Hofer, in the court of the Museum of the Plastic Arts; and a large monumental fountain on the Eugensplatte. The Hof-theater was burned down in 1902. The royal library contains about 500,000 volumes, 3800 MSS., and a collection of some 7300 Bibles. There is a rapidly growing trade, and important cloth, horse, and hop markets. The art and educational institutions embrace the industrial exhibition, the state archives, numismatic, art, and antiquarian collections, zoological and botanical gardens, an excellent conservatory of music, a chemical laboratory, an art academy, higher commercial institute, a commercial improvement school, and school of the building trades. The technical high school was attended by 1033 students in 1900, and the veterinary high school by about 100 students in the same year. The latter institution was raised to academic ("high") rank in 1890; and the same status is also enjoyed by the school of art. In 1899 the right to confer the degree of doctor of engineering was conferred upon the technical high school. Stuttgart is not only a residential town; it is also the seat of considerable industries, especially the weaving of cottons, publishing, the manufacture of furniture, pianofortes, chemicals, confectionery, paper, leather, clothing, colours, carriages, &c. At Berg, beside the Neckar, there are saline springs. Population (1885), 125,901; (1890), 139,817; (1895), 158,321; (1900), 176,318.

Styria (German, *Steiermark*), a duchy and crownland in the Cisleithan part of the Austro-Hungarian Monarchy. Population in 1880, 1,213,597; in 1890, 1,282,708; and in 1900, 1,356,058, which is equivalent to 156·7 inhabitants per square mile. Proportion of females to males, 1017 to 1000; 67·8 per cent. German, 32·2 per cent. Slovene; 99 per cent. Roman Catholic, the remainder consisting of 10,556 Protestants and 1979 Jews. In 1897 the marriage-rate was 6·99; the birth-rate, 31·15, or excluding still-births 29·94; and the death-rate, 24·02. Of the births 23·10 per cent. were illegitimate, a declining ratio.

Styria sends 27 members to the Reichsrath, 4 of whom are returned by the new general suffrage curia. In the Diet there are 55 Germans and 8 Slovenes. Owing to the steady increase of the industrial population and the chronic irritation produced by the nationality struggle, Styria has become one of the most Radical and strongly German Nationalist provinces of Austria. This applies even to a considerable and growing minority of the agricultural population. Indeed, in its Pan-Germanic leanings it approaches the German districts on the Bohemian frontier. Socialism is widely prevalent in the industrial districts, and more particularly at Gratz, although, owing to the restricted suffrage and large rural population, it is but slightly represented.

In addition to the University (1306 students in 1901), the Polytechnic (373 students), and an Academy of Commerce at Gratz, the province has over 100 other educational institutions. There are 12 intermediate and 860 elementary schools. Of the latter, 568 are German, 212 Slovene, and 40 bilingual. In 1890 the illiterates amounted to 20 per cent. of the population, an improvement of 7·8 per cent. on 1880.

Notwithstanding its mountainous character, Styria is exceptionally well cultivated, and in addition is one of the principal pastoral regions of Austria. The principal crops are oats, maize, buckwheat, and turnips, but considerable quantities of wheat, rye, millet, legumes, and fodder plants are also grown. In 1899 515,181 hectolitres of wine were produced. Fruit culture and poultry are also of some importance. In 1890 there were 66,871 horses, 700,012 horned cattle, 162,416 sheep, 42,238 goats, 637,607 pigs, and 100,573 bee-hives. In 1899 the total yield of the mines in lignite and a small quantity of coal, in iron, lead, zinc, manganese, and graphite, amounted in value to £853,911, to which should be added salt recovered at Aussee to the value of £151,700. The value of the furnace products (iron and zinc) was £758,552. The manufacture of iron and steel wares (including small-arms, bicycles, machinery, railway material, agricultural implements, &c.), glass, celluloid, paper and tobacco comes next in importance. These articles, together with cattle, timber, lignite, fruit, and wine, constitute the principal part of the exports.

In 1899 Styria had 1283 kilometres of railway, 4958 kilometres of roads, and 538 kilometres of waterway, of which 413 were only available for floating timber. There were 422 post and 209 telegraph offices, with 2237 kilometres of line and 8258 kilometres of wire.

AUTHORITIES.—*Mitteilungen des historischen Vereins für Steiermark* (Gratz, 1850, &c.), and other publications of the same society; together with histories and descriptive works by Göth, Muchar, Kohl, Hlubek, Gebler, Zahn, Stur, Janisch, Schlossar, and Rosegger.

(Æ. O'N.)

Suakin, a town and seaport on the west side of the Red Sea, at the point where the conventional line laid down in 1899 between Upper Egypt and Anglo-Egyptian Sudan reaches the coast. This part of the seaboard is thickly studded with reefs, and Suakin itself stands on a coralline islet connected with the suburb of El-Kef on the mainland by an embankment, and since 1884 by a railway viaduct. Access is gained to the harbour, which is the safest in the Red Sea, through a winding passage over 2 miles long, terminating in a deep oval-shaped basin several acres in extent, and completely sheltered from all winds. Suakin is of great importance both as the outlet of much of the produce of eastern Sudan and more especially as the place where a large number of Moslem pilgrims embark for Jedda, the port of Mecca on the opposite side of the Red Sea, here about 20 miles wide. Hence after the Mahdist revolt it was occupied in force by the British in

1883, to prevent the contagion from spreading from Africa through this channel to the whole of the Mahommedan world (see SUDAN, ANGLO-EGYPTIAN). It is still held by an Anglo-Egyptian garrison, and it is proposed to improve its strategical and commercial position by extending the railway begun in 1884 up the Khor Baraka valley to Kassala and Khartum, and also across the steppe, here 260 miles wide to Berber on the eastern bend of the Nile where it approaches nearest to the Red Sea. Since the overthrow of the Mahdist power, the trade of Suakin has revived and even increased, the imports having advanced from about £170,000 in 1880 before the war to £180,000 in 1899. They consist chiefly of textiles, flour, spirits, cutlery, preserves, dyes, and drugs, while the chief exports (£66,000 in 1899) are gums, mother-of-pearl, ivory, and tobacco. In the same year the entries, mostly British, were 37 ships of 29,000 tons, much less than formerly (758 vessels of 172,000 tons in 1880), the falling off being due to the total suppression of the slave trade, in which large numbers of Arab dhows were engaged before the British occupation. (A. H. K.)

Submarine Boats. See SHIP.

Submarine Mines.—(1) GENERAL CONSIDERATIONS, AND BRITISH PRACTICE. The employment of floating or submerged mines for defensive purposes has long been an attractive subject for study and experiment. Unseen dangers appeal powerfully to the imagination, and the fact that ships may be and have been sunk by mines has caused extravagant claims to be advanced by the advocates of this adjunct of defence. Mines capable of being exploded if struck by a vessel were employed by the Russians in the Crimean war without effect. In the American Civil War they were largely used by the Confederates, who were driven to adopt all possible expedients; and as several ships were thus destroyed, the system was afterwards greatly developed and widely adopted by great and small Powers. Submarine mines have in recent years usurped a position in national defence which they are quite unfit to fill, and a modification of views which have been upheld by electrical experts who ignored the experience of war is to be expected. The conditions of the American contest were special and peculiar. The Confederate states had no sea-going navy, and the naval operations were practically limited to interior waters. Provided that means existed for the entry of blockade-runners into a few Southern ports, obstruction of waterways could be accepted to any extent. The exigencies of the war stimulated invention, and submarine mines afforded a cheap and ready method of defending channels. The essential conditions of the British Empire being in every respect absolutely different from those of the Southern states, the war provided no lessons in harbour defence for our guidance. In the Franco-German war the small Prussian navy was powerless. Keil, Wilhelmshaven, and other ports were defended by mines which were not required, as the French fleet was effectually prevented, on other grounds, from attacks on the Prussian littoral. The only effect of the mines was to impede the entry of German ships into their own ports, and thus to bring about several captures, while the subsequent removal of the mine-fields led to a fatal accident. That the prevailing views of mine defence were hopelessly confused is shown by the fact that the French spent three months in installing the mine-field at Toulon, and failed to complete that at Cherbourg before the conclusion of the war. As the Prussian squadron was unable to approach a French port, the futility of their proceedings could not have been surpassed. The Paraguayans are said to have employed submarine mines in the Parana river during the irregular warfare which was carried on by Brazil for nearly six years; but the operations were not thereby affected. In 1866 the Austrians appear to have laid out mine-fields at Pola and Venice, which events proved to be superfluous; while a powerful Italian fleet was repulsed at Lina without any assistance from this adjunct. A little Turkish river gun-boat was sunk in the Danube by an electro-mechanical mine in October 1887. The Peruvians are reputed to have laid mines during the war of 1879–81, which, if they existed, effected nothing. The Egyptians had provided themselves with an expensive equipment of submarine mines, which were found in store at Meks after the British occupation of Alexandria in 1882. The Chinese were rumoured to have laid mines in the Min river in 1884; but, after careful search, the French squadron could not discover anything except fishermen's buoys. At Tamsui the river was obstructed by sunken junks and mines; but as Admiral Leipés had only one gun-boat in his squadron which could have ascended the river, the exclusion of this craft is all that can be claimed for the mine-field. As, further, the French landing party was repulsed with heavy loss, it is clear that mines were not required by the Chinese. There is no war experience which justifies either the claims of the extreme advocates of submarine mines, or the immense expenditure to which Great Britain has been committed in providing defence of this nature.

Submarine mines may be roughly divided into three classes: (1) Mechanical mines, which, once laid, are uncontrollable, and are fired automatically if struck by any passing vessel. (2) Electrically-controlled mines, connected by cables with the shore, and capable of being rendered active when struck. (3) Observation mines laid on the ground or at depths greater than a ship's draught, and fired electrically from an observatory station when a hostile vessel is ascertained to be within their sphere of action.

The first class are so dangerous as to be inadmissible except in cases where it is desired to close a channel alike to friend and foe.

The second necessarily constitutes an obstruction to waterways, and involves special pilotage arrangements and delay to maritime traffic. Moreover, no mine which contains its own means of ignition is entirely free from danger; and there is no evidence that such mines, even when nominally inactive, might not be fired if cut through by a ship's screw.

The third class is open to no objection on the ground of physical obstruction to waterways; but, unless the identification of an enemy's vessels can be absolutely guaranteed, it evidently involves great danger; and in any case it breaks down altogether as a protection in thick weather.

Wet gun-cotton, on account of its safety in storage, has been adopted for the charges of submarine mines in this country. Data as to the destructive radius of mines upon the hulls of modern ships are far from complete; but the formulæ given (see *United States* below) embody the experience gained by such practical trials as have at present been carried out. The careful inquiry into the destruction of the *Maine* in 1898 led the United States officers to the conclusion that a mine had been fired close to her bottom. In this case the vessel sank rapidly; but there was no means of ascertaining the amount of explosive employed.

The fact that the whole question of submarine mine defence has been allowed to remain in the hands of experts, who ignored naval requirements and the practical conditions of war, accounts for much misdirected energy and some evident danger. During the Spanish-American war mine-fields were laid in the approaches to New York, Philadelphia, and Boston, in obedience to the dictates of a humiliating and wholly superfluous scare which arose along the Atlantic sea-board when Admiral Cervera was believed to be contemplating a descent. The result was an almost intolerable hindrance to traffic, which would have greatly facilitated the operations of a Spanish commerce destroyer, if such a vessel had been able to maintain herself off these ports.

The general principles which should guide and limit the employment of submarine mines may be briefly stated. In the first place, it is clearly superfluous to mine channels which an enemy's vessels could not be expected to enter. The considerable expense incurred by a now abandoned project for thus defending the Liffey was therefore wholly unjustifiable. It may safely be assumed that hostile vessels will not enter cramped interior waters under effective fire, and the provision of a few guns in such cases is far more economical than an equipment of submarine mines. In any case the latter afford no protection against torpedo craft. Most British ports are in the category of those which no ship of war would enter if effective fire is brought to bear upon their waters. In war the free entry of British ships into all the Imperial ports is a condition of primary importance, and restrictions entailing delay would frequently be dangerous. Observation mines can be employed, provided they are always under the control of responsible officers capable of identifying with certainty an enemy's armed vessels. They have also the advantage that they can be laid down at any time without offering any hindrance to navigation. Contact mines are generally unsuitable for British requirements. Powers which contemplate the cessation of their commerce and naval inaction during war can employ mines of any form in profusion without disadvantage. As, however, artillery fire is usually required for objects which no amount of mines may be able to secure, it is evidently desirable to consider in each case whether the one form of defence will not include the other. The submarine mine is thus an adjunct of little importance to Great Britain; but, if judiciously employed, it may serve the purposes of a weak naval Power when confronted with a fleet too strong to be opposed on the seas. If ever the conditions of the American Civil War or of the fighting on the Parana are repeated, and naval action is limited to interior waters, the perfected submarine mine of the present day will play an effective *rôle*. As peculiar moral value has always been claimed for this form of defence, the mining of channels will generally be proclaimed whether it has been carried out or not.

(G. S. C.)

(2) United States.

Mines were planted in large numbers during the Spanish-American war of 1898. In the waters of Cuba, Puerto Rico, and Manilla the Spaniards used observation, electro-contact, and mechanical mines, ground and buoyant, with charges of gun-cotton as large as 500 ℔ in the former and 120 ℔ in the latter. Ground mines were planted in depths of water as great as 66 feet; buoyant were submerged about 11 feet. Mechanical mines were placed in advance of electro-contact mines at Santiago; 48 mines were planted in Guantanamo Bay.

The United States had the revision of its submarine mining system under study for two years prior to the war, and had adopted many improvements in details of materials and in the operation of the system. The system involves the use of seven-cored cable, each core of which is connected through disconnectors to three single-cored cables; at the end of each single core is a mine, either buoyant or ground. Each main group therefore consists of twenty-one mines. Buoyant mines contain a circuit-closer and a circuit-regulator; the latter contains a coil of 4500 ohms resistance, with a magnetic device for cutting out this resistance. Skirmish mines are not provided with circuit-regulators, and are electro-contact mines. Mines can be fired automatically on contact with a vessel, or at will, either with or without prior contact. Contact serves to notify the observer of the mine struck. The explosive used is chiefly dynamite; forcite gelatine has also been used. Charges are fired either by storage or Leclanché batteries. When planted, mines are subject to frequent tests to determine their condition. Buoyed channels were provided, which vessels drawing over 3 feet were directed to follow in their passage through mine-fields; but trespassing beyond these channels was frequent. Mines are prepared and planted by trained soldiers of the engineer battalion, assisted by skilled civilians from private corporations, boatmen, and labourers. Cable tanks are used for the storage of the submarine cable. The Americans planted over 1500 mines, operated from forty-four mining casemates in twenty-eight harbours—210 in Boston harbour, about 250 in the entrances to New York harbour, and 108 in Hampton Roads. The cost of all the mine-fields was $2,390,749. It is officially reported that the system fully realized all expectations, and that changes were contemplated only in a few minor details. Prior to the destruction of Admiral Cervera's fleet the Americans contemplated countermining at Santiago Bay by the method described under Torpedoes. Though they had a vessel equipped with dynamite guns, it was not used in countermining.

The Spanish-American war furnished arguments against (*a*) the use of certain forms of contact mines; (*b*) firing mines at will without utilizing the circuit-closer to announce the vicinity of the enemy; and (*c*) the use of gun-cotton; and in favour (*d*) of lightning arresters. (*a*) The Americans removed forty-eight mines from Guantanamo Bay, after having entered without precautionary measures regarding mines. An outer row of contact mines in Santiago harbour was of doubtful value. Marine growth rapidly accumulates on mine cases and prevents the action of exterior movable parts. All mechanism for firing contact mines should be covered; plungers, by thin metal caps. (*b*) Two mines were prematurely fired without injury to vessels in Manilla Bay. Tables of destructive ranges of mines given below show the need of great accuracy in the determination of the position of a vessel if it is intended to fire an observation mine in the vicinity. The horizontal destructive range of a mine charged with even 200 ℔ of gun-cotton is comparatively small. (*c*) In Santiago harbour half of the gun-cotton charge of a mine was found burned without explosion. (*d*) American mines were exploded by lightning on the Mississippi and Potomac rivers.

Destructive Range.—Two formulæ, A and B, have been advanced for determining the pressure due to varying charges of explosives at varying distances; A, by General Henry L. Abbot, a retired officer of the Corps of Engineers, U.S. Army, and B, by Lieutenant-Colonel John Townsend Bucknill, late Major R.E. A is for explosive compounds only; B, for both explosive mixtures and explosive compounds. The general use of explosive compounds makes it unnecessary to quote Abbot's formula for mixtures. A is based upon recorded pressures obtained by its author while firing a large number of charges, mostly of 5 ℔ or under, the formula having been afterwards checked by recorded pressures of larger charges, some as great as 200 ℔ of 75 per cent. dynamite exploded under wooden and iron targets. B is based upon a number of American and British experiments. Both authors had knowledge of the experiments of the Royal Engineers and the British Torpedo Commission, 1874–76, with the steamer *Oberon*, to determine the destructive range of large submarine mines. This steamer, with sides adapted to be about equal in strength to those of H.M.S. *Hercules*, had a total weight of about 1000 tons. Charges of 500 ℔ of gun-cotton were fired. Widely divergent conclusions were reached as to the pressure necessary to destroy a modern first-class battleship, General Abbot deeming an instantaneous pressure of 6500 ℔ per square inch sufficient; Colonel Bucknill, one of 12,000 ℔.

The following are the formulæ above referred to:—

$$P=\sqrt[3]{\left[\frac{6636\,(a+E)C}{(D+0{\cdot}01)^{2{\cdot}1}}\right]^2} \qquad \text{A.}$$

$$P=\frac{9CI}{D}\left(1+\frac{25}{D^2}\right)\left(1+\frac{a-90^\circ}{90}\times\frac{e}{100}\right) \qquad \text{B.}$$

P=pressure in pounds per square inch of surface exposed to the shock.

a=angle with the vertical passing through the centre of the charge, made by a line drawn from that point to the exposed surface, measured from the nadir and expressed in degrees.

E=the relative intensity of action of the explosive. Its values, determined by firing charges of 5 ℔ or less, are—for dynamite, 186; gun-cotton, 135; extra No. 1 forcite gelatine, 333; blasting gelatine, 375.

C=weight of explosive in pounds.

D=distance in feet from centre of charge to exposed surface.

I=relative intensity of action of explosive in a horizontal direction.

e=a percentage used for the several explosives.

The values taken for I and e are:—

	I.	*e*.
Blasting gelatine	142	12
Forcite gelatine, extra No. 1 .	133	14
Dynamite No. 1	100	20
Gun-cotton	100	20
Gunpowder	25	35

With these formulæ have been computed the following ranges in feet of submarine mines charged with No. 1 dynamite at which a modern battleship would be destroyed:—

Charge.	Horizontal Range.		Vertical Range.	
	A.	B.	A.	B.
100 ℔	16·3	9·5	18·6	11·0
200 ℔	22·6	16·5	25·9	19·0
500 ℔	35·0	38·2	40·0	45·6

After the conclusion of trials in 1875 a French High Commission adopted rules regulating the charges of ground mines as below: in the columns A and B are given the extreme destructive ranges of the *gun-cotton* charges computed by the corresponding formulæ:—

Depth of Water.	A.	B.	Gun-cotton.	Gunpowder.
Feet	Feet.	Feet.	℔.	℔.
26 to 36 . . .	39·4	50	550	2200
50	42·6	60	660	3300
60	48·8	79·5	880	4400
67	54·3	99·2	1100	...
73	59·2	118·9	1320	...
80	63·7	138·7	1540	...

(J. G. D. K.)

Suczawa (Rumanian, *Suceava*), the chief town of a government district in Bukovina, Austria, situated on the river of the same name, which there forms the boundary between the crownland and Moldavia. It is the last Austrian station. One of its numerous churches contains the grave of the patron-saint of Bukovina. Its principal industry is the tanning and leather trade, particularly of the finer qualities, and the manufacture of colored linen and cotton stuffs, &c. It was at one time the residence of the Moldavian princes, and in 1675 was besieged by Sobieski and plundered by the Turks. Population (1890), 10,221; (1900), 10,946, more than one-fifth Rumanian, the remainder mostly German-speaking.

Sudan.—According to present usage, this term is extended to the whole region in Africa which is bounded by the Sahara on the north and southwards by the Nile-Congo and Congo-Chad water-partings, and stretches from the Atlantic Ocean to the Red Sea, mainly between 4°–18° N. It thus corresponds in great measure to what may be called the "Black Zone," that section of the African continent which is regarded by many anthropologists as the true home of the negro race, and is largely inhabited by full-blood Negro populations, as distinguished from the Negroid Bantu peoples whose domain comprises most of the southern section of the continent south of Sudan. But the recent explorations of Baumann, Johnston, Dybowski, Clozel, and others about the borderlands of the conterminous territories show that there are many overlappings, and that the Bantus range northwards into the Chad basin and some other parts of Sudan proper, while the Sudanese Negroes have penetrated far into Bantuland on both sides of the equatorial lakes, as in Kavirondo and the Semliki valley. The expression Sudan is thus seen to differ considerably, according as it is regarded from the geographical or the ethnical points of view. Politically it may now be described as a dependency of Europe, at least from the international standpoint. No doubt some of the former native states, such as Sokoto, Bornu, Baghirmi, and Wadai, continue to enjoy a measure of independence; but all except Wadai have by numerous treaties recognized the overlordship of one or other of the three European powers—Great Britain, France, and Germany—amongst whom the whole region has now been definitely partitioned.

To Great Britain has been assigned the greater and by far the most valuable portion of *Central Sudan*, comprising the three administrative divisions of Lagos, Northern and Southern Nigritia, and including the greater part of the empire of Sokoto and of the ancient kingdom of Bornu: But the northern districts of Damerghu and Kanem—dependent the one on Sokoto, the other on Bornu—are included in the French sphere, which also extends east to Wadai and south-east to Baghirmi; while to Germany are awarded the southern districts of Bornu (Logon, Mosgu), together with nearly the whole of Adamawa, which was formerly attached to Sokoto. The result of this disposition of Central Sudan is that all three Powers have direct access to Lake Chad—Great Britain from the Gulf of Guinea through Nigritia to the west side; Germany also from the Gulf of Guinea through Cameroon and Adamawa to the south side; France both from French Congo and French Sudan to the north and east sides.

With the exception of the German enclave of Togoland, the old British colonies of the Gold Coast, Sierra Leone, and Gambia, the Portuguese territory Guinea, and the independent state of Liberia, the whole of *West Sudan* from the Niger to the Atlantic belongs to France. But "French Sudan," as it was officially designated till the year 1900, is now decomposed into the separate but conterminous colonies of *Senegal*, *French Guinea*, *Ivory Coast*, *Dahomey* and *Military Territories*. In one or other of these divisions are absorbed the former empires of Samory, of Tiéba, and Ahmadu, the states of Massina, Kaarta, Bambara, and Kong, the kingdoms of Mossi, Gurma, and Borgu, and the district of Timbuktu.

Since the overthrow of Mahdism, *East* (formerly Egyptian) *Sudan* has practically become British territory. All the shadowy claims of Turkey to this region are tacitly set aside by the Anglo-French agreement of March 1899 determining its western frontiers towards the French spheres of influence, and by the Anglo-Egyptian agreement of January, 1899, under which East Sudan is constituted an Anglo-Egyptian condominium, with effective British control. *Anglo-Egyptian Sudan*, as it may now be called (see below), is rearranged in four first-class and three second-class districts, comprising the former provinces of Dongola, Khartum, Suakin, Sennaar, Kordofan, Dar-Fur, and the Equatorial Province, with Fázogli and Bahr-el-Ghazal. All the other outlying territories—Massawa, Harrar, Berbera—which were formerly included for administrative purposes in Egyptian Sudan, have been ceded absolutely to Italy, Abyssinia, and Great Britain respectively.

Areas and populations.

Excluding the insignificant districts of Portuguese Guinea and Liberia, Sudan, taken in its widest sense, thus comprises three great political domains, with approximate areas and populations (1900) as under:—

	Area in Square Miles.	Population.
British, (West, Central, and East)	1,516,000	42,000,000
French (West and Central) .	620,000	9,000,000
German (West and Central, with Cameroon)	224,000	6,000,000
Total . . .	2,360,000	57,000,000

Anglo-Egyptian Sudan.

The Anglo-Egyptian Sudan.—The region which before the rise of the Mahdi was known as *Egyptian Sudan*, and comprised the whole of the Khedive's possessions beyond Egypt proper, has, since their recovery by the Anglo-Egyptian expedition of 1897–98, been reorganized under the joint control of Great Britain and Egypt. This territory has, in fact, become a *condominium,* in which Great Britain is the dominant partner. It is not, however, quite coincident with the Egyptian Sudan of the pre-Mahdi period, several of the outlying districts having been permanently ceded either to Italy, Abyssinia, or Great Britain. A strip of territory along the left bank of the Bahr-el-Jebel (Upper Nile), from below Lado south to Dafile, has also been temporarily leased by the agreement of May 1894 to King Leopold, as sovereign of the Congo Free State, while France acquires by the agreement of March 1899 certain commercial rights at a few, not yet defined, points on the White Nile and its affluents. Moreover, the Egyptian frontier has, by the Anglo-Egyptian agreement of January 1899, been advanced from Assuan at the First Cataract to Wadi Halfa at the Second Cataract, which henceforth marks the northern boundary of the condominium.

As thus delimited, Anglo-Egyptian Sudan forms a compact territory which, being conterminous southwards with the British Uganda Protectorate, brings the whole of the Nile valley from the equatorial lakes to the Mediterranean under the direct control of Great Britain. The eastern frontiers towards Abyssinia and the Italian colony of Eritrea, as determined by the international conventions of 1891, 1895, 1897, and 1898, coincide for the most part with the meridian of 35° E. Gr., but beyond 13° N. follow an irregular line, which runs from Sennaar north-eastwards to the Red Sea at Cape Kasar (18° 2′ N.). Westwards the frontiers, as laid down by the Anglo-German agreement of November 1893 and the Anglo-French agreement of March 1899, follow an irregular north-westerly line, which is drawn from 5° N. and 27° 30′ E. to the Tropic of Cancer at 16° E., in such a way as to include the whole of the Bahr-el-Ghazal, Dar-Fertit, and Dar-Fur within the British sphere. The boundary thus mainly coincides in the south with the low Nile-Congo water-parting, is conterminous in the west with the French Sudan and French Sahara (Wadai, Ennedi, Borku, Tibesti), and merges beyond Dar-Fur and Kordofan northwards in the uninhabitable Libyan Desert. Here the boundary is necessarily undefined, although vaguely indicated by the line which, according to the Turkish firman of 1814, describes a semicircle from the Siwa Oasis to Wadai, approaching very near the left bank of the Nile between the Second and Third Cataracts. But by an informal Franco-Italian agreement (1901) France withdraws from the hinterland of Tripolitana in favour of Italy, in the event of that Power occupying the Turkish possessions between Tunis and Egypt.

Speaking generally, the condominium constitutes two distinct physical areas—an arid, hot zone of steppes and deserts in the north and west; a moist, hot zone of superabundantly watered alluvial tracts in the south and south-east. In the dry zone are comprised the whole of Lower Nubia, Kordofan, and Dar-Fur; that is, everything on both sides of the Nile between Egypt and Khartum, together with the region above Khartum which extends from the White Nile westwards to Wadai. In the moist zone are comprised Upper Nubia, Sennaar, the Sobat and Bahr-el-Ghazal basins; that is, everything above Khartum between the White Nile and Abyssinia, together with the whole region on both sides of the Upper Nile from about the Sobat confluence to the Nile-Congo water-parting and to the Uganda Protectorate.

The dry zone, which occupies perhaps two-thirds of the condominium, is far from destitute of economic value, and besides gums, cattle, hides and skins, and ostrich feathers, here is great store of gold, iron, and copper. For ages gold-dust has been sent down the Nile from Kordofan; iron ores abound especially in the eastern parts of the same region and in Dar-Fur; while extremely rich copper-beds occur in the hilly Tagala district, and especially at Hofrah, on the banks of the Bahr-el-Fertit affluent of the Bahr-el-Arab. It was these Hofrah mines, which have been famous throughout Central Africa from remote times, that first attracted the attention of the Egyptians to Dar-Fur, and led to the conquest of the country in 1875. Gold is also widely distributed in the Sobat valley and some other parts of the moist zone. But here the chief resources are pastoral and agricultural. Magnificent herds of horned cattle are owned especially by the Dinka people; heavy crops of durra and other cereals are raised in the well-watered Bahr-el-Ghazal province; and many valuable kinds of timber abound on the eastern slopes about the headwaters of the Sobat and Atbara, and along the banks of the Blue Nile. But the climate is either too hot or too moist for colonization, and, with the doubtful exception of the Marrah uplands in Dar-Fur, there appear to be no districts in Anglo-Egyptian Sudan suitable for permanent European settlement. Experience, however, shows that with due precautions Europeans may reside in the country for a limited period with impunity.

Recent History.—It was probably no mere coincidence that the revolt of Arabi Pashi against the Khedivial Government in Egypt occurred in the same year, 1881, as the revolt of Mohammed Ahmed, the Mahdi ("Guided") against the same Government in Sudan. One took the form of a military outbreak, the other of a religious revival. But both were inspired by the same motives, even if they were not promoted by the same secret agencies. In any case, the Mahdist rising, by which Egypt was deprived of her Sudanese domain for sixteen years (1882–98), was admittedly a protest against the growth of European influences, by which the Mahommedan power in North-East Africa was being rapidly transformed to a civilized state based on liberal institutions, and not on the Moslem system of domestic slavery. By administrators such as Gordon, Lupton, and Gessi a deadly blow was being struck at the slave trade itself, in the maintenance of which the "Khartumers," that is, the Arabo-Nubian commercial classes, were deeply interested on mercenary even more than on religious grounds. But the astonishing success of the religious upheaval was also largely due both to the fanaticism of the Baggara and other Arab tribesmen, commonly called "Dervishes," and to the indifference and even open hostility of those half-subdued Nilotic Negro populations, such as the Shilluks, the Bari, and the Dinkas, who had suffered beyond endurance from the tyranny and exactions of the Egyptian officials, covert allies if not open abettors of the Arabo-Nubian slave dealers and raiders. The history of the military operations from 1881 to 1899, when the Anglo-Egyptian forces once more recovered the Sudan from the power of barbarism, is told under EGYPT, and it is not necessary here to repeat it.

After the reoccupation of Khartum, which was again made the seat of government, a proposal to raise £100,000 for the purpose of erecting a memorial to its heroic defender, General Gordon, on the spot, met with an enthusiastic response in England. It took the practical form of an educational establishment for the Sudanese natives, and the foundation stone of the Gordon College was laid by Lord Cromer in January 1900. At the same time provision was made for the future administration of the country by the agreement of 19th January 1899, which stipulates that a governor-general shall be appointed by Egypt with the assent of Great Britain. It was also stipulated that the British and Egyptian flags are to be used together, while special provision is made for the final suppression of the slave trade, and for the exclusion of arms, ammunition, and spirits from Anglo-Egyptian Sudan.

For administrative purposes the reconstituted territory is divided into four first-class districts—Omdurman, Sennaar, Kassala, and Fashoda; and three second-class districts—Assuan, Wady Halfa, and Suakin. These districts replace the former provinces of Dongola, Khartum, Suakin, Sennaar, Kordofan, Dar-Fur, Bahr-el-Ghazal, and the Equatorial Province with Fazogli. They have a collective area of 1,000,000 square miles, with a population reduced from about 10,000,000 before the Mahdist revolt to probably not more than 7,000,000 in 1900. Lord Kitchener was appointed first Governor-General in January 1899, and when summoned next year to cooperate with Field Marshal Lord Roberts in the war against the Boer States, was succeeded by the Sirdar, Colonel Sir Reginald Wingate. Henceforth the consuls appointed by foreign Powers are accredited to the British Government, which implies the abolition of the capitulations (local consular courts of justice) and the full recognition of the British suzerainty over the newly constituted dominion of Anglo-Egyptian Sudan.

Khartum, the restored capital, is now in railway and telegraphic communication with Cairo, from which it is distant about 1300 miles. Before the revolt it was the most flourishing city in North-East Africa south of Cairo, with a population estimated in 1884 at 70,000. From this point, at the confluence of the two Niles some distance above the Sixth Cataract, there is a clear waterway navigable by steamers of some size all the way to Duflé, some miles below Lake Albert, where the river is again obstructed by insurmountable rocky barriers. But the *sudd*, or floating masses of vegetation, by which the upper reaches about and above the Sobat confluence have been frequently blocked, was entirely cleared away after many months of hard work in 1900, and steps taken to prevent it from again accumulating. To the old caravan routes have thus been added two main lines of communication—the waterway from the Equator to the Mediterranean, and the railway from Egypt to Khartum, to be continued to the Great Lakes as the northern section of the already projected Cape-to-Cairo trunk line, running mainly through British territory in a north to south direction across the continent.

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French Sudan.

THE FRENCH SUDAN, since the decree of 18th October 1899, has been only a geographical expression, indicating a region whose outlines are not everywhere clearly traced. By that decree the region was, in fact, divided among the three colonies of Senegal, the Ivory Coast, and Guinea. Separate existence remains only to two military commands, intended to check the populations, but in this article the name recently in use is retained, that the geography and history of the whole country, which long had a distinct individuality, may be presented in one connected view. It was bounded on the west by Senegal, on the south-west by the Futa Jallon, on the south by British Guinea, the republic of Liberia, the French colony of the Ivory Coast, the British Gold Coast, and the hinterland of Dahomey. On the east it extended beyond the Niger and, in the region of Lake Chad, joined the French portion of the Congo basin. The French Sudan is, in short, the link connecting all the African possessions of the Third Republic. Its area is estimated at 400,000 square miles, but is probably greater. No trustworthy estimate of the numbers of the black population has been formed.

The territory, as a whole, consists of a great plateau of granite and sandstone, rarely more than 1600 feet high, and in its northern part, the Kaarta, assuming a desert aspect. No interesting orographic feature is presented. Hydrographically the western porton (Bambouk) belongs to the basin of the Senegal; the central, to that of the Niger, which is divided into three reaches—the upper Niger from Kardamania to the frontier of the Futa Jallon as far as Bammako, the middle Niger from Bammako to Bussa, and the lower Niger beyond Bussa. The points situated on the river are Komussa, Siguiri, Bammako, Ségu Sikoro, Sansanding, Kabara, Sinder, Say, and Fort Archinard. At Mopti the Niger receives the Mahel Babrel, which drains the country of Kong, and whose numerous arms uniting with offshoots from the Niger form in the flood season an immense lake. The lakes or widenings of the Niger itself occupy vast expanses of ground; Lake Deboe, the Lake of Hero, the Lake of Daouna, the Lake of Tole are all to the south or west of Timbuktu, and are permanent. The eastern part of the Sudan slopes towards the hollow of Lake Chad.

History.—The first French expedition into the heart of the country was undertaken in 1860, when General Faidherbe sent Lieutenant Maze and Dr Quintin to explore the zone to the east of the Senegal. The two travellers pushed on as far as Ségu Sikoro, then the capital of the sultanate of Ahmadu. In 1878 Soleillet renewed the visit. In 1879 Colonel Brière de l'Isle appointed two officers, Gallieni and Derrien, to investigate the route for a railway, and at the same time the post of Bafoulabé was constructed. The armed conquest began in 1880, and for more than fifteen years was carried on by Borgnise Desbordes, Gallieni, Frey, Archinard, Combes, and Bonnier. In 1881 the Niger was reached; the fort of Kita was erected to the east of Medine, to watch the region between the Senegal and the Joliba; the fort of Bammako above the latter river was built in 1883; a road was made, 400 miles of telegraph line laid down, and the work of railway construction began. The revolted population was crushed; Mahmadu Lamine was overthrown, while Ahmadu in the north of the Sudan and Samory in the south acknowledged the French protectorate, and Lieutenant Caron in a gunboat descended as far as Timbuktu (1886–89). The struggle was resumed in 1890: Ahmadu lost Ségu Sikoro and Konio Kary; then Nioro lost his capital of Kaarta (1891), 150 miles north of the Senegal; Jenné, near Mahel Babrel was taken in 1893. The war was prosecuted also in the south against Samory, who multiplied pretences, tried negotiation for the purpose of breaking his promises, shifted his empire to the states of Kong, and after numberless encounters was finally defeated on the Conally, to the north of Liberia, and was taken prisoner in September 1898. Timbuktu was occupied in 1894; Colonel Bonnier perished beneath its walls. In the meantime France had signed with Great Britain the convention of 5th August 1890, which bounded the French possessions on the south by a line running from Say on the Niger to Barrawa on Lake Chad; and this convention was supplemented by another on 14th June 1898 (see also NIGERIA).

Trade, &c.—Gum is produced in the northern districts, including Kaarta; the quantity dealt with at Timbuktu, Medine, and Nioro in 1898 exceeded 2000 tons. Gold is found in the basin of the Falemé and of the Tankisso. Caoutchouc is produced in the bend of the Niger and in the Wassulu. Bissandugu is the centre of its exploitation. The natives cultivate millet, rice, and wheat; the earth-nut is grown round Kayes. In 1898 the commerce reached £580,000 sterling, of which £432,000 was for imports. The imports from France amounted to about £160,000, chiefly for cotton goods, which form also the base of the import trade from India. The trade routes run westwards through Senegal, northwards through Taoudeni and Morocco, by In Salah and El Goléa, southwards through French and British Guinea.

The railway from Kayes to Bammako, begun in 1881, has only reached a length of 110 miles, and will scarcely be finished before 1906. The Sudan hitherto has been set down in the budget of France for about £300,000 a year. The troops in the colony in 1898 were 154 officers and 3410 men.

The centres of population are Kayes (8000), on the Senegal, 560 miles from St Louis, the capital of the colony up to 1899; Bafulabé, at the confluence of the Dakhar and the Bafing (2900 inhabitants); Bammako, on the Niger; Bissandugu, formerly Samory's capital, a military station with 20,000 inhabitants; Kankan, a military station (3000), 36 miles north of Bissandugu; Kita (3000), a station on the track from Kayes to the Niger; Jenné (8000); Medine (1500), connected by railway with Kayes; Ségu Sikoro; Timbuktu (12,000), an important market, and the head of the caravan line.

See GAFFAREL. *Senegal et Soudan Français.* Paris, 1890.—GALLIENI. *Deux Campagnes au Soudan.* Paris, 1890.—MOUNIER. *La France Noire.* Paris, 1894.—BINGER. *Les Routes Commerciales du Soudan.* (P. L.)

Sudd is the name given to the vegetable obstruction which has at various dates closed the upper waters of the Nile to navigation. It seems to have stopped the Roman centurions whom Nero sent to explore the Nile. In modern times attention was first drawn to its existence by Sir Samuel Baker, who found his efforts to suppress the slave trade in the Sudan seriously hampered by the impossibility of maintaining a service of steamers between Gondokoro and Khartum (see *Ency. Brit.,* vol. xvii. p. 506). Down to 1863 the two branches of the White Nile, the Bahr al-Jebel and the Bahr al-Zeráf, had been navigable within the memory of man. But in that year both were blocked above their junction at Lake No by an accumulation of vegetable flotsam. When Baker proceeded to Gondokoro in 1870 he thus described the increase that neglect had caused in the obstruction:—"The immense number of floating islands that were constantly passing down the stream of the White Nile had no exit; thus they were sucked under the original obstruction by the force of the stream, which passed through some mysterious channel, until the subterranean passage became choked with a wondrous accumulation of vegetable matter. The entire river became a marsh, through which, by the great pressure of water, the stream oozed through innumerable small channels. In fact, the White Nile had disappeared." Baker, who had to cut through fifty miles of sudd in his passage to Gondokoro, urged the Khedive to reopen the Nile. This work was efficiently done by Ismail Ayub Pasha, and the White Nile was clear for large vessels when Gordon reached Khartum in 1874. The importance of the work was clear: "It would be quite useless to annex and attempt to civilize Central Africa," wrote Baker, "unless a free communication existed with the outer world by which a commercial channel could be opened." But the obstruction was always ready to reappear. In 1878 Emin Pasha was unable to ascend the Bahr al-Jebel from the south on account of the sudd. It was cleared in 1879–80 by an Italian in the Egyptian service, but had again accumulated in 1884. The rise of Mahdism and the consequent closing of the Sudan caused the river to be completely neglected, and in 1895 the Egyptian Intelligence Department received a report that the White Nile was completely blocked above Lake No. This proved to be the case. The closing of the upper waters of the Nile not only hampered communication with Central Africa; it was also believed to diminish the supply of fertilizing water on which the whole life of Egypt depended. The unprecedented failure of the Nile flood in 1899–1900 drew general attention to the sudd, which was thought by some to be responsible for it, and in the former year £(E)10,000 were placed at the disposal of the Governor-General of the Sudan for the purpose of reopening the White Nile, by removing the great mass of weed which blocked the Bahr al-Jebel almost from Lake No to Shambeh. The work was begun, under the direction of Sir William Garstin, in December 1899. "The primary object of this measure," he wrote, "is to open the Bahr al-Jebel to navigation, and to permit an examination of the river and the surrounding swamps. When this examination has been made, it will be possible to study the feasibility of closing off all the spill-channels which wander through the marshes, and, by confining the river in one single stream, prevent the present ruinous waste of water." Little or nothing was then known of the real effect of the sudd on the discharge of the Lower Nile. In 1900 the greater part of the sudd was successfully removed by the exertions of Major Peake, and navigation was reopened from Khartum to Rejaf. Some of the blocks of sudd removed were a mile long and 15 to 20 feet thick; underneath them the river passed with a high velocity. The work was harder than had been expected: "Instead of the sudd being, as had been supposed, a tangle of weed floating on the water and descending a few feet below the surface, it proved in most cases to be a mass of decayed vegetation, papyrus roots, and earth, much resembling peat in its consistency, and compressed into such solidity by the force of the current that men could walk over it everywhere, and even elephants could in places cross it without danger." The surface was first burnt; then trenches were cut dividing the sudd into blocks 10 feet square, and each of these was hauled out with wire hawsers and chains by gunboats working from below. Two portions of the Bahr al-Jebel, which were still blocked in 1900, were cleared in 1901–02 at an additional expense of £(E)4000, and the sudd is now practically abolished on the whole course of the White Nile. In some parts of the channel constant patrolling and inspection will be necessary to prevent it from accumulating again, and the permanent maintenance of the channel by piling, planting willows, &c., requires very serious study. The pressure of the sudd on vessels enclosed within it has been compared, both by Sir Samuel Baker and Sir William Garstin, to what Arctic travellers relate of "the motion of the ice-floes when the pack is breaking up." It is mainly caused by large masses of papyrus and *omm súf* reeds, which are loosened by storms, and drift down until they lodge on some obstruction and form a dam across the channel, rapidly converted by fresh arrivals into a block that may be as much as 25 miles in length. In time the whole river is blotted out, as Baker found it. It is still doubtful whether the removal of the sudd has been of any practical benefit to the Egyptian cultivator; but Sir William Garstin is of opinion, from personal observation of the sudd, "that its removal undoubtedly checked the fall in the river levels which would otherwise have taken place, owing to the extra supply brought down by the removal of each successive block." However that may be, the removal of the sudd, by opening up the water-way to the equatorial provinces, is certainly not among the least benefits which British enterprise has already brought to the Sudan.

See *Ismailia*, by Sir SAMUEL W. BAKER (1874).—*Parliamentary Papers:* Egypt, No. 5 (1899); Egypt, No. 1 (1900); Egypt, Nos. 1 and 2 (1901); Egypt, No. 1 (1902).

(W. E. G. F.)

Sudja, a district town of Russia, in the government of Kursk, connected by a narrow-gauge railway (40 miles) with the main railway system at Rylsk. It was founded in the 17th century, and had in 1897 12,856 inhabitants. It has several potteries and a few tanneries, and does a considerable trade in grain, horses, cattle, and wooden ware.

Sueca, a town of Spain, in the province of Valencia, on the left bank of the river Yucar, near the sea, to the west of the sierra of Cullera. It has a station on the Silla–Cullera railway. Its population was 13,613 in 1887, and 13,949 in 1897. The town has regular, modern streets, with fine houses and large squares well paved. The most remarkable buildings are the town hall, theatre, hospital, parish church, and some hermitages. It is in a well-watered, fertile district, of which the fruit and agricultural products form the almost exclusive staple of the trade of Sueca.

Suffolk, one of the eastern counties of England, bounded on the E. by the North Sea, on the S. by Essex, on the W. by Cambridgeshire, and on the N. by Norfolk.

Area and Population.—In 1901 the area of the ancient (geographical) county was 952,709 acres, and in 1891 the population was 371,235, of whom 180,441 were males and 190,794 females, and in 1901, 384,198, showing an increase of 12,963 since 1891, or at the rate of 3·5 per cent. between 1891 and 1901, as compared with an increase of 3·7 per cent. during the ten years 1881–91 and an increase of 5·8 per cent. during 1871–81. The 1901 returns give 0·4 persons to an acre and 2·58 acres to a person. In 1891 the area of the registration county was 931,134 acres, and the population 353,758, of whom 172,067 were males and 181,691 females, and in 1901 was 361,856. Particulars of the birth-rate, death-rate, and the number of persons married per 1000 inhabitants, as well as the percentage of illegitimate births, are given in the accompanying table:—

	1871–80.	1881–90.	1889–98.	1899.
Birth-rate . .	32·1	31·1	28·3	26·5
Death-rate . .	18·8	17·3	16·7	16·1
Illegitimacy-rate .	62	57	55	59
Marriage-rate .	13·8	13·0	13·3	14·2

In 1891 the county contained 1001 persons of Scottish birth, 934 of Irish birth, and 474 foreigners. At the same date there were 356 blind, 196 deaf and dumb, and 1266 insane.

Government, &c.—For parliamentary purposes the ancient county is divided into five divisions, each returning one member (Northern or Lowestoft, North-Eastern or Eye, North-Western or Stowmarket, South or Sudbury, South-Eastern or Woodbridge), the borough of Bury St Edmunds, returning one member; the borough of Ipswich, returning two members; and part of the borough of Great Yarmouth. For administration purposes Suffolk is divided into the two counties East Suffolk and West Suffolk, together with the county borough of Ipswich and part of the county borough of Great Yarmouth. The administrative counties embrace the eight municipal boroughs of Aldeburgh, Beccles, Bury St Edmunds, Eye, Ipswich, Lowestoft, Southwold, and Sudbury. There is one court of quarter sessions for the two administrative counties, which is usually held at Ipswich for East Suffolk, and then by adjournment at Bury St Edmunds for West Suffolk. East Suffolk is divided into eleven and West Suffolk into nine petty sessional divisions. The boroughs of Bury St Edmunds, Ipswich, Sudbury, Eye, and Southwold have separate commissions of the peace, and the three first-named have also separate courts of quarter sessions. The administrative county of East Suffolk contains 318, that of West Suffolk 176, and the county borough 14, entire civil parishes; there are besides 6 parishes which are partly in the county borough and partly in the administrative county of East Suffolk, and 6 which are partly in West Suffolk and other administrative counties. The ancient county of Suffolk contains 448 entire ecclesiastical parishes and districts, and parts of 15 others; it is situated partly in the diocese of Ely and partly in the diocese of Norwich.

Education.—On 31st August 1900 the number of elementary schools was 424, namely, 103 board schools and 321 voluntary schools; the latter including 309 National Church of England schools, 1 Wesleyan, 3 Roman Catholic, and 11 "British and other." The average attendance during the year was 47,136 out of a total of 56,719 on the register. The total school board receipts during the year were £77,862, of which £248 were earnings under the Technical Instruction Act and £2394 earnings under the Agricultural Rates Act.

Agriculture.—From 1885 to 1895 the general tendency was towards a decrease in the area of corn crops and green crops, with an increase in the area of pasture and hay, but since 1895 there has been a reversal of the process. In 1889, 594,491 acres were farmed by tenants, in 1895, 576,255 acres, and in 1900, 581,266 acres; the areas farmed by owners were 179,079 acres in 1900, 192,882 in 1895, and 184,605 in 1889. The annual rainfall averages 23 inches only; that is, 13 inches less than the average for all England.

The table immediately following shows the areas under the different kinds of crops at the periods named:—

Year.	Area in Cultivation.	Area under Corn Crops.	Area under Green Crops.	Area of Bare Fallow.	Area under Permanent Grass.
1885	781,860	369,931	124,684	28,151	171,727
1890	777,370	359,510	111,737	32,625	181,451
1895	769,137	330,459	104,494	34,720	188,020
1900	760,345	337,438	114,012	20,463	180,712

The next table shows the number of the live-stock at the periods named:—

Year.	Cows and Heifers.	Other Cattle.	Total Cattle.	Horses.	Sheep.	Pigs.
1885	22,805	47,302	70,107	42,807	447,058	135,525
1890	22,802	47,624	70,426	41,248	427,750	147,543
1895	22,631	43,871	66,502	42,259	387,590	167,521
1900	25,530	52,896	78,426	42,101	433,013	149,030

Industries.—In the year 1897, 22,794 persons were employed in the factories and workshops of the county, 6004 being employed in the clothing trades, 5279 in making machinery, implements, &c., 1355 in the paper and printing trades, and 1281 in the wood industries. Fishing at Lowestoft is growing in importance. The chief quarry products are clay and chalk; of the former 67,249 tons were extracted in 1900, and of the latter 14,366 tons.

AUTHORITIES.—H. W. ALDRED. *History of Suffolk.* London, 1888.—Rev. A. JESSOPP. *Arcady.* London, 1887.—P. H. EMERSON. *Pictures of East Anglian Life*, London (1888), and other works; and the works of the poet CRABBE.

SUGAR, AND SUGAR MANUFACTURE.

Commercial value of sugar-canes.

THE value of sugar-canes at a given plantation or central factory would at first sight appear to vary directly as the amount of saccharine contained in the juice expressed from them varies, and if canes with juice indicating 9° Beaumé be made a basis of value or worth, say at 10s. per ton, then canes with juice indicating

in degrees Beaumé	10°	9°	8°	7°	6°
and containing in sugar	18·05%	16·23%	14·42%	12·61%	10·80%
would be worth per ton	11/1¼	10/-	8/10½	7/9¼	6/8

But this is not an accurate statement of the commercial value of sugar-canes—that is, of their value for the production of sugar to the planter or manufacturer—because a properly equipped and balanced factory, capable of making 100 tons of sugar per day, for 100 days' crop, from canes giving juice of 9° B., or say 10,000 tons of sugar, at an aggregate expenditure for manufacture (*i.e.*, the annual cost of running the factory) of £3 per ton, or £30,000 per annum, will not be able to make as much sugar per day with canes giving juice of 8° B., and will make still less if they yield juice of only 6° B. In practice, the expenses of upkeep for the year and of manufacturing the crop remain the same whether the canes are rich or poor and whether the crop is good or bad, the power of the factory being limited by its power of evaporation. For example, a factory able to evaporate 622 tons of water in 24 hours could treat 1000 tons of canes yielding juice of 9° B., and make therefrom 100 tons of sugar in that time; but this same factory, if supplied with canes giving juice of 6° B., could not treat more than 935 tons of canes in 24 hours, and would only make therefrom 62·2 tons of sugar.

The following table may be useful to planters and central factory owners. It shows the comparative results of working with juice of the degrees of density mentioned above, under the conditions described, for one day of 24 hours, and the real value, as raw material for manufacture, of cane giving juice of 6° B. to 10° B., with their apparent value based solely on the percentage of sugar in the juice. The canes in each case are assumed to contain 88 per cent. of juice and 12 per cent. of fibre, and the extraction by milling to be 75 per cent. of the weight of canes—the evaporative power of the factory being equal to 622 tons per 24 hours. The factory expenses are taken at £30,000 per annum, or £3 per ton on a crop of 10,000 tons (the sugar to cost £8 per ton all told at the factory)—equivalent to £300 per day for the 100 working days of crop time. But it is obvious that it would not pay a planter to sell canes at 4s. 2¾d. a ton instead of at 10s. a ton, any more than it would pay a factory to make only 62·2 tons of sugar in 24 hours, or 6220 tons in the crop of 100 days, instead of 10,000 tons. Hence arises the imperative necessity of good cultivation by the planter, and of circumspection in the purchase and acceptance of canes on the part of the manufacturer.

Degrees Beaumé.	6°	7°	8°	9°	10°
Tons of canes crushed per day	935·6	956·2	977·4	1000	1023·8
Tons of juice expressed . . .	701·7	717·2	733·1	750	767·9
Tons of water evaporated . .	622	622	622	622	622
Tons of 1st Massecuite . . .	79·7	95·2	11·11	128	145·9
Tons sugar of all classes recovered . . .	62·2	74·3	86·7	100	114·0
Total output of sugar in 100 days. Tons .	6220	7430	8670	10,000	11,400
Total value of all sugars per day at £8 per ton .	£497, 6/-	£594, 4/-	£693, 6/-	£800	£912
Less factory expenses per day.	£300	£300	£300	£300	£300
Leaves for canes crushed . . .	£197, 6/-	£294, 4/-	£393, 6/-	£500	£612
Real value of canes per ton .	4/2¾	6/2	8/-	10/-	11/11½
Apparent value (see preceding Table) . . .	6/8	7/9¼	8/10½	10/-	11/1¼

The details of manufacture of sugar from canes and of sugar from beetroots differ, but there are five operations in the production of the sugar of commerce from either material which are common to both processes. These are :—

1. The extraction of the juice.
2. The purification or defecation of the juice.
3. The evaporation of the juice to syrup point.
4. The concentration and crystallization of the syrup.
5. The curing or preparation of the crystals for the market by separating the molasses from them.

Cane Sugar Manufacture.

Extraction by pressure.

Extraction of Juice.—The juice is extracted from canes by squeezing them between rollers, *i.e.*, by crushing and pressure. In India at the present day there are thousands of small mills worked by hand, through which the peasant cultivators pass their canes two or three at a time, squeezing them a little, and extracting perhaps a fourth of their weight in juice, from which they make a substance resembling a dirty sweetmeat rather than sugar. In Barbados there are still many estates making good Mascabado sugar ; but as the juice is extracted from the canes by windmills, and then concentrated in open kettles heated by direct fire, the financial results are disastrous, since nearly half the yield obtainable from the canes is lost. In the best organized modern cane sugar estates as much as 12½ per cent. of the weight of the canes treated is obtained in crystal sugar of high polarizing power, although in Louisiana, where cultivation and manufacture are alike most carefully and admirably carried out, the yield in sugar is only about 7 per cent. of the weight of the canes, and sometimes, but seldom, as much as 9 per cent. This is due to conditions of climate, which are much less favourable for the formation of saccharine in the canes than in Cuba. The protection afforded to the planters by their Government, however, enables them to pursue the industry with considerable profit, notwithstanding the poor return for their labour in saleable produce. As an instance of the influence of climatic conditions combined with high cultivation the cane lands of the Sandwich Islands may be cited. Here the tropical heat is tempered by constant trade winds, there is perfect immunity from hurricanes, the soil is peculiarly suited for cane-growing, and by the use of specially-prepared fertilizers and an ample supply of water at command for irrigation the land yields from 50 to 90 tons of canes per acre, from which from 12 to 14 per cent. of sugar is produced. To secure this marvellous return, with an annual rainfall of 26 inches, as much as 52,000,000 gallons of water are pumped per 24 hours from artesian wells on one estate alone. When the great dam at Assuan is completed and an inexhaustible supply of irrigation water obtainable, there is no reason why the lands in Upper Egypt, if scientifically cultivated and managed, should not yield as abundantly as those in the Sandwich Islands.

In the Paris Exhibition of 1900 a cane-crushing mill was shown with three rollers 32 inches in diameter by 60 inches long. It is driven by a powerful engine through triple gearing of 42 to 1, and speeded to have a surface velocity of rollers of 15 feet 9 inches per minute. This mill is guaranteed to crush thoroughly and efficiently from 250 to 300 tons of canes in 24 hours. In Louisiana two mills, set one behind the other, each with three rollers 32 inches in diameter by 78 inches long, and driven by one engine through gearing of 15 to 1, are speeded to have a surface velocity of rollers of 25 feet 6 inches per minute (or 60 per cent. more than that of the French mill described above), and they are efficiently crushing 900 to 1200 tons of canes in 24 hours. In Australia, Demerara, Cuba, Java, and Peru *double crushing* and *maceration* (first used on a commercial scale in Demerara by the late Hon. William Russell) have been generally adopted; and in many places, especially in the Sandwich Islands, *triple crushing* (*i.e.*, passing the canes through three consecutive sets of rollers, in order to extract everything possible of extraction by pressure) is employed. In the south of Spain, in some favoured spots where sugar-canes can be grown, they are submitted even to four successive crushings.

It has been found in practice advantageous to prepare the canes for crushing in the mills, as above described, by passing them through a pair of preparing rolls which are grooved or indented in such manner as to draw in and flatten down the canes, no matter in which way they are thrown or heaped upon the cane-carrier, and thus prepare them for feeding the first mill of the series; thus the work of crushing is carried on uninterruptedly and without constant stoppages from the mills choking, as is often the case when the feed is heavy and the canes are not prepared.

Although it cannot be said that any one system of extraction is the best for all places, yet the following considerations are of general application:—

Yield from crushing.

(*a*) Whatever pressure be brought to bear upon it, the vegetable or woody fibre of crushed sugar-canes will hold and retain *for the moment* a quantity of moisture equal to its own weight, and in practice 10 per cent. more than its own weight; or in other words, 100 ℔ of the best crushed megass will consist of 47·62 ℔ of fibre and 52·38 ℔ of moisture—that is, water with sugar in solution, or juice.

(*b*) Canes vary very much in respect of the quality and also as to the quantity of the juice they contain. The quantity of the juice is the test to which recourse must be had in judging the efficiency of the extraction, while the quality is the main factor to be taken into account with regard to the results of subsequent manufacture.

For the application of the foregoing considerations to practice, the subjoined table has been prepared. It shows the greatest quantity of juice that may be expressed from canes, according to the different proportions of fibre they contain, but without employing maceration or imbibition, to which processes reference is made hereafter. The percentages are percentages of the original weight of the uncrushed canes.

	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Percentage of fibre in canes . . .	10	11	12	13	14	15
Percentage of juice in canes . . .	90	89	88	87	86	85
Percentage of juice retained in megass	10	11	12	13	14	15
Percentage of maximum expression .	80	78	76	74	72	70
Percentage of best average expression, in practice .	79	76·9	74·9	72·9	70·6	68·5
Percentage of juice left in megass, in practice .	11	12·1	13·2	14·3	15·4	16·5

The British Guiana Planters' Association appointed a sub-committee to report to the West India Commission on the manufacture of sugar, who stated the following:—

With canes containing 12 per cent. fibre the following percentages of sugar are extracted from the canes in the form of juice:—

Single crushing	76 per cent.
Double crushing	85 ,,
Double crushing with 12 % dilution .	88 ,,
Triple crushing with 10 % dilution . .	90 ,,
Diffusion with 25 % dilution	94 ,,

These results are equivalent to

66·88 % extraction for single crushing.
74·80 % ,, ,, double crushing.
77·44 % ,, ,, double crushing with 12 % dilution.
79·20 % ,, ,, triple ,, ,, 10 % ,,
82·72 % ,, ,, diffusion with ,, 25 % ,,

Maceration or imbibition.

To prevent the serious loss of juice left in the megass by even the best double and triple crushing, maceration or imbibition was introduced. The megass coming from the first mill was saturated with steam and water, in weight equal to between 20 per cent. and 30 per cent. and up to 40 per cent. of the original weight of the uncrushed canes. Consequently, after the last crushing the mixture retained by the residual megass was not juice, as was the case when crushing was employed without maceration, but juice mixed with water; and it was found that the loss in juice was reduced by one-half. A further saving of juice was sometimes possible if the market prices of sugar were such as to compensate for the cost of evaporating an increased quantity of added water, but a limit was imposed by the fact that water might be used in excess. Hence in the latest designs for large factories it has been proposed that as much normal juice as can be extracted by double crushing only shall be treated by itself, and that the megass shall then be soused with twice as much water as there is juice remaining in it; after which, on being subjected to a third crushing, it will yield a degraded juice, which would also be treated by itself. It is found that in reducing the juice of these two qualities to syrup, fit to pass to the vacuum pans for cooking to crystals, the total amount of evaporation from the degraded juice is about half that required from the normal juice produced by double crushing.

Mechanical improvements.

Great improvements have been made in the means of feeding the mills with canes by doing away with hand labour and substituting mechanical feeders or rakes, which by means of a simple steam-driven mechanism will rake the canes from the cane waggons on to the cane-carriers. By the adoption of this system in one large plantation in the West Indies, crushing upwards of 1200 tons of canes per day, the labour of sixty-four hands was dispensed with, and was thus made available for employment in the fields. In Louisiana the use of mechanical feeders is almost universal.

With a view of safeguarding themselves from breakdowns caused by the inequality of feeding, or by the action of malicious persons introducing foreign substances, such as crowbars, bolts, &c., among the canes, and so into the mills, many planters have adopted so-called hydraulic attachments, applied either to the megass roll or the top roll bearings. These attachments, first invented by Jeremiah Howard, and described in the *United States Patent Journal* in 1858, are simply hydraulic rams fitted into the side or top caps of the mill, and pressing against the side or top brasses in such a manner as to allow the side or top roll to move away from the other rolls, while an accumulator, weighted to any desired extent, keeps a constant pressure on each of the rams. An objection to the top cap arrangement is, that if the volume or feed is large enough to lift the top roll from the cane roll, it will simultaneously lift it from the megass roll, so that the megass will not be as well pressed as it ought to be; and an objection to the side cap arrangement on the megass roll as well as to the top cap arrangement is, that in case more canes are fed in at one end of the rolls than at the other, the roll will be pushed out farther at one end than at the other; and though it may thus avoid a breakdown of the rolls, it is apt, in so doing, to break the ends off the teeth of the crown wheels by putting them out of line with one another. The toggle-joint attachment, which is an extremely ingenious way of attaining the same end as the hydraulic attachments, is open to the same objections.

Extraction by diffusion.

Extraction of cane juice by diffusion (a process more fully described under the head of beetroot sugar manufacture) is adopted in a few plantations in Java and Cuba, in Louisiana and the Sandwich Islands, and in one or two factories in Egypt; but hitherto, except under exceptional conditions (as at Aska, in the Madras Presidency, where the local price for sugar is three or four times the London price), it would not seem to offer any substantial advantage over double or triple crushing. With the latter system practically as much sugar is obtained from the canes as by diffusion, and the resulting megass furnishes, in a well-appointed factory, sufficient fuel for the crop. With diffusion, however, in addition to the strict scientific control necessary to secure the benefits of the process, fuel—that is, coal or wood—has to be provided for the working off of the crop, since the spent chips or slices from the diffusers are useless for this purpose; although it is true that in some plantations the spent chips have to a certain extent been utilized as fuel by mixing them with a portion of the molasses, which otherwise would have been sold or converted into rum. The best results from extraction by diffusion have been obtained in Java, where there is an abundance of clear, good water; but in the Sandwich Islands, and in Cuba and Demerara, diffusion has been abandoned on several well mounted estates and replaced by double and triple crushing; and it is not likely to be resorted to again, as the extra cost of working is not compensated by the slight increase of sugar produced. In Louisiana diffusion is successfully worked on two or three large estates; but the general body of planters are shy of using it, although there is no lack of water, the Mississippi being near at hand.

Purification.—The second operation is the coagulation of the albumen, and the separation of it with other impurities from the juice which holds them in suspension or solution. The moment the juice is expelled from the cells of the canes chemical inversion commences, and the sooner it is stopped the better. This is effected by the addition of lime to neutralize the free acid. As cold juice has a greater affinity for lime than hot juice, it is best to treat the juice with lime when cold. This is easily done in liming or measuring tanks of known capacity, into which the juice is run from the mill. The requisite amount of milk of lime set up at 10° Beaumé is then added. Cream of lime of 17° Beaumé is sometimes used, but the weaker solution is preferable, since the proper proportion is more easily adjusted. In Demerara and other places the juice is then heated under pressure up to 220° F. to 250° F. for a few moments, on its way to a steam and juice separator, where the steam due to the superheated juice flashes off, and is either utilized for aiding the steam supplied to the multiple effect evaporators, or for heating cold juice on its way to the main heater, or it is allowed to escape into the atmosphere. The boiling juice is run down into subsiding

Subsiding tanks.

tanks, where it cools, and at the same time the albumen, which has been suddenly coagulated by momentary exposure to high temperature, falls to the bottom of the tank, carrying with it the vegetable and other matters which were in suspension in the juice. After reposing some time, the clear juice is carefully decanted by means of a pipe fixed by a swivel joint to an outlet in the bottom of the tank, the upper end of the pipe being always kept at the surface of the liquor by a float attached to it. Thus clear liquor alone is run off, and the mud and cloudy liquor at the bottom of the tank are left undisturbed, and discharged separately as required.

Continuous juice separator.

In Australia a continuous juice separator is generally used, and preferred to ordinary subsiding or filtering tanks. It is a cylindrical vessel about 6 feet deep, fitted with a conical bottom of about the same depth. Such a vessel is conveniently made of a diameter which will give the cylindrical portion sufficient capacity to hold the juice expressed from the cane-mill in one hour. The hot liquor is conducted downwards in a continuous steady stream by a central pipe to eight horizontal branches, from which it issues into the separator at the level of the junction of the cylindrical and conical portions of the vessel. Since the specific gravity of hot liquor is less than that of cold liquor, and since the specific gravity of the scum and particles of solid matter in suspension varies so slightly with the temperature that practically it remains constant, the hot liquor rises to the top of the vessel, and the scums and particles of solid matter in suspension separate themselves from it and fall to the bottom. By the mode of admission the hot liquor at its entry is distributed over a large area relatively to its volume, and while this is necessarily effected with but little disturbance to the contents of the vessel, a very slow velocity is ensured for the current of ascending juice. In a continuous separator, of which the cylindrical portion measures 13 feet in diameter and 6 feet deep (a suitable size for treating a juice supply of 4000 to 4500 gallons per hour), the upward current will have a velocity of about 1 inch per minute, and it is found that all the impurities have thus ample time to separate themselves. The clear juice when it arrives at the top of the separator flows slowly over the level edges of a cross canal and passes in a continuous stream to the service tanks of the evaporators or vacuum pan. The sloping sides of the conical bottom can be freed from the coating of scum which forms upon them every two or three hours by two rotatory scrapers, formed of L-irons, which can be slowly turned by an attendant by means of a central shaft provided with a suitable handle. The scums then settle down to the bottom of the cone, whence they are run off to the scum tank. Every twenty-four hours or so the flow of juice may be conveniently stopped, and, after all the impurities have subsided, the superincumbent clear liquor may be decanted by a cock placed at the side of the cone for the purpose, and the vessel may be washed out. These separators are carefully protected by non-conducting cement and wood lagging, and are closed at the top to prevent loss of heat; and they will run for many hours without requiring to be changed, the duration of the run depending on the quality of the liquor treated and amount of impurities therein. Smaller separators of the same construction are used for the treatment of syrup.

Double-bottomed defecators.

In Cuba, Martinique, Peru, and elsewhere the old-fashioned double-bottomed defecator is used, into which the juice is run direct, and there limed and heated. This defecator is made with a hemispherical copper bottom, placed in an outer cast-iron casing, which forms a steam jacket, and is fitted with a cylindrical curb or breast above the bottom. If double-bottomed defecators are used in sufficient number to allow an hour and a half to two hours for making each defecation, and if they are of a size which permits any one of them to be filled up by the cane-mill with juice in ten to twelve minutes, they will make as perfect a defecation as is obtainable by any known system; but their employment involves the expenditure of much high-pressure steam (as exhaust steam will not heat the juice quickly enough through the small surface of the hemispherical inner bottom), and also the use of filter presses for treating the scums. A great deal of skilled superintendence is also required, and first cost is comparatively large. When a sufficient number are not available for a two hours' defecation, it is the practice in some factories to skim off the scums that rise to the top, and then boil up the juice for a few minutes and skim again, and, after repeating the operation once or twice, to run off the juice to separators or subsiders of any of the kinds previously described. In Java and Mauritius, where very clean canes are grown, double-bottomed defecators are generally used, and to them, perhaps as much as to the quality of the canes, may be attributed the very strong, fine sugars made in those islands. They are also employed in Egypt, being remnants of the plant used in the days when the juice passed through bone-black before going to the evaporators.

Continuous defecation.

A modification of the system of double-bottom defecators has lately been introduced with considerable success in St Domingo and in Cuba, by which a continuous and steady discharge of clear defecated juice is obtained on the one hand, and on the other a comparatively hard dry cake of scum or cachaza, and without the use of filter presses. These results are brought about by adding to the cold juice as it comes from the mill the proper proportion of milk of lime set up at 8° B., and then delivering the limed juice in a constant steady stream as near the bottom of the defecator as possible; it is thus brought into immediate contact with the heating surface, and heated once for all before it ascends, with the result of avoiding the disturbance caused in the ordinary defecator by pouring cold juice from above on to the surface of the heated juice, and so establishing down-currents of cold juice and up-currents of hot juice. In the centre of the defecator an open-topped cylindrical vessel is placed, with its bottom about 6 inches above the bottom of the defecator and its top about 12 inches below the top of the defecator. In this vessel is placed the short leg of a draw-off syphon, reaching to nearly the bottom. The action of the moderate heat, 210° F., on the limed juice causes the albumen in it to coagulate; this rising to the surface collects the cachazas, which form and float thereon. The clear juice in the meantime flows over the edge of the cylindrical vessel without disturbance and finds its way out by the short leg of the syphon, and so passes to the canal for collecting the defecated juice. The admission of steam must be regulated with the greatest nicety, so as to maintain an equable temperature, 208° to 210° F., hot enough to act upon the albumen and yet not enough to cause ebullition or disturbance in the juice, and so prevent a proper separation of the cachazas. This is attained by the aid of a copper pipe, 4 inches in diameter, which follows the curve of the hemispherical bottom, and is fitted from one side to the other of the defecator; one end is entirely closed, and the other is connected by a small pipe to a shallow circular vessel outside the defecator, covered with an indiarubber diaphragm, to the centre of which is attached a light rod actuating a steam throttle-valve, and capable of being adjusted as to length, &c. The copper pipe and circular vessel are filled with cold water, which on becoming heated by the surrounding juice expands, and so forces up the indiarubber diaphragm and shuts off the steam. By adjusting the length of the connecting rod and the amount of water in the vessel, the amount of steam admitted can be regulated to a nicety. To make this apparatus more perfectly automatic, an arrangement for continually adding to and mixing with the juice the proper proportion of milk of lime has been adapted to it; and although it may be objected that once the proportion has been determined no allowance is made for the variation in the quality of the juice coming from the mill owing to the variations that may occur in the canes fed into the mills, it is obviously as easy to vary the proportion with the automatic arrangement from time to time as it is to vary it in each separate defecation, if the man in charge will take the trouble to do so, which he very seldom does with the ordinary defecators, satisfying himself with testing the juice once or twice in a watch. The scums forming on the top of the continuous defecator become so hard and dry that they have to be removed from time to time with a specially constructed instrument like a flat spade with three flat prongs in front. These scums are not worth passing through the filter presses, and are sent to the fields direct as manure.

Treatment of the scums.

The scums separated from the juice by ordinary defecation entangle and carry away with them a certain amount of the juice with its contained saccharine. In some factories they are collected in suitable tanks, and steam is blown into them, which further coagulates the albuminous particles. These in their upward passage to the top, where they float, free themselves from the juice, which they leave below them comparatively clear. The juice is then drawn off and pumped up to one of the double-bottomed defecators and redefecated, or, where juice-heaters have been used instead of defecators, the scums from the separators or subsiders are heated and forced through filter presses, the juice expressed going to the evaporators and the scum cakes formed in the filter presses to the fields as manure.

In diffusion plants the milk of lime is added, in proper proportion, in the cells of the diffusion battery, and the chips or slices themselves act as a mechanical filter for the juice; while in the Sandwich Islands coral-sand filters have been employed for some years, in addition to the chips, to free the juice from impurities held in mechanical suspension. In Germany very similar filters have also been used, pearl-quartz gravel taking the place of coral sand, which it closely resembles. In Mexico filters filled with dry powdered megass have been found very efficient for removing the large quantity of impurities contained in the juice expressed from the very vigorous but rank canes grown in that wonderfully fertile country, but unless constant care is taken in managing them, and in changing them at the proper time, there is great risk of inversion taking place, with consequent loss of sugar.

After the juice has been defecated or purified by any of the means above mentioned it is sent to the evaporating apparatus, hereinafter described, where it is concentrated to 26° or 28°

Beaumé, and is then conducted in a continuous stream either into the service tanks of the vacuum pan, if dark sugars are required, or, if a better colour is wanted, into clarifiers. The latter are circular or rectangular vessels, holding from 500 to 1500 gallons each, according to the capacity of the factory, and fitted with steam coils at the bottom and skimming troughs at the top. In them the syrup is quickly brought up to the boil and skimmed for about five minutes, when it is run off to the service tanks of the vacuum pans. The heat at which the syrup boils in the clarifiers, 220° F., has the property of separating a great deal of the gum still remaining in it, and thus cleansing the solution of sugar and water for crystallization in the vacuum pans; and if after skimming the syrup is run into separators or subsiders of any description, and allowed to settle down and cool before being drawn into the vacuum pan for crystallization, this cleansing process will be more thorough, and the quality of the final product will be improved. Whether the improvement will be profitable or not to the planter or manufacturer depends on the market for the sugar, and on the conditions of foreign tariffs, which are not infrequently hostile.

Evaporation of the Juice to Syrup.—The third operation is the concentration of the approximately pure, but thin and watery, juice to syrup point, by driving off a portion of the water in vapour through some system of heating and evaporation. Since on an average 70 per cent. by measurement of the normal defecated cane juice has to be evaporated in order to reduce it to syrup ready for final concentration and crystallization in the vacuum pan, and since to attain the same end as much as 90 to 95 per cent. of the volume of mixed juices has to be evaporated, when maceration or imbibition is employed, it is clear that some more economical mode of evaporation is necessary in large estates than the open fire batteries still common in Barbados and some of the West Indian islands, and in small haciendas in Central America and Brazil, but seldom seen elsewhere. With open fire batteries for making the syrup, which was afterwards finished in the vacuum pan, very good sugar was produced, but at a cost that would be ruinous in to-day's markets.

In the best days of the so-called Jamaica Trains in Demerara, three-quarters of a ton of coal in addition to the megass was burned per ton of sugar made, and with this for many years planters were content, because they pointed to the fact that in the central factories, then working in Martinique and Guadeloupe with charcoal filters and triple effect evaporation, 750 kilos of coal in addition to the megass were consumed to make 1000 kilos of sugar. All this has now been changed. It is unquestionably better and easier to evaporate *in vacuo* than in an open pan, and with a better system of firing, a more liberal provision of steam generators, and multiple effect evaporators of improved construction, a far larger yield of sugar is obtained from the juice than was possible of attainment in those days, and the megass often suffices as fuel for the crop.

Multiple effect evaporators.

The multiple effect evaporator, originally invented and constructed by Norberto Rilleux in New Orleans in 1840, has undergone many changes in design and construction since that year. The growing demand for this system of evaporation for application in many other industries besides that of sugar has brought to the front a large number of inventors. Forgetful or ignorant of the great principle announced and established by Rilleux, they have mostly devoted their energies and ingenuity to contriving all sorts of complicated arrangements to give the juice the density required, by passing and repassing it over the heating surface of the apparatus, the saving of a few square feet of which would seem to have been their main object. In some instances the result has been an additional and unnecessary expenditure of high-pressure steam, and in all the well-known fact—of the highest importance in this connexion—appears to have been disregarded, that the shorter the time the juice is exposed to heat the less inversion will take place in it, and therefore the less will be the loss of sugar. But this competition among inventors, whatever the incentive, has not been without benefit, because to-day, by means of very simple improvements in details, such as the addition of circulators and increased area of connexions, what may be taken to be the standard type of multiple effect evaporator (that is to say, vertical vacuum pans fitted with vertical heating tubes, through which passes the liquor to be treated, and outside of which the steam or vapour circulates) evaporates nearly double the quantity of water per square foot of heating surface per hour which was evaporated by apparatus in use so recently as 1885—and this without any increase in the steam pressure. That evaporation *in vacuo*, in a multiple effect evaporator, is advantageous by reason of the increased amount of sugar obtained from a given quantity of juice, and by reason of economy of fuel, there is no doubt, but whether such an apparatus should be of double, triple, quadruple, or quintuple effect will depend very much on the amount of juice to be treated per day, and the cost of fuel. Thus, supposing that 1000 ℔ of coal were required to work a single vacuum pan, evaporating say, 6000 ℔ of water in a given time, then 500 ℔ of coal would be required for a double effect apparatus to do the same work, 333 ℔ for a triple effect, 250 for a quadruple effect, and 200 ℔ for a quintuple effect. In some places where coal costs 60s. a ton, and where steam is raised by coal, as in a beetroot factory, it might pay to adopt a quintuple effect apparatus, but on a cane sugar estate, where the steam necessary for the evaporator is raised by burning the megass as fuel, and is first used in the engines working the mills, the exhaust alone passing to the evaporator, there would be very little, if any, advantage in employing a quadruple effect instead of a triple effect, and practically none at all in having a quintuple effect apparatus, for the interest and sinking fund on the extra cost would more than counterbalance the saving in fuel.

With the juice of some canes considerable difficulty is encountered in keeping the heating surfaces of the evaporators clean and free from incrustations, and cleaning by the use of acid has to be resorted to. In places where work is carried on day and night throughout the week, the standard type of evaporator lends itself more readily to cleaning operations than any other. It is obviously easier to brush out and clean vertical tubes open at both ends, and about 6 feet long, on which the scale has already been loosened by the aid of boiling with dilute muriatic acid or a weak solution of caustic soda in water, than it is to clean either the inside or the outside of horizontal tubes more than double the length. This consideration should be carefully remembered in the future by the planter who may require an evaporator and by the engineer who may be called upon to design or construct it, and more especially by a constructor without practical experience of the working of his constructions.

Howard's vacuum pan.

Concentration and Crystallization.—The defecated cane juice, having lost about 70 per cent. of its bulk by evaporation in the multiple effect evaporator, is now syrup, and ready to enter the vacuum pan for further concentration and crystallization. In a patent (No. 3607, 1812) granted to E. C. Howard it is stated, among other things, that "water dissolves the most uncrystallizable in preference to that which is most crystallizable sugar," and the patentee speaks of "a discovery I have made that no solution unless highly concentrated of sugar in water can without material injury to its colouring and crystallizing power, or to both, be exposed to its boiling temperature during the period required to evaporate such solution to the crystallizing point." He stated that "he had made a magma of sugar and water at atmospheric temperature, and heated the same to 190° or 200° F. in a water or steam bath, and then added more sugar or a thinner magma, and the whole being then in a state of imperfect fluidity, but so as to close readily behind the stirrer, was filled into moulds and purged" (drained). "I do further declare," he added, "that although in the application of heat to the refining of sugar in my said invention or process I have stated and mentioned the temperature of about 200° F. scale as the heat most proper to be used and applied in order to secure and preserve the colour and crystallizability of the sugars, and most easily to be obtained with precision and uniformity by means of the water bath and steam bath, yet when circumstances or choice may render the same desirable I do make use of higher temperatures, although less beneficial." Howard at any rate saw clearly what was one of the indispensable requisites for the economical manufacture of fine crystal sugar of good colour—the treatment of saccharine solutions at temperatures very considerably lower than 212° F., which is the temperature of water boiling at normal atmospheric pressure. Nor was he long in providing means for securing these lower temperatures. His patent (No. 3754 of 1813) describes the closed vacuum pan and the air pump with condenser for steam by injection, the use of a thermometer immersed in the solution in the pan, and a method of ascertaining the density of the solution with a proof stick, and by observations of the temperature at which, while fluid and not containing grain, it could be kept boiling under different pressures shown by a vacuum gauge. A table is also given of boiling points from 115° F. to 175° F., corresponding to decimal parts of an inch of mercury of the vacuum gauge. Since Howard published his invention the vacuum pan has been greatly improved and altered in shape and power, and especially of recent years, and the advantages of concentrating *in vacuo* having been acknowledged, the system has been adopted in many other industries, and crowds of inventors have turned their attention to the principle. In endeavouring to make a pan of less power do as much and as good work as one of greater power, they have imagined many ingenious mechanical contrivances, such as currents produced mechanically to promote evaporation and crystallization, feeding the pan from many points in order to spread the feed equally throughout the mass of sugar being cooked, and so on. All their endeavours have obtained at best but a doubtful success, for they have overlooked the fact, that to evaporate a given weight of water from the syrup in a vacuum pan at least an equal weight (or in practice about 15 per cent. more) of steam must be condensed, and the first cost of mechanical agitators, together with the expenditure they involve for motive power and maintenance, must be put against the slight saving in the heating surface effected by their employment. On the other hand, the advocates of admitting the feed into a vacuum pan in many minute streams appeal rather to the ignorant and incompetent sugar-boiler than to a man who, knowing his business thoroughly, will boil 150 tons of hot raw sugar in a pan in a few hours, feeding it through a single pipe and valve 10 inches in diameter. Nevertheless it has been found in practice, when syrups with low quotient of purity and high quotient of impurity are being treated, injecting the feed at a number of different points in the pan does reduce the time required to boil the pan, though of no practical advantage with syrups of high quotient of purity and free from the viscosity which impedes circulation and therefore quick boiling. Watt, when he invented the steam engine, laid down the principles on which it is based, and they hold good to the present day. So also the principles laid down by Howard with respect to the vacuum pan hold good to-day: larger pans have been made and their heating surface has been increased, but it has been found by practice now, as it was found then, that an ordinary worm or coil 4 inches in diameter and 50 feet long will be far more efficient per square foot of surface than a similar coil 100 feet long. Thus the most efficient vacuum pans of the present day are those which have their coils so arranged that no portion of them exceeds 50 or 60 feet in length; with such coils, and a sufficient annular space in the pan free from obstruction, in order to allow a natural down-current of the cooking mass, while an up-current all round is also naturally produced by the action of the heated worms or coils, rapid evaporation and crystallization can be obtained, without any mechanical adjuncts to require attention or afford excuse for negligence.

The choice of the size of the crystals to be produced in a given pan depends upon the market for which they are intended. It is of course presupposed that the juice has been properly defecated, because without this no amount of skill and knowledge in cooking in the pan will avail; the sugar resulting must be bad, either in colour or grain, or both, and certainly in polarizing power. If a very large firm grain like sugar-candy is required the syrup when first brought into the pan must be of low density, say 20° to 21° Beaumé, but if a smaller grain be wanted it can easily be obtained from syrup of 27° to 28° Beaumé. On some plantations making sugar for particular markets and use in refineries it is the custom to make only one class of sugar, by boiling the molasses produced by the purging of one strike with the sugar in the next strike. On other estates the second sugars, or sugars produced from boiling molasses alone, are not purged to dryness, but when sufficiently separated from their mother-liquor are mixed with the defecated juice, thereby increasing its saccharine richness, and after being converted into syrup in the usual manner are treated in the vacuum pan as first sugars, which in fact they really are.

In certain districts, notably in the Straits Settlements, syrup is prepared as described above for crystallization in a vacuum pan, but instead of being cooked *in vacuo*, it is slowly boiled up in open double-bottom pans. These pans are sometimes heated by boiling oil, with the idea that under such conditions the sugar which is kept stirred all the time as it thickens cannot be burnt or caramelized; but the same object can be attained more economically with steam of a given pressure by utilizing its latent heat. The sugar thus produced, by constant stirring and evaporation almost to dryness, forms a species of small-grained concrete. It is called "Basket Sugar," and meets with a brisk sale, at remunerative prices, among the Chinese coolies; and as the sugar as soon as cooled is packed ready for market, without losing any weight by draining, this branch of sugar-making is a most lucrative one wherever there is sufficient local demand. Very similar kinds of sugar are also produced for local consumption in Central America and in Mexico, under the names of "Panela" and "Chancaca," but in those countries the sugar is generally boiled in pans placed over special fire-places, and the factories making it are on a comparatively small scale, whereas in the Straits Settlements the "Basket Sugar" factories are of considerable importance, and are fitted with the most approved machinery.

Curing or Preparation of Crystals for the Market.—The crystallized sugar from the vacuum pan has now to be separated from the molasses or mother-liquor surrounding the crystals. In some parts of Mexico and Central America this separation is still effected by running the sugar into conical moulds, and placing on the top a layer of moist clay or earth which has been kneaded in a mill into a stiff paste. The moisture from the clay, percolating through the mass of sugar, washes away the adhering molasses and leaves the crystals comparatively free and clear. It may be noted that sugar that will not purge easily and freely with clay will not purge easily and freely in centrifugals. But for all practical purposes the system of claying sugar is a thing of the past, and the bulk of the sugar of commerce is now purged in centrifugals, as indeed it has been for many years. The reason is obvious. The claying system involved the expense of large curing houses and the employment of many hands, and forty days at least were required for completing the operation and making the sugar fit for the market, whereas with centrifugals sugar cooked to-day can go to market to-morrow, and the labour employed is reduced to a minimum.

When Cuba was the chief sugar-producing country making clayed sugars, it was the custom (followed in refineries, and found advantageous in general practice) to discharge the strike of crystallized sugar from the vacuum pan into a receiver heated below by steam, and to stir the mass for a certain time, and then distribute it into the moulds in which it was afterwards clayed. When centrifugals were adopted for purging the whole crop (they had long been used for curing the second or third sugars), the system then obtaining of running the sugar into waggons or coolers, which was necessary for the second and third sugars cooked only to string point, was continued, but latterly "crystallization in movement," a development of the system which existed in refineries and in Cuba forty years ago or more, has come into general use, and with great advantage, especially where proprietors have been able to erect appropriate buildings and machinery for carrying out the system efficiently. The vacuum pan is erected at a height which commands the crystallizers, each of which will, as in days gone by in Cuba, hold the contents of the pan, and these in their turn are set high enough to allow the charge to fall into the feeding-trough of the centrifugals, thus obviating the necessity of any labour to remove the raw sugar from the time it leaves the vacuum pan to the time it falls into the centrifugals. For this reason alone, and without taking into consideration any increase in the yield of sugar brought about by "crystallization in movement," the system is worthy of adoption in all sugar factories making crystal sugar.

Crystallizers.

The crystallizers are long, horizontal, cylindrical or semi-cylindrical vessels, fitted with a strong horizontal shaft running from end to end, which is kept slowly revolving. The shaft carries arms and blades fixed in such a manner that the mass of sugar is quietly but thoroughly moved, while at the same time a gentle but sustained evaporation is produced by the continuous exposure of successive portions of the mass to the action of the atmosphere. Thus also the crystals already formed come in contact with fresh mother-liquor, and so go on adding to their size. Some crystallizers are made entirely cylindrical, and are connected to the condenser of the vacuum pan; in order to maintain a partial vacuum in them, some are fitted with cold water pipes to cool them, and with steam pipes to heat them, and some are left open to the atmosphere at the top. But the efficiency of all depends on the process of almost imperceptible yet continuous evaporation and the methodical addition of syrup, and not on the idiosyncrasies of the experts who manage them; and there is no doubt that in large commercial processes of manufacture, the simpler the apparatus used for obtaining a desired result, and the more easily it is understood, the better it will be for the manufacturer. The sugar made from the first syrups does not require a crystallizer in movement to prepare it for purging in the centrifugals, but it is convenient to run the strike into the crystallizer, and so empty the pan at once and leave it ready to commence another strike, while the second sugars will be better for twenty-four hours' stirring and the third sugars for forty-eight hours' stirring before going to the centrifugals. To drive these machines electricity has been applied, with indifferent success, but they have been very efficiently driven, each independently of the others in the set, by means of a modification of a Pelton wheel, supplied with water under pressure from a pumping engine. A comparatively small stream strikes the wheel with a pressure equivalent to a great head, say 300 feet, and as the quantity of water and number of jets striking the wheel can be regulated with the greatest ease and nicety, each machine can without danger be quickly brought up to its full speed when purging high-class sugars, or allowed to run slowly when purging low-class sugars, until the heavy, gummy molasses has been expelled; and it can then be brought up to its full speed for finally drying the sugar in the basket, a boon which all practical sugar makers will appreciate. The water forced by the force-pump against the Pelton wheels returns by a waste-pipe to the tank, from which the force-pump takes it again.

BEETROOT SUGAR MANUFACTURE.

About 1760 the Berlin apothecary Marggraff obtained in his laboratory, by means of alcohol, 6·2 per cent. of sugar from a white variety of beet and 4·5 per cent. from a red variety. At the present day, thanks to the careful study of many years, the improvements of cultivation, the careful selection of seed, and suitable manuring, especially with nitrate of soda, the average beet worked up contains 7 per cent. of fibre and 93 per cent. of juice, and yields in Germany 12·79 per cent. and in France 11·6 per cent. of its weight in sugar. In Great Britain the experiments in the cultivation of sugar beets on Lord Denbigh's estates at Newnham Paddox, in Warwickshire, in 1900, produced excellent results, both in respect of the weight of the beets per acre and of the saccharine value and purity of the juice. The average weight per acre was over 25½ tons, and the mean percentage of pure sugar in the juice exceeded 15½. The roots were grown under exactly the same cultivation and conditions as a crop of mangel wurzel—that is to say, they had the ordinary cultivation and manuring of the usual root crops. The weight per acre, the saccharine contents of the juice, and the quotient of purity compare favourably with the best results obtained in Germany or France, and with those described in the ninth edition of the *Encyclopædia Britannica,* vol. i. p. 382, as achieved by the Suffolk farmers, who between 1868 and 1872 supplied Mr Duncan's beetroot sugar factory at Lavenham; for the weight of their roots rarely reached 15 tons per acre, and the percentage of sugar in the juice appears to have varied between 10 and 12. On the best equipped and most skilfully managed cane sugar estates, where the climate is favourable for maturing the cane, a similar return is obtained. Therefore, roughly speaking, one ton of beetroot may be considered to-day as of the same value as one ton of canes; the value of the refuse chips in one case, as food for cattle, being put against the value of the refuse megass, as fuel, in the other. Before beetroot had been brought to its present state of perfection, and while the factories for its manipulation were worked with hydraulic presses for squeezing the juice out of the pulp produced in the raperies, the cane sugar planter in the West Indies could easily hold his own, notwithstanding the artificial competition created and maintained by sugar bounties. But now that so great a degree of perfection in the cultivation of the roots and their subsequent manipulation has been reached, and has been supplemented with Government subsidies, a most serious crisis has come about, and it remains to be seen whether the British Government will, like that of the United States, put on countervailing duties to protect their own people from ruin, or be able to persuade the Continental Governments to abandon the sugar bounties. The immediate effect would be to double the consumption of sugar in the bounty-paying countries, as a consequence of reducing the price by more than one-half, and at the same time English planters and refiners would be relieved from an unfair and almost fatal competition, dependent both for its existence and intensity not on anything in nature or on any permanent conditions of national life, but on the merest expedients of a time-serving and indefensible policy.

In beetroot sugar manufacture the operations are washing, slicing, diffusing, saturating, sulphuring, evaporation, concentration, and curing.

Slicing.—The roots are brought from the fields by carts, canals, and railways. They are weighed and then dumped into a washing machine, consisting of a large horizontal cage, submerged in water, in which revolves a horizontal shaft carrying arms. The arms are set in a spiral form, so that in revolving they not only stir the roots, causing them to rub against each other, but also force them forward from the receiving end of the cage to the other end. Here they are discharged (washed and freed from any adherent soil) into an elevator, which carries them up to the top of the building and delivers them into a hopper feeding the slicer. Slicers used to be constructed with iron discs about 33 to 40 inches diameter, which were fitted with knives and made 140 to 150 revolutions per minute, under the hopper which received the roots. This hopper was divided into two parts by vertical division plates, against the bottom edge of which the knives in the disc forced the roots, and sliced and pulped them. Such machines were good enough when the juice was expelled from the small and, so to speak, chopped slices and pulp by means of hydraulic presses. But hydraulic presses have now been abandoned, for the juice is universally obtained by diffusion, and the small slicers have gone out of use, because the large amount of pulp they produced in proportion to slices is not suitable for the diffusion process in which evenly cut slices are required, which present a much greater surface with far less resistance to the diffusion water. Instead of the small slicers, machines made on the same principle, but with discs 7 feet and upwards in diameter, are used. Knives are arranged around their circumference in such a way that the hopper feeding them presents an annular opening to the disc, say 7 feet outside diameter and 5 feet inside, with the necessary division plates for the knives to cut against, and instead of making 140 to 150 revolutions, the discs revolve only 60 to 70 times per minute. Such a slicer is capable of efficiently slicing 300,000 kilos of roots in twenty-four hours, the knives being changed four times in that period, or oftener if required, for it is necessary to change them the moment the slices show by their rough appearance that the knives are losing their cutting edges.

Diffusion.—The diffusion cells are closed, vertical, cylindrical vessels, holding generally 60 hectolitres or 1320 gallons, and are arranged in batteries of 12 to 14. Sometimes the cells are erected in a circle, so that the spout below the slicing machine revolving above them with a corresponding radius can discharge the slices into the centre of any of the cells. In other factories the cells are arranged in lines, and are charged from the slicer by suitable telescopic pipes or other convenient means. A circular disposition of the cells facilitates charging by the use of a pipe rotating above them, but it renders the disposal of the hot spent slices somewhat difficult and inconvenient. The erection of the cells in straight lines may cause some little complication in charging, but it allows the hot spent slices to be discharged upon a travelling band which takes them to an elevator, an arrangement simpler than any which is practicable when the cells are disposed in a circle. Recently, however, a well-known sugar maker in Germany has altered his battery in such manner that instead of having to open a large door below the cells in order to discharge them promptly, he opens a comparatively small valve, and applying compressed air at the top of the cell, blows the whole contents of spent slices up a pipe to the drying apparatus, thus saving not only a great deal of time but also a great deal of labour of a kind which is both arduous and painful, especially during cold weather. The slices so blown up, or elevated, are passed through a mill which expels the surplus water, and are then pressed into cakes and dried until they hold about 12 per cent. of water and 88 per cent. of beet fibre. These cakes, sold as food for cattle, fetch as much as £4 per ton in Rumania, where four or five beetroot factories are now at work. A cell when filled with fresh slices becomes the head of the battery, and where skilled scientific control can be relied upon to regulate the process, the best and most economical way of heating the slices, previous to admitting the hot liquor from the next cell, is by direct steam; but as the slightest inattention or carelessness in the admission of direct steam might have the effect of inverting sugar, and thereby causing the loss of some portion of saccharine in the slices, water heaters are generally used, through which water is passed and heated up previous to admission to the freshly-filled cell. When once a cell is filled up and the slices are warmed through, the liquor from the adjoining cell, which hitherto has been running out of it to the saturators, is turned into the new cell, and beginning to displace the juice from the fresh slices, runs thence to the saturators. When the new cell comes into operation and becomes the head of the battery, the first or tail cell is thrown out, and number two becomes the tail cell, and so the rounds are repeated; one cell is always being emptied and one filled or charged with slices and heated up, the latter becoming the head of the battery as soon as it is ready.

Saturation.—The juice, previously treated with lime in the diffusion battery, flows thence into a saturator. This is a closed vessel, into which carbonic acid gas (produced as described hereafter) is forced, and combining with the lime in the juice forms carbonate of lime. The whole is then passed through filter presses, the clear juice being run off for further treatment, while the carbonate of lime is obtained in cakes which are taken to the fields as manure. The principal improvement made of recent years in this portion of the process has been the construction of pipes through which the carbonic acid gas is injected into the juice in such a manner that they can be easily withdrawn, and a clean set substituted. The filter presses remain substantially unchanged, although many ingenious but slight alterations have been made in their details. The juice, which has now become comparatively clear, is again treated with lime, and again passed through a saturator and filter presses, and comes out still clearer than before. It is then treated with sulphurous acid gas, for the purpose of decolorization, again limed to neutralize the acid, and then passed through a third saturator wherein all traces of lime and sulphur are removed.

A process for purifying and decolorizing the juice expressed from beetroots by the addition of a small quantity of manganate of lime (20 to 50 grammes per hectolitre of juice) under the influence of an electric current, was worked with considerable success in a sugar factory in the department of Seine-et-Marne in the year 1900–01. A saving of 40 per cent. is stated to be effected in lime.

The use of sulphurous acid gas is entirely abandoned, and instead of three carbonatations with corresponding labour and plant only one is required. The coefficient of purity is increased, and the viscosity of the juice diminished. The total saving effected is stated to be equivalent to 3 francs per ton of beetroot worked up. This system is also being tried on a small scale with sugar-cane juice in the West Indies. If by this process a more perfect defecation and purification of the juice is obtained, it will no doubt be highly beneficial to the cane planter, though no great economy in lime can be effected, because but very little is used in a cane factory in comparison with the amount used in a beet factory.

Evaporation and Crystallization.—The clear juice thus obtained is evaporated in a multiple effect evaporator and crystallized in a vacuum pan, and the sugar is purged in centrifugals. From the centrifugal the sugar is either turned out without washing as raw sugar, only fit for the refinery, or else it is well washed with a spray of water and air until white and dry, and it is then offered in the market as refined sugar, although it has never passed through animal charcoal (bone-black). The processes of evaporation and concentration are carried on as they are in a cane sugar factory, but with this advantage, that the beet solutions are freer from gum and glucose than those obtained from sugar-canes, and are therefore easier to cook.

Curing.—There are various systems of purging refined, or so-called refined, sugar in centrifugals, all designed with a view of obtaining the sugar in lumps or tablets, so as to appear as if it had been turned out from moulds and not from centrifugals, and great ingenuity and large sums of money have been spent in perfecting these different systems, with more or less happy results. But the great achievement of recent manufacture is the production, without the use of animal charcoal, of a cheaper, but good and wholesome, article, in appearance equal to refined sugar for all intents and purposes, except for making preserves of fruits in the old-fashioned way. The wholesale jam manufacturers of the present day use this sugar; they boil the jam *in vacuo*, and secure a product that will last a long time without deteriorating, but it lacks the delicacy and distinctive flavour of fruit preserved by a careful housekeeper, who boils it in an open pan with cane sugar to a less density, though exposed for a short time to a greater heat.

Carbonatation.—The carbonic acid gas injected into the highly-limed juice in the saturators is made by the calcination of limestone in a kiln provided with three cleaning doors, so arranged as to allow the lime to be removed simultaneously from them every six hours. The gas generated in the kiln is taken off at the top by a pipe to a gas-washer. In this it passes through four sheets of water, by which it is not only freed from any dust and dirt that may have come over with it from the kiln, but is also cooled to a temperature which permits an air-pump to withdraw the gas from the kiln, through the gas-washer, and force it into the saturators, without overheating. In some factories for refining sugar made from beet or canes this system of carbonatation is used, and enables the refiner to work with syrups distinctly alkaline, and to economize a notable amount of animal charcoal.

REFINING.

Briefly, sugar-refining consists of melting raw or unrefined sugar with water into a syrup of 27° to 28° Beaumé, or 1230 specific gravity, passing it through filtering cloth to remove the sand and other matters in mechanical suspension, and then through animal charcoal to remove all traces of colouring matter and lime, thus producing a perfectly clear white syrup, which, cooked in the vacuum pan and crystallized, becomes the refined sugar of commerce.

Melting Pans.—The melting pans are generally circular vessels, fitted with a perforated false bottom, on which the sugar to be melted is dumped. The pans are provided with steam worms to keep the mass hot as required, and with mechanical stirrers to keep it in movement and thoroughly mixed with the water and sweet water which are added to the sugar to obtain a solution of the specific gravity desired. Any sand or heavy matter in suspension is allowed to fall to the bottom of the pan into the "sand box" before the melted sugar is run off to the cloth filters. In a process employed with great success in some refineries the raw sugars are washed before being melted, and thus a purer article is obtained for subsequent treatment. In this process the raw sugar is mixed with a small amount of syrup so as to form a suitable magma, and is then run into a continuous centrifugal, where it is sufficiently washed, and from which it runs out, comparatively clean, into the melting pans described above.

Filters.—Taylor bag filters are generally used for clearing the melted liquor of its mechanical impurities. They were introduced years ago by the man whose name they still retain, but they are very different in construction to-day from what they were when first employed. They consist of tanks or cisterns fitted with "heads" from which a number of bags of specially woven cloth are suspended in a suitable manner, and into which the melted sugar or liquor to be filtered flows from the melting pans. The bags, though 60 inches or more in circumference, are folded up in such a way that a sheath about 15 inches in circumference can be passed over them. Thus a maximum of filtering surface with a minimum of liquor in each bag is obtained, and a far greater number of bags are got into a given area than would otherwise be possible, while the danger of bursting the bags by leaving them unsupported is avoided. As the liquor goes on filtering through the bags they gradually get filled up with slime and sludge, and the clear liquor ceases to run. Steam is then turned on to the outside of the bags and sheaths, and hot water is run through them to wash out all the sweets they contain. Large doors at the side of the cistern are then opened, and as soon as the bags are cool enough they are removed at the expense of very exacting labour and considerable time, and fresh bags and sheaths are fixed in their places ready for filtering fresh liquor. The dirty bags and sheaths are then washed, mangled, and dried, and made ready for use again. In a refinery in Nova Scotia a system has been introduced by which a travelling crane above the bag filters lifts up any head bodily with all its bags attached, and runs it to the mud and washing tanks at the end of the battery, while another similar crane drops another head, fitted with fresh bags, into the place of the one just removed. The whole operation of thus changing a filter occupies about ten minutes, and there is no need for any one to enter the hot cistern to detach the bags, which are removed in the open air above the mud tank. By this arrangement the work of a refinery can be carried on with about one-half the cisterns otherwise required, because, although it does not reduce the number of bags required per day for a given amount of work, it enables the refiner to use one cistern twice a day with fresh bags, instead of only once as heretofore. In some refineries the travelling cranes are now run by electricity, which still further facilitates the work. Another method of enabling more work to be done in a given time in a given cistern is the use of a bag twice the ordinary length, open at both ends. This being folded and placed in its sheath is attached by both ends to the head, so that the melted liquor runs into both openings at the same time. The mud collects at the bottom of the U, and allows the upper part of the bag to filter for a longer time than would be the case if the bottom end were closed and if the bag hung straight like the letter I.

The clear, bright syrup coming from the bag filters passes to the charcoal cisterns or filters. These are large cylindrical vessels from 20 to 50 feet high, and of such diameter as to hold a given quantity of animal charcoal (also called "bone-black" and "char") in proportion to the contemplated output of the refinery. A very usual size of cistern forming a convenient unit is one that will hold 20 tons of char. Each cistern is fitted with a perforated false bottom, on which a blanket or specially woven cloth is placed, to receive the char which is poured in from the top, and packed as evenly as possible, until the cistern is filled. The char is then "settled" by water being slowly run on to it, in order to prevent the syrup making channels for itself and not permeating the whole mass evenly. The cistern being thus packed and settled is closed, and the syrup from the bag filters, heated up to nearly boiling-point, is admitted at the top until the cistern is quite full. A small pipe entering below the false bottom allows the air in the cistern to escape as it is displaced by the water or syrup. In some refineries this pipe, which is carried up to a higher level than the top of the cistern, is fitted with a whistle which sounds as long as the air escapes. When the sound ceases the cistern is known to be full, and the entrance of further water or syrup is stopped. The syrup in the cistern is allowed to remain for about twelve hours, by which time the char will have absorbed all the colouring matter in it, as well as the lime. A cistern well packed with 20 tons of char will hold, in addition, about 10 tons of syrup, and after settling, this can be pressed out by allowing second quality syrup, also heated to nearly boiling-point, to enter the cistern slowly from the top, or it may be pressed out by boiling water. By carefully watching the flow from the discharge cock of the cistern the change from the first liquor to the next is easily detected, and the discharge is diverted from the canal for the first liquor to the canal for the second liquor, and when required, to the canals for the third and fourth liquors. Finally, boiling water is admitted and forces out all the last liquor, and then continues to run and wash out the sweets until only a trace remains. This weak solution, called "sweet water," is sometimes used for melting the raw sugar, or it is evaporated in a multiple effect apparatus to 27° Beaumé density, passed through the char filter, and cooked in the vacuum pan like the other liquors. After the sweets have come away, cold water is passed through the char until no trace of lime or sulphate of lime is found in it; then a large manhole at the bottom of the cistern is opened, and the washed and spent char is removed. In most modern refineries the cisterns are so arranged that the spent char falls on to a travelling band, and is conducted to an elevator which carries it up to the drying floor of the charcoal kiln.

Retorts for Reburning Char.—The kilns are made with either fixed or revolving retorts. The former perhaps produce a little better char, but the latter, working almost automatically, require less labour and attention for an equal amount of work, and on the whole have proved very satisfactory. From the drying floor on which the spent char is heaped up it falls by gravitation into the retorts. These are set in a kiln or oven, and are kept at as even a temperature as possible, corresponding to a dull cherry-red. Below each retort, and attached to it, is a cooler formed of thin sheet-iron, which receives the hot char as it passes from the retort, and at the bottom of the cooler is an arrangement of valves which permits a certain amount of char to drop out and no more. With the fixed retorts these valves are worked from time to time by the attendant, but with revolving retorts they are worked continuously and automatically, and allow from sixteen to twenty-four ounces of char to escape per minute from each cooler, and so make room in the retort above for a corresponding quantity to enter from the drying floor. The reburnt and cooled char is collected and sent back to the char cisterns. In the best appointed refineries the whole of the work in connexion with the char is performed mechanically, with the exception of packing the filter cisterns with fresh char and emptying the spent and washed char on to the carrying bands. In former days, when refining sugar or "sugar baking" was supposed to be a mystery only understood by a few of the initiated, there was a place in the refinery called the "Secret Room," and this name is still used in some refineries, where, however, it applies not to any room, but to a small copper cistern, constructed with five or six or more divisions or small canals, into which all the charcoal cisterns discharge their liquors by pipes led up from them to the top of the cistern. Each pipe is fitted with a cock and swivel, in such a manner that the liquor from the cistern can be turned into the proper division according to its quality.

Vacuum Pans and Receivers.—The filtered liquors being collected in the various service tanks according to their qualities, are drawn up into the vacuum pans and boiled to crystals. These are then discharged into large receivers, which are generally fitted with stirrers, and from the receivers the cooked mass passes to the centrifugal machines. As in the beetroot factories, these machines work on different systems, but nearly all are arranged to turn out sugar in lumps or tablets presenting an appearance similar to that of loaf sugar made in moulds, as this kind of sugar meets with the greatest demand. Granulated sugar, so called, is made by passing the crystals, after leaving the centrifugals, through a large and slightly inclined revolving cylinder with a smaller one inside heated by steam. The sugar fed into the upper end of the cylinder gradually works its way down to the lower, showering itself upon the heated central cylinder. A fan blast enters the lower end, and passing out at the upper end, carries off the vapour produced by the drying of the sugar, and at the same time assists the evaporation. The dry sugar then passes into a rotating screen fitted with two meshes, so that three grades of sugar are obtained, the coarsest being that which falls out at the lower end of the revolving screen.

Recent Improvements.—Systematic feeding for the vacuum pan and systematic washing of the massecuite have been recently introduced not only into refineries, but also into sugar houses or factories on plantations of both cane and beetroot, and great advantages have resulted from their employment. The first-mentioned process consists of charging and feeding the vacuum pan with the richest syrup, and then as the crystals form and this syrup becomes thereby less rich the pan is fed with syrup of lower richness, but still of a richness equal to that of the mother-liquor to which it is added, and so on until but little mother-liquor is left, and that of the poorest quality. The systematic washing of the massecuite is the reverse of this process. When the massecuite, well pugged and prepared for purging, is in the centrifugals, it is first washed with syrup of low density, to assist the separation of mother-liquor of similar quality, this washing being supplemented by the injection of pure syrup of high density, or "clairce," when very white sugar is required. The manufacturers who have adopted this system assert that, as compared with other methods, not only do they obtain an increased yield of sugar of better quality, but that they do so at a less cost for running their machines, and with a reduced expenditure in sugar and "clairce." "Clairce" is the French term for syrup of 27° to 30° Beaumé specially prepared from the purest sugar. (A. CH.)

STATISTICS.

The foregoing sketch of the principal processes employed in making sugar from canes and beetroot, and in refining the raw sugar produced from both of these sugar-bearing plants, may be conveniently supplemented by a brief review of the progress made by the sugar industry since 1887 and its state at the present time, showing the importance and magnitude of the trade interests involved, and the serious extent to which these interests and those of the public at large in all countries are affected by the incidence of the sugar bounties.

Tables are annexed containing statistical statements relating to the production of sugar and the sugar trade.

COMMERCE.

Since the article on sugar in the earlier volume of the *Encyclopædia Britannica* (ninth edition) was written, the sugar trade of the world has grown considerably in volume. The system of protection then existent in European countries producing beet sugar offered and paid bounties, directly or indirectly, to manufacturers and refiners on their exports, and to growers on their crops; and until quite lately it successfully withstood all attempts to upset it. Under this system the production of sugar in bounty-paying countries has been encouraged and pushed far beyond the limits it could have reached without State aid. At the same time the consumption of sugar among the mass of their populations has been greatly restricted owing to the dearness of the commodity, caused by heavy excise duties imposed mainly to provide for the payment of the bounties. The very large quantity of output made available for export under these exceptional conditions has brought about the flooding of the British and other markets with sugars at depressed prices, not unfrequently below the prime cost of production, to the harassment of important industries carried on by British refiners and sugar-growing colonies. In these circumstances, the British Government sent out invitations on the 2nd July 1887 for an International Conference to meet in London. The conference met, and on the 30th August 1888 a convention was signed by all the Powers represented except France—namely, by Austria, Belgium, Germany, Great Britain, Italy, the Netherlands, Russia, and Spain. France withdrew because the United States was not a party to it. The first article declared that "The High Contracting Parties engage to take such measures as shall constitute an absolute and complete guarantee that no open or disguised bounty shall be granted on the manufacture or exportation of sugar." The seventh article provided that bountied sugars (*sucres primés*) must be excluded from import into the territories of the signatory Powers, by absolute prohibition of entry or by levying thereon a special duty in excess of the amount of the bounties, from which duty sugars coming from the contracting countries, and not bounty-fed, must be free. The convention was to be ratified on the 1st August 1890, and was to be put in force on the 1st September 1891.

The convention of 1888 was never ratified, and it is doubtful whether its ratification was urged, for a Bill introduced by the British Government in 1889 to give it effect was not pressed, and it was manifest that there was hesitation—which presently became refusal—to uphold the policy of the penalties on the importation of bountied sugar imposed by the seventh article, without which the convention would be so much waste paper.

Eight years later, on 1st August 1896, the bounties offered by the Governments of Germany and Austria-Hungary were approximately doubled, and France had a Bill in preparation to increase hers correspondingly, although it was computed that they were even then equivalent to a grant of £3, 5s. per ton. So wrote Mr Chamberlain, the Colonial Secretary, on the 9th November following, to the Treasury. The minute plainly stated that it had become a question whether the continued enjoyment of advantages resulting from the importation of cheap bounty-fed sugar to some British industries did not involve the ruin of the British sugar-producing colonies; and that he was not prepared, as Secretary of State for the Colonies, to accept the responsibility of allowing matters to take their course, and to acquiesce in the policy of non-intervention hitherto pursued in regard to the bounties without having satisfied himself as to what such a policy might entail as regarded both the colonies and the Exchequer; nor would he think it right that the Government should adhere to their then attitude on the question, without knowing as clearly as possible its cost to the welfare and stability of an important part of the Empire and to industries in which English capital was largely invested. Mr Chamberlain concluded by asking whether the Treasury would consent to sending a Royal Commission to the West Indies to inquire into the effect of the foreign sugar bounties on their principal industry.

Here were plain words, and they expressed a plain purpose. The Treasury without delay accepted the proposal, and a Royal Commission proceeded to the West Indies in December 1896, and reported a few months later in 1897. Only one commissioner, however, denounced the bounties as the real cause of the utter breakdown of trade and of the grievous distress which all three had witnessed and fully acknowledged. But the minute and Commission were not barren of result. A fresh Conference of the Powers assembled at Brussels, on the invitation of the Belgian Government, on the 7th June 1898; and although the British delegates were not empowered to consent to a penal clause imposing countervailing duties on bountied sugar, the Belgian Premier who presided, was able to assure them that if Great Britain would agree to such a clause, he could guarantee the accession of the Governments of Germany, Austria, Holland, and his own. [Mr Ozanne to the Revenue Secretary, India Office, 18th June 1898 (East India Sugar [C. 9287], 1899, p. 17).] The representative of India added, "It is certain that neither France nor Russia could afford to remain outside, and it is probable they will readily join." He was, however, mistaken. A few days later the Conference met for its seventh and final sitting. Of all the countries represented—Germany, Austria-Hungary, Belgium, Spain, France, Great Britain, the Netherlands, Russia, and Sweden—only one, namely France, was opposed to the complete suppression of all export bounties, direct or indirect; and Russia declined to discuss the question of her internal legislation, contending that her system did not amount to a bounty on exportation. [The British Delegates to Lord Salisbury, 27th June 1898 [C. 8938], 1898, p. 3.]

Apart from the proceedings at the sittings, much of the actual work of the Conference was done by informal discussion, undertaken to discover some means of arriving at a common understanding. Was a compromise possible which would bring about a satisfactory settlement? The British delegates wrote that it appeared that there were at that time but two methods of securing the suppression of the bounty system—an arrangement for limitation of the French and Russian bounties acceptable to the other sugar-producing States, in return for the total abolition of their bounties; or, a convention between a certain number of these States, providing for the total suppression of their bounties, and for the prohibition of entry into their territory of bounty-fed sugars, or countervailing duties prohibiting importation. The United States, they said, had closed her markets by these means; and now England and India were become essential to the bounty-paying countries; and should their markets also be closed, the speedy abolition of the bounty system, which was felt to press heavily on the States having recourse to it, must follow; while if these markets were left open, a worse state of things might result, by the increase of the bounties in various countries. [*Ibid.*, p. 4.]

The Belgian Government thought a compromise might be possible. A proposal was annexed to the *procés-verbal* of the final sitting, and the president closed the first session of the Conference on the 25th June 1898 with the expression of a hope that the delegates would soon reassemble. [*Ibid.*, pp. 56, 57.]

The annual aggregate output of cane and date sugar in India was short of 4,000,000 tons. Exportation had long ceased, partly owing to the bountied competition of beet sugar, and partly because the people had become able to afford the consumption of a greater quantity than they produced; and German and Austrian sugars were pouring into the country to supply the deficiency. But the importation of foreign sugar, cheapened by foreign State aid to a price which materially reduced the fair and reasonable profit of native cultivators, and with that profit their ability to meet canal charges and pay the legitimate return on public funds invested in irrigation works, was a state of things the Indian Government could not accept, and no time was lost in following the example set by America. On the 20th March 1899 an Act, authorizing the imposition of countervailing duties on bounty-fed articles at the port of importation, was passed by the Council of India, and received the assent of the Governor-General. [East India (Sugar) [C. 9287], 1899, pp. 19 and 89.]

This decisive step was not long in making itself felt in the chanceries of Europe. In October 1900 a conditional agreement for the reduction of the bounties was made at Paris between France, Germany, and Austria-Hungary; in February 1901 the Belgian Government proposed a new session of the Conference of 1898, and on the 16th December following Brussels welcomed once more the delegates of all the Powers, with the exception of Russia, to the eighth European Sugar Bounty Conference since that of Paris in 1862. The discussion lasted over eight sittings, but the Conference, to which the British delegates had come with powers to assent to a penal clause, arrived at an understanding, and a convention was signed in March 1902.

The full text in French, with an English translation, of the Sugar Convention, signed at Brussels on the 5th March 1902 by the plenipotentiaries of the Governments of Germany, Austria-Hungary, Belgium, Spain, France, Great Britain, Italy, the Netherlands, and Sweden, will be found in a return presented to Parliament in April 1902 (Miscellaneous No. 5, 1902, Cd. 1013).

The following is a summary:—

Article 1.—The High Contracting Parties agree, from the date of putting in force this present Convention, to suppress the direct and indirect Bounties which might benefit the production or export of Sugar, and not to establish Bounties of this kind during the whole duration of the Convention. The agreement applies to confectionery, chocolate, and all analogous products containing sugar artificially incorporated in a notable proportion; and to all advantages, resulting directly or indirectly for producers, from fiscal legislation, including: (*a*) Direct Bounties granted to exports; (*b*) and to production; (*c*) total or partial exemption from taxation as to any part of the output; (*d*) advantages derived from excess of yield; (*e*) and from the exaggeration of drawback; (*f*) and from any Surtax in excess of the rate fixed by Article 3.

Article 2.—Sugar factories and refineries of all kinds are to be placed in bond, and worked under the continuous supervision of revenue officers; and finished sugars are to be stored in bonded warehouses.

Article 3.—The Surtax is limited to a maximum of 6 francs per 100 kilogrammes (=2s. 5¼d. per cwt., or £2, 8s. 9d. per ton) for refined and assimilable sugars; and of 5 francs 50 centimes per 100 kilogrammes (=2s. 2·8d. per cwt., or £2, 4s. 8½d. per ton) for other sugars.

The Surtax is the difference between the rate of duty imposed on imported foreign sugar and the rate of duty or tax imposed on the home product. The provisions of this article do not apply to import duties on sugar imposed by countries that do not produce sugar, nor to the by-products of sugar manufacture or of refining.

Article 4.—The High Contracting Parties agree to impose a special duty on the importation into their respective territories of sugars from countries that grant Bounties either on production or export. This duty shall not be less than the amount of the Bounties direct or indirect granted in the country of origin; and each of the parties reserves the right to prohibit the importation of bountied sugars (*sucre primés*).

In order to compute the advantage which may be derived by the imposition of an excessive Surtax as specified in paragraph *f* of Article 1, the Surtax, at the agreed rate fixed by Article 3, is deducted from such excessive Surtax, and the half of the difference is considered to represent Bounty. A Permanent Commission, instituted by Article 7, will have the right, on the demand of a Contracting Party, to revise the rate imposed in excess.

Article 5.—The High Contracting Parties agree to admit, at the lowest rate of import duty, sugars of any of the contracting countries, or of any Colonies or Possessions belonging to them that do not grant Bounties, and to which the obligations imposed by Article 8 apply.

Cane and beet sugars shall not be subjected to different rates of duties.

Article 6.—Spain, Italy, and Sweden are exempt from the obligations of Articles 1, 2, and 3 so long as they do not export sugars; but they agree to make their sugar legislation conform to the provisions of this Convention, within a year, or earlier if possible, from the time when the Permanent Commission gives notice that the above-mentioned condition has ceased to exist.

Article 7.—The High Contracting Parties agree to establish a Permanent Commission to watch the execution of the provisions of this Convention.

This Commission shall be composed of the Delegates of the Contracting Powers, and a Permanent Bureau will be connected with it. It will elect its President, and it will sit at Brussels, and assemble at the summons of the President.

The duties of the Delegates will be:—

(*a*) To ascertain whether in the Contracting States any Bounty, direct or indirect, is granted on production or export of sugar;

(*b*) Whether the States named in Article 6 continue to conform to the conditions of that Article;

(*c*) Whether any Bounties exist in non-signatory States, and to estimate their amount for the purposes of Article 4;

(*d*) To pronounce an opinion on contested points (*questions litigieuses*);

(*e*) To consider requests for admission to the Union made by non-signatory States.

The Permanent Bureau shall collect, translate, arrange, and publish information of all kinds respecting legislation on, and statistics of, sugar, not only in contracting countries, but in all other countries.

The High Contracting Parties shall transmit to the Belgian Government, which shall forward them to the Commission, all laws, regulations, &c., and full statistical information respecting sugar in their countries.

Austria and Hungary shall be considered separately as Contracting Parties.

The first meeting of the Commission shall be held in Brussels, under the auspices of the Belgian Government, at least three months before the present Convention comes into force.

The Commission shall only have the duty of examination and report. It shall forward the Report to the Belgian Government, which will communicate with the Powers interested, and at the request of any one of them shall convoke a conference to take decisions and measures, as circumstances may demand.

The Examinations and Valuations referred to in paragraphs *b* and *c* will be binding on the Contracting Powers, and will take effect in two months' time, at the latest, after being determined by a majority vote, each Contracting Party having one vote. An appeal is to lie to a fresh meeting of the Commission.

The expenses of the establishment and working of the Permanent Bureau and Commission, the salaries of the Delegates excepted, shall be borne by all the Contracting States, subject to equitable division of the same.

Article 8.—The Parties agree for themselves, their Colonies and Possessions—an exception being made for the self-governing Colonies of Great Britain and the British East Indies—to prevent Bounty-fed sugar, which has traversed territory of a contracting State, from enjoying the advantages of this Convention in the market of destination.

Article 9.—States not parties to this Convention will, on request, and after approval by the Permanent Commission, be admitted to it.

Article 10.—The Convention will come into force on 1st September 1903, and remain in force five years from that date; and thenceforward, in case no State denounces it twelve months before the 1st September 1908, it will remain in force for a year, and so on from year to year. The denunciation will only have effect on the party making it.

Article 11.—The provisions of the Convention apply to the over-sea Colonies and Possessions of the parties, those of the Netherlands and Great Britain excepted, save as regards the provisions of Articles 5 and 8.

Article 12.—The Convention shall be ratified at Brussels on or before 1st February 1903.

The Plenipotentiaries, having signed this Convention, agreed to a Final Protocol.

As regards Article 3, they agreed that the object of the Surtax is the efficacious protection of the market of each producing country, and that it might be increased in respect of sugars coming from any State in excessive quantity, and so invading a home market, not as the result of a factitious increase of price by agreement between producers, but as the consequence of actual economic inferiority.

The Permanent Commission will decide the question by a majority vote, and the increase of the Surtax is limited to 1 franc per 100 kilogrammes (=4·875d. per cwt., or 8s. 1½d. per ton).

As regards Article 11, the Governments of Great Britain and the Netherlands ageeed that, during the existence of the Convention, no Bounty, direct or indirect, or preference as against foreign sugars, shall be given to sugars of their Colonies, in their respective countries.

The Brussels Convention of 1902—if it be ratified—will put an end to a costly system, mischievous in principle, which has benefited a comparatively small number of people at the expense of unmerited and wholly unnecessary privation to the greater part of the population of the Continent; and it will constitute international legislation of a novel type which may prove beneficial to the world at large, for it will be a veritable organic law ruling a great trade under the common sanction of the leading European Powers.

The rates of the bounties it will remove are given in the subjoined table:—

TABLE I.

Amounts (reduced to English money per cwt. avoirdupois) of the total net sugar bounties granted by European Powers, according to the computation issued by the Secretary of the United States Treasury on the 12th December 1898. This forms the basis on which the United States countervailing duties are now being levied (July 1902) on all sugars imported from the countries specified:—

Sugars polarizing

From . . . To . . .	75° 88°	88° 93°	65° 98°	90° 98°	88° 99°	93° 99½°	98° 99½°	98° 100°	99° 100°	99½° 100°
	Bounties (per cwt.)									
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Countries—										
Russia .	2 3·3				2 11·1				3 4·65	
Austria-Hungary		1 2				1 3				1 9·3
France .			4 4¾							
Crystals								4 6½		
Refined								4 10½		
Germany .				1 3			1 6			1 9·3

Sugars classed as (per cwt.)

	Raw Sugar.	Refined Sugar.
	s. d.	s. d.
Countries—		
Belgium	1 10	2 2¼
Denmark		0 7·6

Sugars analysing in pure sugar (per cwt.)

			Hard Dry Refined.
Less than . .	98%	98% and over.	(Additional)
Country—	s. d.	s. d.	s. d.
Holland . .	1 10·8	1 6	0 3

The following table does not give the *Production of Sugar* in the world, but only the quantities of sugar dealt with in the sugar trade. The production of India, for instance, is not included:—

TABLE II.

The world's trade in cane and beet sugar in tons avoirdupois at decennial periods from 1840 to 1870 inclusive, and yearly from 1871 to 1901 inclusive, with the percentage of beet sugar and the average price per cwt. in shillings and pence.

Tons avoirdupois of 2240 pounds=1016 kilogrammes.

Year.	Cane.	Beet.	Total.	Per Cent. Beet.	Average Price per Cwt.
					s. d.
1840	1,000,000	50,000	1,150,000	4·35	48 0
1850	1,200,000	200,000	1,400,000	14·29	40 0
1860	1,510,000	389,000	1,899,000	20·43	35 0
1870	1,585,000	831,000	2,416,000	34·40	32 0
1871–72	1,599,000	1,070,000	2,619,000	38·95	24 0
1872–73	1,793,000	1,210,000	3,003,000	40·29	24 8
1873–74	1,840,000	1,288,000	3,128,000	41·17	22 10
1874–75	1,712,000	1,219,000	2,931,000	41·59	20 1
1875–76	1,590,000	1,343,000	2,933,000	45·78	18 1
1876–77	1,673,000	1,045,000	2,718,000	38·44	22 8
1877–78	1,825,000	1,419,000	3,244,000	43·74	23 0
1878–79	2,010,000	1,571,000	3,581,000	43·89	19 2
1879–80	1,852,000	1,402,000	3,244,000	43·21	19 3
1880–81	1,911,000	1,748,000	3,659,000	46·13	20 4
1881–82	2,060,000	1,782,000	3,842,000	46·38	20 4
1882–83	2,107,000	2,147,000	4,254,000	50·47	20 2
1883–84	2,323,000	2,361,000	4,684,000	50·40	16 8
1884–85	2,351,000	2,545,000	4,896,000	51·98	12 4
1885–86	2,339,000	2,223,000	4,562,000	48·72	13 1
1886–87	2,345,000	2,733,000	5,078,000	53·82	11 9
1887–88	2,465,000	2,451,000	4,916,000	49·85	12 9
1888–89	2,263,000	2,725,000	4,988,000	54·63	14 10
1889–90	2,069,000	3,633,000	5,702,000	63·71	15 1
1890–91	2,555,000	3,710,000	6,265,000	59·21	14 0
1891–92	2,852,000	3,501,000	6,353,000	55·10	13 6
1892–93	3,045,000	3,428,000	6,473,000	52·95	14 3
1893–94	3,490,000	3,890,000	7,380,000	52·71	13 5
1894–95	3,530,000	4,792,000	8,322,000	57·75	9 11
1895–96	2,830,000	4,315,000	7,155,000	50·30	10 7
1896–97	2,864,000	4,954,000	8,818,000	56·18	9 3
1897–98	2,898,000	4,872,000	7,770,000	62·70	11 9
1898–99	2,995,000	4,977,000	7,937,000	62·70	11 9
1899–1900	2,904,000	5,510,000	8,414,000	65·48	11 6
1900–1901	2,850,000	5,950,000	8,800,000	67·61	11 6

The quantities of cane sugar are based on the trade circulars of Messrs Willett & Gray of New York; those of beet sugar on the trade circulars of Messrs. F. O. Licht of Magdeburg; and the prices are obtained from statements supplied by importers into the United States of the cost in foreign countries of the sugars which they import. The table has been adapted from the Monthly Summary of Commerce and Finance of the United States, January 1902, prepared in the Bureau of Statistics, Treasury Department, Washington Government Printing Office, 1902.

TABLE III.

Quantities of raw and refined cane and beet sugar in tons avoirdupois, imported into the United Kingdom in 1870 and in 1875, and yearly from 1880 to 1901 inclusive, with the consumption per head of the population in pounds, and the price per cwt. of raw and refined sugar.

Year.	Raw Cane.	Raw Beet.	Refined Cane.	Refined Beet.	Total.	Consumption per Head.		Total.	Price per Cwt.	
						Raw.	Refined.		Raw.	Refined.
	Tons.	Tons.	Tons.	Tons.	Tons.	Pounds.	Pounds.	Pounds.	s. d.	s. d.
1870	556,000	84,000	3,000	82,000	725,000	...	...	...	...	...
1875	705,000	107,000	16,000	128,000	956,000	50·64	8·88	59·52	21 2	30 4
1880	590,000	260,000	11,000	140,000	1,001,000	51·09	9·46	60·55	21 9	29 5
1881	623,000	310,000	5,000	135,000	1,071,000	56·01	8·44	64·45	21 9	28 11
1882	726,000	265,000	6,000	133,000	1,130,000	58·78	8·38	67·16	21 1	28 8
1883	597,000	420,000	7,000	157,000	1,183,000	58·73	9·87	68·10	20 1	27 2
1884	582,000	399,000	53,000	160,000	1,194,000	55·57	12·58	68·15	15 6	28 11
1885	561,000	410,000	114,000	152,000	1,237,000	55·46	15·75	71·21	13 10	18 2
1886	468,000	339,000	71,000	247,000	1,125,000	44·61	18·75	63·36	13 0	16 8
1887	439,000	461,000	39,000	311,000	1,250,000	50·80	20·25	71·05	12 1	15 8
1888	574,000	319,000	2,000	342,000	1,237,000	47·97	19·99	67·96	13 5	17 8
1889	470,000	407,000	1,000	448,000	1,326,000	48·38	26·54	74·92	15 5	19 8
1890	283,000	503,000	15,000	484,000	1,285,000	42·87	28·22	71·09	12 6	16 4
1891	349,000	461,000	27,000	540,000	1,377,000	45·08	32·94	78·02	12 10	16 6
1892	386,000	429,000	2,000	529,000	1,346,000	44·58	30·63	75·21	13 0	17 1
1893	368,000	434,000	2,000	575,000	1,379,000	42·41	33·17	75·58	14 2	18 4
1894	324,000	391,000	1,000	696,000	1,412,000	37·18	39·90	77·08	11 5	15 6
1895	388,000	463,000	1,000	706,000	1,558,000	45·28	40·10	85·38	9 7	13 4
1896	381,000	406,000	1,000	738,000	1,526,000	40·94	41·53	82·47	10 5	13 7
1897	242,000	434,000	1,000	793,000	1,469,000	34·52	43·92	78·44	9 0	12 3
1898	286,000	478,000	1,000	825,000	1,560,000	39·89	45·29	85·18	9 8	12 5
1899	186,000	469,000	1,000	889,000	1,545,000	35·63	48·68	84·31	10 6	12 7
1900	150,000	512,000	1,000	961,000	1,624,000	35·48	52·23	87·71	10 5	12 10
1901	178,472	526,451	1,000	1,079,553	1,785,476	36·8	56·4	93·2	10 6	12 0

This table has been compiled from the Board of Trade Returns. The population of the United Kingdom in 1901 has been estimated at 41,605,220. In 1870 Mr Lowe, in Mr Gladstone's first administration, reduced the sugar duties to 6s. per cwt. on refined sugar and 4s. 2d. on raw sugar; and he further reduced these rates in 1873 to 3s. and 2s. In 1874 all duties on sugar were repealed by Sir Stafford Northcote's budget, in Mr Disraeli's second administration. In 1901 Sir Michael Hicks Beach, in Lord Salisbury's third administration, to meet extraordinary war expenditure imposed a duty of 4s. 2d. on refined sugar polarizing 98° to 100°, and on lower qualities at lower rates, down to 2s. on sugar not exceeding 76° polarization; and duties on molasses and sweetened goods on a scale adjusted to the percentage of the sweetening matter. [Regulations, Customs Bill of Entry Bill, B, 6th August 1901.] In the six months ending 30th June 1902, 959,142 tons of sugar have been imported, viz.:—Raw cane, 132,351 tons; raw beet, 284,055 tons; refined cane, 500 tons; refined beet, 542,236 tons. (Board of Trade Returns, July 1902.) In the statements for 1901 and 1902 the quantities of raw cane sugar include molasses—40 per cent. of the weight of the molasses as given in the returns being taken as raw sugar.

The following table gives the world's production of sugar for the seven years ending 1901–1902. It must be borne in mind that the figures obtainable in many cases do not in fact include the sugar consumed in the country; *i.e.*, they represent the quantities brought to market in the country, but not the whole crop. In other cases they represent the whole crop.

Table IV.

The cane and beet sugar crops of the world for 1901–1902, with the average of the crops for the seven preceding years from 1894–1895, in tons of 2240 lb.

(A) Cane Sugar. (Compiled from the United States Monthly Summary of Commerce and Finance, January 1902.)

Country.	Crop 1901–1902.	Average Crop for 7 years ending 1900–1901.
	Tons.	Tons.
Africa—		
Egypt	95,000	91,898
Mauritius	145,000	150,449
Réunion	35,000	37,764
Natal	26,000	20,745
Total in Africa	301,000	300,856
America—		
Argentina	115,000	110,394
Brazil	215,000	206,028
British Colonies—		
Trinidad	50,000	52,153
Barbados	60,000	47,992
Jamaica	30,000	29,143
Antigua and St Kitts	25,000	23,386
Demerara	95,000	94,826
Lesser Antilles	8,000	8,000
Total in British Colonies	268,000	255,500
Costa Rica	1,500	565
Cuba	875,000	443,309
Danish Colony, St Croix	13,000	11,151
Dutch Colony, Surinam	6,000	6,000
French Colonies—		
Martinique	32,000	32,519
Guadeloupe	35,000	40,342
Total in French Colonies	67,000	72,861
Ecuador	7,000	6,000
Guatemala	9,000	7,000
Haiti and St Domingo	45,000	46,400
Mexico	95,000	32,715
Nicaragua	3,500	2,036
Peru	105,000	82,927
Salvador	27,000	22,000
America (*continued*)—		
United States—		
Louisiana	290,000	257,142
Hawaiian Islands	300,000	227,839
Porto Rico	100,000	54,761
Total in United States	690,000	539,742
Venezuela	3,000	715
Total in America	2,653,000	1,795,743
Asia—		
British India and Dependencies	3,250,000	3,500,000
China	1,000,000	1,000,000
Dutch Colony, Java	765,000	612,905
Japan and Formosa	93,000	87,768
Siam	7,000	7,000
United States Possession— Philippine Islands	70,000	129,683
Total in Asia	5,185,000	5,337,306
Australia and Polynesia—		
British Colonies—		
Fiji Islands	33,000	30,715
New South Wales	19,000	27,072
Queensland	117,000	106,498
Total in Australia	169,000	164,285
Europe—Spain: Total in Europe	33,000	21,030
Summary—		
Africa	301,000	300,856
America	2,631,000	1,776,743
Asia	5,185,000	5,337,306
Australia and Polynesia	169,000	164,285
Europe	33,000	21,030
Total Production of Cane Sugar in the World	8,341,000	7,618,820

(B) Beet Sugar.

Country.	1894–1895.	1895–1896.	1896–1897.	1897–1898.	1898–1899.	1899–1900.	1900–1901.	1901–1902.	Average of 7 years (1894–1901).
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Austria-Hungary	1,039,145	778,926	919,256	818,532	1,034,686	1,090,509	1,076,764	1,299,154	822,545
Belgium	240,103	232,070	283,460	261,206	240,163	298,083	327,858	344,472	268,992
Denmark	48,155	47,887	52,422	38,661	43,215	54,757	49,676	56,861	47,826
France	779,994	675,305	740,203	808,264	817,021	962,406	1,151,851	1,181,050	845,292
Germany	1,815,452	1,589 602	1,807,529	1,823,592	1,694,525	1,770,223	1,952,846	2,263,670	1,779,110
Holland	83,260	101 142	171,455	123,674	147,398	168,328	175,268	196,841	139,218
Italy	2,057	2,605	2,263	3,816	5,878	22,746	59,175	79,721	14,077
Russia	605,337	700,849	717,158	727,057	763,809	891,431	904,325	1,082,630	758,566
United States	30,000	40,000	39,684	34,453	62,826	82,736	124,859	180,000	59,222
Other Countries	103,334	103,378	145,099	150,669	156,719	178,794	253,257	257,100	155,893
Total Crop of the World	4,746,837	4,257,764	4,878,529	4,789,924	4,966,240	5,520,013	6,075,879	6,941,499	5,033,312

Summary.

	Crop, 1901–1902.	Average of 7 years (1894–1901).
	Tons.	Tons.
Cane Sugar	8,341,000	7,618,820
Beet Sugar	6,941,499	5,033,312
Total Cane and Beet Sugar Crop of the World	15,282,499	12,652,132

Table B is compiled from data furnished by Messrs F. O. Licht, 7 and 8 Westendstrasse, Magdeburg, through Mr C. Czarnikow of London. The data for the Italian crop and the Danish crop are taken from official returns.

TABLE V.

Consumption per head of the population of nineteen principal countries for the year ending 21st August 1900, according to F. O. Licht of Magdeburg, with prices of sugar:—

Country.	Consumption per Head in Pounds.	Prices of Sugar per Pound.	
		Raw.	Refined.
		d.	d.
United Kingdom	91·6	2·0	2·125
United States	65·2	2·03	2·5
Switzerland	60·3	2·0	2·176
Denmark	54·8	1·57	2·42
Sweden and Norway	38·2	3·35	4·2
France	37·0	3·90	4·57
Germany	33·9	3·0	3·4
Netherlands	32·5	4·53	5·0
Belgium	23·3	3·7	4·35
Austria-Hungary	17·6	3·5	3·85
Portugal	14·6	4·14	5·27
Russia	14·0	3·4	4·27
Spain	10·6	4·0	4·64
Turkey	8·0	2·7	3·0
Rumania	7·8	none consumed	5·5
Greece	7·2	none consumed	3·7
Bulgaria	6·7	none consumed	3·4
Italy	6·0	6·3	6·85
Servia	5·3	none consumed	3·5

Beet sugar costs about £9, 6s. 8d. per ton—one penny per pound—to produce, and cane sugar a little less, and nearly all countries can produce one or the other. Yet for years past over 100 millions of people in Europe have been deprived of a sufficiency of most wholesome and desirable food, which would have been within their reach had not its production and consumption been hampered by vicious fiscal legislation. If the Brussels Convention end this state of things, much will be done for the comfort and comity of nations throughout the world. (V. W. CH.)

Suicide.—It is within comparatively recent years that the study of suicide by means of the vital statistics of various countries has demonstrated that while the act may be regarded as a purely voluntary one, yet that suicide as a whole is a phenomenon in the sociological history of every community which conforms to certain general laws, and which is influenced by conditions other than mere individual circumstances or surroundings. Thus it can be shown that each country has a different suicide-rate, and that while the rate for each country may fluctuate from year to year, yet it maintains practically the same relative proportions to the rates of other countries. The following table shows the suicide-rate for various countries (Bertillon):—

TABLE I.

Country.	Period of Observation.	Annual Number of Suicides per Million Inhabitants.
Saxony	1878–82	392
Denmark	1880–82	251
Switzerland	1878–82	239
Baden	,,	198
Würtemberg	1877–81	189
France	1878–82	180
Prussia	,,	166
Belgium	,,	100
Sweden	,,	92
England and Wales	,,	75
Norway	,,	69
Scotland	1877–81	49
Ireland	1878–82	17

In addition to furnishing materials for an approximately accurate estimate of the number of suicides which will occur in any country in a year, statistics have demonstrated that the proportion of male to female suicides is practically the same from year to year, viz., 3 or 4 males to 1 female; that it is possible to predict the month of greatest prevalence, the modes of death adopted by men on the one hand and women on the other, and even the relative frequency of suicide amongst persons following different professions and employments; and that in most of the countries of Europe the suicide-rate is increasing. In England and Wales the annual death-rate per million from suicide has steadily advanced, as is shown by the following figures for six quinquennia:—

1861–65	65	per million	living.
1866–70	66	,,	,,
1871–75	66	,,	,,
1876–80	74	,,	,,
1881–85	75	,,	,,
1886–90	79	,,	,,

The next table illustrates the continued increase in recent years, and at the same time shows the total number and the number of male and female suicides each year from 1888 to 1897:—

TABLE II.—Total Suicides—Male and Female—in England and Wales, 1888–97, together with the annual rate per million living (Registrar-General's Reports).

Year.	Male.	Female.	Total.	Suicide-rate per Million Living.
1888	1,732	576	2,308	81
1889	1,626	544	2,170	77
1890	1,635	570	2,205	79
1891	1,863	620	2,483	85
1892	1,907	676	2,583	87
1893	1,940	659	2,599	87
1894	2,052	677	2,729	91
1895	2,071	726	2,797	92
1896	1,979	677	2,656	86
1897	2,090	702	2,792	90
Total	18,895	6427	25,322	...

The reason of the high suicide-rate in some countries as compared with others, and the causes of its progressive increase, are not easily determined. Various explanations have been offered, such as the influence of climate, the comparative prevalence of insanity, and the proportionate consumption of alcoholic drinks, but none satisfactorily accounts for the facts. It may, however, be remarked that suicide is much more common amongst Protestant than amongst Roman Catholic communities, while Jews have a smaller suicide-rate than Roman Catholics. A point of considerable interest is the increase of suicide in relation to the advance of elementary education. Ogle states that suicide is more common among the educated than the illiterate classes. It is also more prevalent in urban than in rural districts. A curious feature in large towns is the sudden outbreak of self-destruction which sometimes occurs, and which has led to its being described as epidemic. In such cases force of example and imitation undoubtedly play a considerable part, as it is well recognized that both these forces exert an influence not only in causing suicide, but also in suggesting the method, time, and place for the act. No age above five years is exempted from furnishing its quota of suicidal deaths, although self-destruction between five and ten years is very rare. Above this age the proportion of suicides increases at each period, the maximum being reached between fifty-five and sixty-five. Among females there is a greater relative prevalence at earlier age periods than among males. The modes of suicide are found to vary very slightly in different countries. Hanging is most common amongst males; then drowning, injuries from firearms, stabs and cuts, poison, and precipitation from heights. Amongst females, drowning comes first, while poison and hanging are more frequent than other methods entailing effusion of blood and disfigurement of the person. The methods used in England and Wales by suicides during 1888–97, and in Scotland during the years 1881–97, are given in the following table:—

TABLE III.

Modes of Suicide in England and Wales, 1888–97.

Order of Frequency.	Males.		Females.		Both Sexes.	
	Mode.	Number.	Mode.	Number.	Mode.	Number.
1	Hanging	5,669	Drowning	2089	Hanging	7,005
2	Stab-cut	3,594	Poison	1652	Drowning	5,532
3	Drowning	3,443	Hanging	1336	Stab-cut	4,365
4	Poison	2,264	Stab-cut	771	Poison	3,916
5	Firearms	2,152	Firearms	52	Firearms	2,204
6	Otherwise	1,773	Otherwise	527	Otherwise	2,300
	Total	18,895	Total	6427	Total	25,322

Modes of Suicide in Scotland, 1881–97.

Order of Frequency.	Males.		Females.		Both Sexes.	
	Mode.	Number.	Mode.	Number.	Mode.	Number.
1	Hanging	741	Drowning	430	Drowning	1060
2	Drowning	630	Hanging	257	Hanging	998
3	Stab-cut	556	Poison	145	Stab-cut	700
4	Poison	257	Stab-cut	144	Poison	402
5	Firearms	245	Firearms	6	Firearms	251
6	Otherwise	207	Otherwise	100	Otherwise	307
	Total	2636	Total	1082	Total	3718

The season of the year influences suicide practically uniformly in all European countries, the number increasing from the commencement of the year to a maximum in May or June, and then declining again to a minimum in winter. Morselli attempts to account for this greater prevalence during what may well be called the most beautiful months of the year, by attributing it to the influence of increased temperature upon the organism, while Durkheim suggests that the determining factor is more probably to be found in the length of the day and the effect of a longer period of daily activity. The suicide-rate is higher in certain male occupations and professions than in others (Ogle). Thus it is high amongst soldiers, doctors, innkeepers, and chemists, and low for clergy, bargemen, railway drivers and stokers. The suicide-rate is twice as great for unoccupied males as for occupied males.

AUTHORITIES.—MORSELLI. *Il Suicidio.* Milan, 1879.—LEGOYT. *Le Suicide ancien et modern.* Paris, 1881.—WESTCOTT. *Suicide, its History, Literature, &c.* London, 1885.—OGLE. "Suicides in England and Wales, in relation to Age, Sex, Season, and Occupation," *Journal of the Statistical Society*, vol. xlix. 1886.—STRAHAN. *Suicide and Insanity.* London, 1893.—MAYR. "Selbstmord statistik," in *Handwörterbuch der Staatswissenschaften.* Jena, 1895.—DURKHEIM. *Le Suicide.* Paris, 1897. (H. H. L.)

Suidun (Chinese, *Sui-din-chen*), a town of China, and capital of the Kulja province. It is the residence of the governor-general, and was founded in 1762 during the Mussulman uprising, and rebuilt in 1883. It is a military town, with little trade, which has military provision stores, an arsenal, and an arms workshop. Its walls are armed with steel guns.

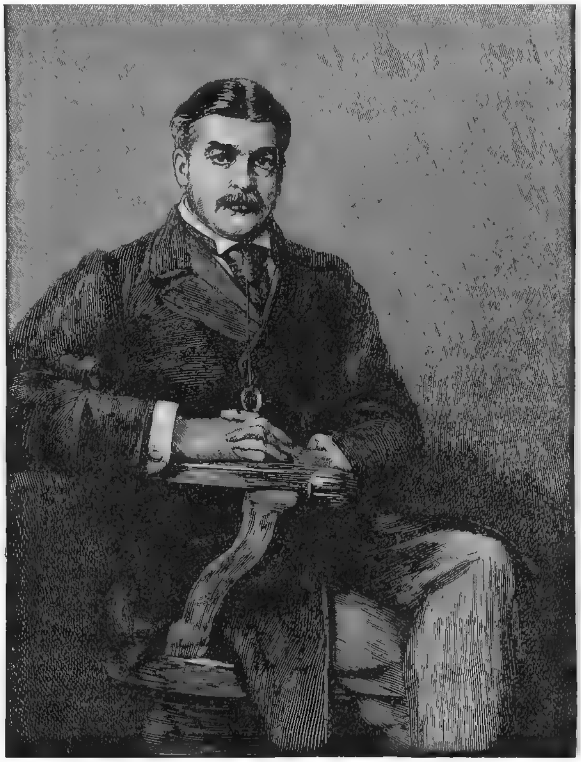
Sukhum-Kale, a seaport and district town in the province of Kutais, Caucasia, Russia. It is the best roadstead on the eastern coast of the Black Sea, being fairly well sheltered and never freezing, and in spite of the difficulties of communication with the interior and the malarial marshes which surround the town, it has lately become an important port for the export of grain (chiefly Indian corn), and has begun rapidly to develop. In 1897 its population was 7809. It was formerly the seat of ancient Dioskuria and of a Turkish fortress.

Sukkur, or SAKHAR, a town of British India, in the Shikarpur district of Sind, Bombay, on the right bank of the Indus, 24 miles north-west of Shikarpur town. Population (1881), 27,389; (1891), 28,935; (1901), 31,316. Sukkur owes its importance to its position on a limestone ridge running down to the Indus, opposite the island of Bukkur. It has always commanded the trade of Sind, and the river is now crossed by a cantilever bridge carrying the North-Western Railway to Kotri. There is an industrial school.

Suleimanieh, the chief town of a sanjak of the same name in the Mosul vilayet of Asiatic Turkey, and a military station, altitude 2550 feet, situated in a bare, treeless plain near the Persian frontier. It commands several routes to Persia, and is sometimes called the capital of southern Kúrdistán. Population, Kúrds 10,000, Christians 150, Jews 850.

Sulina, a town in Rumania, situated at the mouth of the Sulina branch of the Danube. It is the only free port on the Danube, and is much used for the transhipment into sea-going vessels of grain which is brought down the river in large lighters. No grain or other kind of agricultural produce is grown in its neighbourhood, owing to the dense reed-covered swamps with which it is surrounded. It is the headquarters of the technical department of the European Commission of the Danube. Large steamers navigate up to Galatz and Braila. In 1901, 1411 steamers and sailing craft aggregating 1,830,000 tons register cleared from Sulina for European ports carrying, besides other merchandise, nearly thirteen million quarters of grain. Owing to the improvements effected by the European Commission, there is now a depth of 24 feet of water on the bar. The town is dirty and insanitary. It contains a pretty little English church, the only one existing in Rumania. Population (1895), 5000; (1900), 5611.

Sullivan, Sir Arthur Seymour (1842–1900), English musical composer, was born in London 13th May 1842, being the younger of the two sons of Thomas Sullivan, a cultivated Irish musician who was bandmaster at the Royal Military College, Sandhurst, from 1845 to 1856, and taught at the Military School of Music at Kneller Hall from 1857 till his death in 1866. His mother, *née* Mary Coghlan (1811–1882), had Italian blood in her veins. Arthur Sullivan was brought up to music from boyhood, and he had learnt to play every wind instrument in his father's band by the age of eight. He was sent to school at Bayswater till he was twelve, and then, through Sir George Smart, he was, at his own persistent request, made a Chapel Royal chorister, and entered Mr Helmore's school for Chapel Royal boys in Cheyne Walk. He had a fine treble voice, and sang with exceptional taste. In 1856 the Mendelssohn Scholarship at the Royal Academy of Music was thrown open for the first time for competition, and was won by Sullivan, his nearest rival being Joseph Barnby. At the Academy he studied under Sterndale Bennett, Arthur O'Leary, and John Goss, and did so well that he was given an extension of his scholarship for two years in succession. In 1858, his voice having broken, he was enabled by means of his scholarship to go to study at the Conservatorium of Leipzig. There he had for teachers Moscheles and Plaidy for pianoforte, Hauptmann for counterpoint, Rietz and Reinecke for composition, and F. David for orchestral playing and conducting. Among his fellow-students were Grieg, Carl Rosa, Walter Bache, J. F. Barnett, and Edward Dannreuther. Instead of the Mendelssohn *cultus* which represented orthodoxy in London, German musical interest at this period centred in Schumann, Schubert, and the growing reputation of Wagner, while Liszt and Von Bülow were the celebrities of the day. Sullivan thus became acquainted for the first time with masterpieces which were then practically ignored in England. He entered enthusiastically into the spirit of the place, and after two years' hard study returned to London in April 1861. Before doing so, however, he had composed his incidental music for *The Tempest*, which he had begun as a sort of diploma work. Sullivan set himself to find converts in London to the enthusiasms he had imbibed at Leipzig. He became acquainted with George Grove, then secretary of the Crystal Palace, and August Manns, the conductor there; and at his instigation Schumann's First Symphony was introduced at one of the winter concerts. Early in 1862 Sullivan showed Grove and Manns his *Tempest* music, and on 5th April it was performed at the Crystal Palace. The production was an unmixed triumph, and Sullivan's exceptional gifts as a composer were generally recognized from that moment. He had hitherto been occupying himself with teaching, and he continued for some years to act as organist at St Michael's, Chester Square, but henceforth he devoted most of his time to composition. By 1864 he had produced his "Kenilworth" cantata (remembered chiefly for the lovely duet, "How sweet the Moonlight"), the "Sapphire Necklace" overture, and the five beautiful songs from Shakespeare, which include "Orpheus with his lute," "Oh Mistress Mine," and "The Willow Song." His attractive personality, combined with his undoubted genius and brilliant promise, brought him many friends. Costa, who was conductor at Covent Garden, gave him the post of organist, and in 1864 he produced there his *L'Ile Enchantée* ballet. Some of his spare time was spent in Ireland, where in 1863 he began the composition of his ("Irish") Symphony in E, which was produced at the Crystal Palace in 1866. The most important event, however, at this period, as bearing upon his later successes, was his co-operation with F. C. Burnand in the musical extravaganza *Cox and Box*, which first showed his capacity for musical drollery. This was acted privately in 1866, and was completed for public performance in 1867, in which year Sullivan again co-operated with Burnand in *Contrabandista.* Meanwhile he was in request as a conductor, and was made professor of composition at the Academy. His father's sudden death in 1866 inspired him to write the fine "In Memoriam" overture, which was produced at the Norwich Festival. In 1867, besides producing his "Marmion" overture, he and Grove did a great service to their art by bringing to light at Vienna a number of lost Schubert MSS., including the *Rosamunde* music. About this time Sullivan induced Tennyson to write his song-cycle "The Window," to be illustrated by Millais, with music by himself. But Millais abandoned the task, and Tennyson was not happy about his share; and the series, published in 1871, never became popular, in spite of Sullivan's dainty setting. In 1869 he brought out his oratorio "The Prodigal Son" at Worcester, and in 1870 his overture "Di Ballo" at Birmingham.



SIR ARTHUR SULLIVAN.

(From a photograph by Walker & Cockerell of the painting by Sir John Millais in the National Portrait Gallery.)

In 1871 Sullivan had become acquainted with W. S. Gilbert (*q.v.*), and in 1872 they collaborated in a piece for the Gaiety Theatre, called *Thespis; or, The Gods Grown Old*, which was a great success in spite of the limited vocal resources of the performers. In 1875 Mr D'Oyly Carte, then acting as manager for Selina Dolaro at the Royalty, approached Gilbert with a view to his collaborating with Sullivan in a piece for that theatre. Gilbert had already suggested to Sullivan an operetta with its scene in a law court, and within three weeks of his completing the libretto of *Trial by Jury* the music was written. The piece succeeded beyond all expectation; and on the strength of its promise of further successes Mr D'Oyly Carte formed his Comedy Opera Company and took the Opéra Comique Theatre. There in 1877 *The Sorcerer* was produced, Mr George Grossmith and Mr Rutland Barrington being in the cast. In 1878 *H.M.S. Pinafore* was brought out at the Opéra Comique. At first it did not attract large audiences, but eventually it became a popular success, and ran for 700 nights. In America it was enthusiastically received, and the two authors, with Mr D'Oyly Carte, went over to the States in 1879, with a company of their own, in order to produce it in New York. To secure the American rights for their next opera, they brought out *The Pirates of Penzance* first at New York in 1879. In 1880, in London, it ran for nearly 400 nights. In 1881 *Patience* was produced at the Opéra Comique, and was transferred later in the year to the Savoy Theatre. There all the later operas came out: *Iolanthe* (1882), *Princess Ida* (1884), *The Mikado*—perhaps the most charming of all—(1885), *Ruddigore* (1887), *The Yeomen of the Guard* (1888), *The Gondoliers* (1889). This succession of pieces by Gilbert and Sullivan had made their united names stand for a new type of light opera. Its vogue owed something to such admirable performers as Mr George Grossmith—famous for his "patter songs"—Mr Rutland Barrington, Miss Jessie Bond, Miss Brandram, and later Mr W. H. Denny and Mr Walter Passmore; but these artistes only took advantage of the opportunities provided by the two authors. In place of the old adaptations of French *opéra bouffe* they had substituted a genuinely English product, humorous and delightful, without a tinge of vulgarity or the commonplace. But disagreements now arose between them which caused a dissolution of partnership. Sullivan's next Savoy opera, *Haddon Hall* (1892), had a libretto by Mr Sydney Grundy; and the resumption of Mr Gilbert's collaboration in 1893 in *Utopia, Limited*, and again in 1896 in *The Grand Duke*, was not as successful as before. Sullivan's music, however, still showed its characteristic qualities in *The Chieftain* (1894)—largely an adaptation of *Contrabandista; The Beauty Stone* (1898), with a libretto by Mr Pinero and Mr Comyns Carr; and particularly in *The Rose of Persia* (1900), with Captain Basil Hood.

In the public mind Sir Arthur Sullivan (who was knighted in 1883) had during these years become principally associated with the enormous success of the Savoy operas; but these by no means exhausted his musical energies. In 1872 his "Te Deum" for the recovery of the Prince of Wales was performed at the Crystal Palace. In 1873 he produced at the Birmingham Musical Festival his oratorio "The Light of the World," in 1877 he wrote his incidental music to *Henry VIII.*, in 1880 his sacred cantata "The Martyr of Antioch," and in 1886 his masterpiece, "The Golden Legend," was brought out at the Leeds Festival. "The Golden Legend" satisfied the most exacting critics that for originality of conception and grandeur of execution English music possessed in Sullivan a composer of the highest calibre. In 1891, for the opening of Mr D'Oyly Carte's new English opera-house in Shaftesbury Avenue he wrote his "grand opera" *Ivanhoe* to a libretto by Julian Sturgis. The attempt to put an English opera on the stage for a long run was doomed to failure, but *Ivanhoe* was full of fine things. In 1892 he composed incidental music to Tennyson's *Foresters*. In 1897 he wrote a ballet for the Alhambra, called *Victoria and Merrie England*. Among his numerous songs, a conspicuous merit of which is their admirable vocal quality, the best known are "If Doughty Deeds" (1866), "The Sailor's Grave" (1872), "Thou'rt Passing Hence" (1875), "I would I were a King" (1878), "King Henry's Song" (1878), and "The Lost Chord" (1877). This last, hackneyed as it became, was probably the most successful English song of the 19th century. It was written in 1877, during the fatal illness of Sullivan's brother Frederic, who, originally an architect, had become an actor, and by means of his fine voice and powers as a comedian (best shown as the Judge in *Trial by Jury*) had won considerable success. Among Sullivan's many hymn tunes, the stirring "Onward, Christian Soldiers!" (1872) is a permanent addition to Church music. In 1876 he accepted the principalship of the National Training School of Music, which he held for six years; this was the germ of the subsequent Royal College. He received the honorary degree of Mus. Doc. from both Oxford (1879) and Cambridge (1876). In 1878 he was a member of the Royal Commission for the Paris Exhibition. He was conductor of the Leeds Festivals from 1879 to 1898, besides being conductor of the Philharmonic Society in 1885. Apart from his broad sympathy and his practical knowledge of instruments, his work as a conductor must always be associated with his efforts to raise the standard of orchestral playing in England and his unwearying exertions on behalf of British music and British musicians. Sullivan liked to be associated in the public mind with patriotic objects, and his setting of Mr Kipling's "Absent-minded Beggar" song, at the opening of the Boer war in 1899, was, with the exception of *The Rose of Persia*, the last of his compositions brought out in his lifetime. He died somewhat suddenly of heart failure on 22nd November 1900, and his burial in St Paul's Cathedral was the occasion of a remarkable demonstration of public sorrow. He left unpublished a "Te Deum" written for performance at the end of the Boer war, and an unfinished Savoy opera for a libretto by Captain Hood, which, completed by Mr E. German, was produced in 1901 as *The Emerald Isle*.

Sullivan was the one really popular English composer of any artistic standing in his time; and his celebrity as a public man still somewhat interferes with a definite judgment as to his place in the history of English music. One of the most agreeable companions, broad-minded, and free from all affectation, he was intensely admired and loved in all circles of society; and though his health was not robust, for he suffered during many years at intervals from a painful ailment, he was a man of the world who enjoyed the life which his success opened out to him without being spoilt by it. He was always a devoted and an industrious musician, and from the day he left Leipzig his influence was powerfully exerted in favour of a wider and fuller recognition of musical culture. He was accused in some quarters of being unsympathetic towards Wagner and the post-Wagnerians, yet he had been one of the first to introduce Wagner's music to English audiences. He was keenly appreciative of new talent, but his tastes were too eclectic to satisfy the enthusiasts for any particular school; he certainly had no liking for what he considered uninspired academic writing. Serious critics deplored, with more justification, that he should have devoted so much of his great natural gift not merely to light comic opera, but to the production of a number of songs which, though always musicianly, were really of the nature of "pot-boiling." Sullivan was an extremely rapid worker, and his fertility in melody made it easy for him to produce what would please a large public. Moreover, it must be admitted that his great social success, so early achieved, was not calculated to nourish a rigidly artistic ideal. But when all is said, his genius remains undisputed. His Church music alone would entitle him to a high place among composers; and "The Golden Legend," *Ivanhoe*, the "In Memoriam" overture, the "Irish" symphony, and the charming "incidental music" to *The Tempest* and to *Henry VIII.* form a splendid legacy of creative effort, characterized by the highest scholarly qualities in addition to those beauties which appeal to every ear. Whether his memory will be chiefly associated with these works, or rather with the world-wide popularity of some of his songs and comic operas, time alone can tell. The Savoy operas did not aim at intellectual or emotional grandeur, but at providing innocent and wholesome pleasure; and in giving musical form to Gilbert's witty librettos Sullivan showed once for all what light opera may be when treated by the hand of a master. His scores are as humorous and fanciful *quâ* music as Gilbert's verses are *quâ* dramatic literature. Bubbling melody, consummate orchestration, lovely songs and concerted pieces (notably the famous vocal quintets) flowed from his pen in unexhausted and inimitable profusion. If he had written nothing else, his unique success in this field would have been a solid title to fame. As it was, it is Sir Arthur Sullivan's special distinction not only to have been prolific in music which went straight to the hearts of the people, but to have enriched the English *répertoire* with acknowledged masterpieces, which are no less remarkable for their technical accomplishment.

The only regular biography is *Sir Arthur Sullivan: Life-story, Letters, and Reminiscences*. By ARTHUR LAWRENCE. London: Bowden, 1899. Besides being largely autobiographical, this volume contains a complete list of Sullivan's works, compiled by Mr Wilfrid Bendall, who for many years acted as Sir Arthur's private secretary.

(H. CH.)

Sully, James (1842–——), English psychologist, was born 3rd March 1842, at Bridgewater, and was educated at the Independent College, Taunton, the Regent's Park College, and Göttingen. He was originally destined for the Nonconformist ministry, but in 1871 adopted a literary and philosophic career. In 1892 he was appointed professor of the philosophy of mind at University College, London. His published books are entitled *Sensation and Intuition* (1874), *Pessimism* (1877), *Illusions* (1883), *Outlines of Psychology* (1884), *Teacher's Handbook of Psychology* (1886), *The Human Mind* (1892), *Studies of Childhood* (1895), and *Children's Ways* (1897). Professor Sully is an adherent of the associationist school of psychology, and his views have great affinity with those of professor Bain. Without making very striking advances, his monographs, as that on pessimism, have been always ably and brightly written, and his textbooks, of which *The Human Mind* is the most important, are models of sound exposition.

Sully-Prudhomme, René François Armand Prudhomme (1839–——), French poet, was born in Paris on the 16th of March 1839. He was educated at the Lycée Bonaparte, where after a time he devoted himself entirely to the study of science, and took his degree as Bachelier ès Sciences. An attack of ophthalmia then interrupted his studies and necessitated an entire change in the course of his career. The scientific habit of mind, however, which he had derived from these years of technical study never left him; and it is in the combination of this scientific bent, with a soul aspiring towards what lies above and beyond science, and a conscience perpetually in agitation, that the striking originality of Sully-Prudhomme's character is to be found. He found employment for a time in the Schneider factory at Creuzot, but he soon abandoned an occupation to which he was eminently unsuited. He subsequently decided to read law, and entered a notary's office at Paris. It was during this period that he composed those early poems which were not long in acquiring celebrity among an ever-widening circle of friends. In 1865 he published his first volume of poems, which had for sub-title *Stances et Poèmes*. This volume attracted considerable attention in the literary world, and was favourably noticed by Sainte-Beuve. It was at this moment that the small circle of which Leconte de Lisle was the centre were preparing the *Parnasse*, to which Sully-Prudhomme contributed several pieces. In 1866 Lemerre published a new edition of the *Stances et Poèmes* and a collection of sonnets entitled *Les Epreuves* (1866). From this time forward Sully-Prudhomme devoted his life entirely to poetry. It was in the volume of *Les Epreuves* that the note of melancholy which was to dominate through the whole work of his life was first clearly discernible. In 1869 he published a translation of the first book of Lucretius with a preface, and *Les Solitudes*. In 1870 a series of domestic bereavements and a serious paralytic illness resulting from the strain and fatigue of the winter of 1870, during which he served in the Garde Mobile, shattered his health in a way which made an entire recovery impossible. In 1872 he published *Les Écuries d'Augias, Croquis Italiens, Impressions de la Guerre* (1866–72) and *Les Destins, La Révolte des Fleurs* in 1874, in 1875 *Les Vaines Tendresses*, in 1878 *La Justice*, in 1886 *Le Prisme*, and in 1888 *Le Bonheur*. All these poems were collected and republished under the title of *Poesies*, 1879–86. He also published two volumes of prose criticism, *L'Expression dans les Beaux Arts* (1884) and *Réflexions sur l'Art des Vers* (1892). Various monographs by him appeared from time to time in the philosophical reviews, and among them a remarkable series of essays[1] on Pascal. After 1870 there are no remarkable incidents to chronicle in the life of Sully-Prudhomme save his election to the Academy, 8th December 1881, and the award to him by the Swedish Academy on 10th December 1901 of the Nobel prize of 200,000 francs for literature. During later years he lived at Aulnay in great isolation, a victim of perpetual ill-health, mainly occupied with a great work on Pascal.

What strikes the reader of Sully-Prudhomme's poetry first and foremost is the fact that he is a thinker; and moreover a poet who thinks, and not a thinker who turns to rhyme for recreation. The most strikingly original portion of his work is to be found in his philosophic and scientific poetry. If he has not the scientific genius of Pascal, he has at least the scientific habit of mind and a delight in mathematic certainties. In attempting to interpret the universe as science reveals it to us he has created a new form of poetry which is not lacking in a certain grandeur. One of his most beautiful poems, "L'Ideal" (*Stances et Poèmes*), is inspired by the thought, which is due to scientific calculations, of stars so remote from our planet that their light has been on its way to us since thousands of centuries and will one day be visible to the eyes of a future generation. The second chief characteristic of Sully-Prudhomme's poetry is the extreme sensibility of soul, the profoundly melancholy note which we find in his love lyrics and his meditations. Sully-Prudhomme is above all things introspective: he penetrates into the hidden corners of his heart; he lays bare the subtle torments of his conscience, the shifting currents of his hopes and fears, belief and disbelief in face of the riddle of the universe to an extent so poignant as to be sometimes almost painful. And to render the fugitive phases and tremulous adventures of his spirit he finds incomparably delicate shades of expression, an exquisite and sensitive diction. We are struck in reading his poems by the nobility of his ideas, by a religious elevation like that of Pascal; for there is in his work something both of Lucretius and of Pascal. Yet he is far from being either an Epicurean or a Jansenist; he is rather a Stoic to whom the deceptions of life have brought pity instead of bitterness.

As an artist Sully-Prudhomme is remarkable for the entire absence of oratorical effort; for the extreme simplicity and fastidious precision of his diction. Other poets have been endowed with a more glowing imagination; his poetry is neither exuberant in colour nor rich in sonorous harmonies of rhyme. The grace of his verse is a grace of outline and not of colour, his melody one of subtle rhythm; his verse is as if carved in ivory, his music like that of a perfect unison of stringed instruments. His imagination is inseparable from his ideas, and this is the reason of the extraordinary perspicuity of his poetic style. He extends poetry to two extreme limits; on the one hand to the borderland of the unreal and the dreamlike, as in a poem such as "Le Rendezvous" (*Vaines Tendresses*), in which he seems to express the inexpressible in precise language; on the other hand, in his scientific poems he encroaches on the province of prose. His poetry is plastic in the creation of forms which fittingly express his fugitive emotions and his elevated ideas. Both by the charm of his pure and perfect phrase, by his consummate art, and the dignity which informs all his work, Sully-Prudhomme deserves rank among the foremost of contemporary poets.

Sultanpur, a town and district of British India, in the Fyzabad district of Oudh. The town is on the right bank of the river Gumti, half-way between Benares and Lucknow. Population (1881), 9374; (1891), 8751; municipal income (1897–98) Rs.14,494, less than half from octroi; incidence of taxation, 13 annas per head. It is no longer a military cantonment. There is a printing-press and a literary institute.

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[1] *Revue des Deux Mondes*, 15th October to 15th November 1890.

The district of SULTANPUR has an area of 1710 square miles; population (1881), 957,912; (1891), 1,075,851, showing an increase of 12 per cent., compared with a decrease of 8 per cent. in the previous twelve years; average density, 629 persons per square mile. In 1901 the population was 1,084,115, showing an increase of less than 1 per cent. Land revenue and rates, Rs.13,59,371, the incidence of taxation being R.1.3.2 per acre; cultivated area (1896–97), 596,042 acres, of which 273,848 were irrigated from wells, tanks, &c.; number of police, 2383; vernacular schools 120, with 5809 pupils; registered death-rate (1897) 40·75 per 1000. The principal crops are rice, pulse, wheat, barley, sugar-cane, and a little opium. The main line of the Oudh and Rohilkhand railway just touches the eastern corner of the district.

Sumatra, the westernmost and, next to Borneo, the largest of the Great Sunda islands comprised in the East Indian Archipelago, stretching N.W. to S.E. from Malacca Passage to Sunda Strait, between 5° 40′ N. and 5° 59′ S. and 95° 16′ and 106° 3′ 45″ E., with an area, including the neighbouring islands, all but Banka and Billiton, of 178,338 square miles.

Geology.—Dutch mining engineers and the Austrian geologists Professors Suess and Neumayr all concur in the opinion that the mountain-chain of Arakan, dipping under sea-level and following, as a submarine chain, the direction of the Cocos, Andaman, and Nicobar islands, re-emerges in Sumatra, while the parallel chain of Burma, making its submarine passage in the direction of the Mergui Archipelago and Malacca, rises above the water again in the Riouw group, Banka, and Billiton. The same sandstone, slate, older and younger Tertiary formations, volcanoes, beds of petroleum, and the same direction in the folds, characterize both chains alike, which in Sumatra become united. Dr Verbeek has elucidated the folding undergone by the strata of Sumatra in several geological periods. This folding induced oscillations, and hence cleavages and ruptures, through which burst the eruptive rocks, whose differences of altitude register differences of level at different parts of the island in the various geological periods. In the lines of those cleavages, longitudinal and transverse, as in Java, lie the volcanoes of Sumatra, as also lakes like Toba, and Singkara, which had their origin in the breaking down of the edges of craters, mostly in the direction of the longitudinal line. In the same direction lie also the succession of valleys, overspread with fertile pumice-stone, on which the population is most concentrated. Everywhere in Sumatra slate, sandstone, and limestone are found, constituting, with the older eruptive rocks, the Palæozoic chains and ranges which run through the island in a N.W. to S.E. direction. Rocks of the Mesozoic period very rarely crop out on the surface, and refer to a period during which Sumatra was elevated above the sea; Dr Volz has discovered indications of them near Toba Lake. The higher plateaux and valleys are formed of Tertiary rocks and diluvial tuffs; the lower plains, of the alluvium of sea and rivers. As in Java, the younger volcanoes have largely covered the old rocks with their scoriæ, dammed the lakes, diverted the course of rivers, and closed in valleys. According to the W. to E. profiles from the hand of Dr Verbeek, the coast and lower plains of alluvium, here and there of higher diluvium, are succeeded by chains of Palæozoic rocks, known as the Barisan or "Chain," often forming the watershed, which consists of granite and the primary rocks already referred to. Next in order come the tuff plateaux or valleys, deeply eroded by rivers flowing in and out of the crater-formed lakes. Occasionally there are two or three valleys spreading out parallel to one another, hemmed in on both sides by the older chains, varying in height, but declining towards the east from 4000 to 3000 and to 2500 feet, and closed in on the N. and S. by the colossal mass of the higher volcanoes.

Orography.—In order to an appreciation of the orography of the island, the following sections of Sumatra should be well discriminated from one another:—1st. The valley of the Atjeh or Achin or Acheen river. 2nd. The plains around the lake of Toba of varied level and physical character. Those on the S. and N. are higher, 4000 feet high, having the character of steppes, with scantier forest-cover, and, save in the narrow valleys and river-courses, properly available for cattle-rearing. The plains on the E. and W. are of a lower level, eroded by larger rivers, clothed with forest, showing more sawahs and ladangs, or dry rice-fields, and, near the rivers, planted with jagong (maize), coffee, and fruits. Unless on the S.E., where the Asahan flows away to the east coast, Toba Lake is surrounded by steep shores. According to Verbeek, van Dyk, Hagen, and Volz, the lake had its origin in the collapse of a volcano. 3rd. The valley of the Batang Toru, with the plateau of Sipirok in the E. and the mountain-chain of Tapanuli in the W. On the S. and S.E. the valley is bounded by two volcanoes, Lubuk Raja and Si Buwal Buwali, whence were derived the volcanic tuffs of the valley and of the plateau of Sipirok, with their lakes drained by the Batang Toru and its affluents. The valley is in the N. nearly 3000 feet high, in the S. 1150 feet, and varies in breadth from 5½ miles to half a mile and less. Flowing in a deep bed cut in the tuff strata, the river is not navigable. 4th. The longitudinal valley of Batang Gadis, with its affluent the Angkola, and in the S. the valley of the Sumpur, the upper coast of the Rocan, between the Lubuk Raja in the N. and the Merapi Mount in the S. This valley is 64 miles long, with a mean breadth of 4 to 5 miles. All the rivers of this valley, flowing in deep beds of eroded diluvial tuffs, with a fall as much sometimes as 330 to 660 feet a mile (or a little more), are unnavigable. The valley is bounded on the W. and the E. sides by chains of slate and Palæozoic rocks. The bottom is in many parts the diluvium of lakes drained by the rivers. 5th. The section of middle Sumatra between a line on the N. side of the three volcanoes, viz., Singalang-Tandikat, Merapi, and Sago, and the line on the S. formed by the three mountains Patah Sembilan, Peak of Korintyi, and Tujuh. This section is divided by the Middengebergte or middle chain into a northern half watered by the Ombilin or Upper Indragiri with its affluents, and a southern half traversed by the Batang Hari or Upper Jambi. To the N. of the volcanoes, which rise to 9500 feet or more, this section is occupied by a high plateau of volcanic formation, whose elevation declines in a direction from W. to E. from 2950 to 1640 feet, with the lake of Maninyu (about 40 square miles in area) filling the hollow of an old volcano, and with rivers which have eroded their beds in the tuffs to a depth of 300 feet and more. South of the volcanoes the northern affluents of the Ombilin—Sumpur, Sello, and Sinamar—flow through valleys parallel to one another in a N.W. to S.E. direction. Here, too, are found fertile tuffs, and the valleys are densely populated. The rivers, however, are, like those already characterized, and for the same reason, not available as waterways. Singkara Lake (44 square miles) is of origin similar to that of Maninyu. The Ombilin, issuing out of the lake on the east side and flowing through a plateau of Eocene sandstone, has on its banks the coalfields of Sungei Durian, &c., but is not serviceable as a waterway for that part of Sumatra. The coal has to be transported by railway over Solok to Padang (Emmahaven), a seaport on the west coast. Solok lies on the Sumami, which, flowing from the S. to the lake of Singkara, prolongs the valley of the Sumpur to the Middengebergte. Unlike the northern, the southern affluents of the Ombilin do not rejoice in longitudinal valleys hemmed in by the Barisan and ranges of slate, limestone, and sandstone. Here prevailing granite and diabase give rise to a complicated mountain system through which the rivers cleave their way in a curved and irregular course. South of the Middengebergte, however, the northern affluents of the Batang Hari, the Seliti, Gumanti, Si Potar, Mamun, and Pangean, at least those in the W., again run in longitudinal valleys. As shown by the reports of the Sumatra Expedition, these affluents and the Batang Hari itself (except the part at the mouth, Mamun-Simalidu) are navigable only by praus drawing not more than 12 inches. 6th. South Sumatra, so far as known, presents everywhere in its valleys the same character as that of Batang Toru, Batang Gadis, Sumpur, &c. Its eastern valleys, however, are not so high and continuous as its western. They also are closed in on the N. and S. by volcanoes which here produced the same masses of tuff, with lakes and rivers of the same formation as in the N. Such are the valley of Korintyi with the river of the same name, between the Peak of Korintyi and the Raja Mount; the valleys of Serampei and Sungei Tenang (as imperfectly known as that of the Korintyi), in which are to be sought the sources of the Tambesi and Asei, both affluents of the Jambi; the longitudinal valley of Ketaun, in Lebong, flowing to the west coast, and of the Upper Musi flowing to the east coast; the valleys of Makakau and Selabung or the Upper Komering, an affluent of the Musi, between Sebelat and Kaba. The Makakan and Selabung drain into Lake Ranau, which on the south side is dammed by the volcano Seminung. The southernmost valley of Sumatra is that of the Semangka flowing into the bay of the same name. All these valleys, with their rivers, lakes, and volcanoes, are of a like nature with that of those already described. Generally the lower valleys of the rivers have a relief of 600 to 1000 feet; the higher valleys occupy heights of from 2500 to 3000 feet; the mountain chains rise to 5500 feet; the volcanoes tower up from 6500 to nearly 10,000 feet. 7th. The section of south Sumatra between the eastern chain of old rocks and the east coast with its numerous river mouths. This section is formed of the alluvium of sea and rivers. In the river-beds, however, and at some distance from the sea, older strata and eruptive rocks underlie the alluvium. The strata near the mountain chains and volcanoes consist of diluvial tuffs, which, though not reaching the height of the western half of the island, indicate considerable elevation also on that side. The eastern plain increases from N. to S.

Rivers.—The middle and lower courses of the larger rivers—the Musi, Jambi, Indragiri, Kampar, Siak, Rocan, Panei, and Bila, and Asahan—all flowing eastwards, along with many of their affluents are navigable over considerable stretches for craft drawing 6 to 10 feet. The Musi and Jambi are navigable for 372 and 497 miles respectively. As waterways, all the rivers labour under the drawbacks of rapids, mudbanks at their mouths, banks overgrown with forest, sparse population, and currents liable to serious variations due to irregularity of supply from the mountains and sudden rainfalls.

Climate.—As throughout the whole of the Malayan Archipelago, so also in Sumatra, which lies about equally balanced on both sides of the Equator, the temperature stands at a high level subject to but slight variations. The monthly temperature mounts only from 77° Fahr. in February to 80·6° Fahr. in May, August, and November. In the distribution of the rainfall as dependent on the direction of the winds, the following parts of Sumatra must be distinguished:—1st. S.E. Sumatra, on which, as on Banka and Billiton, the heaviest rainfall occurs during the N.W. monsoon, the annual volume of rainfall increasing from 98·4 inches in the E. to 139 inches in the W. Of the 139 inches yearly rainfall, 91·7 inches are brought by the N.W. and 47·3 inches by the S.E. monsoon. 2nd. The west coast. Here the rainfall for the year increases from the S. and the N. ends towards the middle. Benkulen, *e.g.*, gets 126 inches; Singkel (2° 15′ N.), 172 inches; and Padang, 184 inches in the year. Here too the prevailing rainfall is brought by the N.W. monsoon, but in this belt its prevalence is not so pronounced, Padang getting 94 inches of rain during the N.W. monsoon against 90 inches during the S.E. The mountain chain immediately overhanging it, the high temperature of the sea washing it, the frequent thunder-storms to which it is subject, the moist atmosphere of its equatorial situation, and the shorter *régime* of the dry S.E. wind are the principal causes of the heavier rainfall on the west coast. The higher stations of middle Sumatra, on the lee side of the western mountain chain, get off with only a yearly drenching of 78·7 inches. 3rd. The N. and N.E. parts of Sumatra. These are swept by a variety of winds. The S.E. wind, however, predominates. Blowing overland, and in the direction of the longitudinal valleys, the S.E. wind brings so much less rain, and thus favours the formation of steppes in the N., such as the Toba plains. The N.E. and S.W. winds, on the other hand, licking up the moisture of the sea, bring rain if they blow for any length of time.

Area and Population.—The following table gives particulars as to the area and population of the several political divisions of Sumatra and of the island as a whole:—

Division.	Area in square Miles.	Population in 1897.	Density per square Mile.
Sumatra, West Coast	31,649	1,353,515	42·8
Sumatra, East Coast	35,312	335,432	9·5
Benkulen	9,399	158,767	16·9
Lampongs	11,284	137,501	12·2
Palembang	53,497	692,317	12·9
Atjeh	20,471	531,705	26·0
Total	161,612	3,209,237	19·85

Of the total population, 5015 were Europeans, 92,716 Chinese, 2478 Arabs, 7133 foreigners of other nations, and the rest natives.

In the west coast lands European influence, fertile soil, comparatively good roads, agriculture, timber, and coalfields have created populous settlements on the coast at Padang (the capital of the west coast, with 35,158 inhabitants in 1897, of whom 1640 were Europeans), Priaman, Natal, Ayer Bangis, Sibogha, Singkel, and also on the plateaux at Fort de Kock, Payokombo, &c. In the east coast lands it is only at the mouths of rivers—Palembang at the mouth of the Musi with 53,000 inhabitants, and Medan in Deli, the residence of the highest civil and military officials of the east coast, in which a splendid government house is (1900) being erected—that considerable centres of population are to be found. Nine-tenths of the natives of Sumatra live by agriculture, the rest by cattle-rearing, fishing, navigation, and, last but not least, from the products of the forests; they are therefore little concentrated in towns.

Religion and Instruction.—The natives professing Christianity numbered in 1897 about 32,000 in the west coast division of the island, and about 250 in all other parts. The number of Christian missionaries was 51, of whom 42 belonged to the Rheinische Missionsgesellschaft. The number of schools, Government and private, on the west coast was 260, with 19,226 pupils. In Benkulen there were 9 schools with 1241 pupils; in Lampong district, 4 schools with 638 pupils; in Palembang, 8 with 658 pupils; on the east coast, 2 with 145 pupils; in Acheen and dependencies, 2 with 375 pupils.

Productions and Industry.—Forests and natural vegetation cover a much larger part of Sumatra than of Java. Whereas in Java tall timber on the mountains keeps to altitudes of not less than 3000 feet, the tall timber on the mountains of Sumatra descends to below 1000 feet, to 650 feet, and in many cases right down to the coast. In Sumatra, as in Java, the vegetation of the lowlands up to nearly 1000 feet is distinct from the vegetation of the mountain slopes and plateaux from that elevation up to 4000 feet and over. In addition to the 134 plantations of 46,825 acres farmed out by the princes to the planters of Deli, only 38 plantations of 13,823 acres are farmed out by the Government to private persons. For the European market there are grown coffee, tobacco, nutmeg, mace, pepper, &c. The production of coffee cultivated by the Government in Upper Padang varied from 82,233 piculs (each 133⅓ ℔ avoir.) in 1888 to 19,000 piculs in 1894; in Tapanuli from 12,698 piculs in 1888 to 5192 piculs in 1894; in Lower Padang from 4176 piculs in 1888 to 912 piculs in 1894; and in the whole island from 175,000 piculs in 1877 to 26,000 piculs in 1894. On private lands the production increased from 1000 piculs in 1877 to 16,000 piculs in 1899.

The following table shows the number of tobacco plantations and the amount of tobacco produced on the east coast of Sumatra in 1899:—

Deli and Dependencies.		Langkat.		Serdang.		Batu Baru.		Other Establishments (Asahan, Bila, Siak).		Total.	
Establishments.	Production (in kilogs.)	Establishments.	Production (in kilogs.)	Establishments.	Production (in kilogs.)	Establishments.	Production.	Establishments.	Production (in kilogs.)	Establishments.	Production (in kilogs.)
59	12,141,707	36	6,802,864	23	3,305,828	6	478,022	5	921,150	130	23,958,369

Minerals.—The production of the Ombilin coalfields increased from 1758 metric tons in 1892 to 181,325 metric tons in 1899. The production of petroleum on the Lepan river in Langkat mounted from 362,880 gallons in 1891 to 20,141,000 gallons in 1899. Palembang, at Muara Enim, also produces petroleum, the amount not published. Perlak, formerly a tributary state of Acheen, and now a political division of the Acheen Government, has become one of the chief centres of the petroleum industry. The crude oil is conveyed in pipes to Aroo Bay, on the east coast, and refined in the island of Sembilan. There is no gold production.

Exports.—The principal exports from all the regencies alike are black and white pepper, bamboo (*rotan*), gums, caoutchouc, copra, nutmegs, mace, and gambir. From the west coast and Palembang coffee is also exported, and from Deli, tobacco.

Roads and Railways.—In the western half of Sumatra, with its long line of coast and numerous valleys, the transport of coffee has, owing to the want of navigable rivers, induced the construction of very good roads as far as the lake of Toba. In the west coast, under the Dutch Government, there is a railway connecting not only the coalfields of the Ombilin valley with Padang, but also the Ombilin river and the lake of Singkara with the most productive and densely populated plateaux and valleys, N. and S. of the line of volcanoes (Singalang, Merapi, and Sago). A second railway in the district of Deli connects the inland plantations with the coast. Good roads traverse also the broad plains of Benkulen, Palembang, and the Lampong districts; altogether there are in Sumatra (1900) 194 miles of railway. (See also MALAY ARCHIPELAGO: *Dutch East Indies*, for general information as to *Government*, *Finance*, *Defence*, &c.)

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Recent History.—From 1883 to 1894 the Dutch Government, with the help of missionaries, extended its authority over the lands to the S.E. and S.W., and also over some of the lands to the E. and N. of Toba Lake, including the districts of Toba, Silindong, and Tanah Jawa. In 1895 the authority of Holland was extended over the southern part of the island of Samosir in Toba Lake. Its jurisdiction was also extended over Tamiang, till then the northern frontier of the Dutch east coast of Sumatra. By military expeditions (1890–95) the Dutch influence on the Batang Hari, or Upper Jambi, was increased; as also in 1899 in the Lima Kotas in central Sumatra, included within the territory of Siak. It is expected that the new extension will comprise in it mines of tin and gold. Historically, Sumatra has proved to be perhaps the most interesting among the Dutch-Indian possessions in the Malay Archipelago (*q.v.*). The war in Acheen did not materially retard the development of Sumatra, and although the titular Sultan of Acheen has continued a desultory guerilla warfare against the Dutch in the mountainous woodlands of the interior, the almost inaccessible Pasci country, so called, really active warfare has long ceased. All along the main coasts of the former sultanate of Acheen military posts have been established, and military roads are being constructed; even in Pedir, on the north coast, until 1899 the most actively turbulent centre of resistance of the Sultan party, and even in 1902 only pacified in parts, Dutch engineers are building a highway to connect the west with the east coast; and a railway is running in the north from Olehleh, the new capital of the Government of Acheen, a good, free port, with an active trade, carried on by numerous steamers, both Dutch and foreign. A similar state of things has been in existence at Edi on the north-east coast, the harbour capital of a sultanate which formerly owed allegiance to the Sultan of Acheen, but which since 1889, in which year an armed expedition restored order, forms a political division of the Government of Acheen. Edi has become one of the centres of the still extensive pepper trade, carried on mainly with the Chinese at Singapore and Penang, which island faces Edi. South-west of Singapore the archipelago of Riow forms a separate residency, with an assistant-resident at Lingga, to which belongs the island of Singkep, where extensive tin deposits have been discovered, which are being worked by a Dutch company under an exclusive concession, similar to the existing tin concessions for the islands of Banka and Blitong (Billiton). In Singkep the tin output for the ten years ending 1st June 1900 reached 81,000 piculs. The residency of Riow, which embraces many hundreds of islands, big and small, also includes a portion of the Sumatra mainland, between the residencies of Palembang to the south and the east coast of Sumatra to the north. To the latter belong perhaps the richest and best developed districts of northern Sumatra, namely, Deli (with an assistant-resident), Langkat, Serdang, &c.—districts little known in 1875, but by 1902 famous among the largest tobacco countries in the world. Belawan is the harbour to Deli, but the capital is Medan, where the Sultan and the Dutch Resident reside. Belawan is connected with Medan by a railway, constructed before 1890 by a private company, almost entirely dependent for its earnings upon the numerous tobacco plantations, several of which belong to English corporations. The plantation labourers are almost entirely alien coolies, largely Chinese, and the Malays are comparatively few in number. The tobacco plantations of British North Borneo have nearly all been started by planters from Deli. Between the mainland dependency of the Riow residency and the residency of Palembang lies Djambi, an extensive sultanate, which is still in a state of transition; a portion belongs to the residency of Palembang as a protectorate, the Sultan having in his capital (also called Djambi) a Dutch "comptroller," who represents the resident of Palembang; another portion is claimed by a quasi-independent sultan who reigns in the interior. Of this interior very little was known until the scientific expedition despatched by the Dutch Royal Geographical Society towards the end of the 'seventies, but in 1901 an armed Dutch expedition, necessitated by frequent disturbances, penetrated right into the Jambi hinterland, the so-called Gajoo districts, where until then no European had ever trod. Otherwise there is little of a historical or political character to chronicle of Palembang, beyond the fact that many petroleum wells have been started in the interior, and that it is now possible to travel by road from Palembang to Benkulen, on the west coast. The same remark applies to the residency of Banka Island, which includes Billiton Island, with an assistant-resident, and to the residency of the Lampong districts, adjoining the Palembang residency, and comprising the southernmost portion of Sumatra.

The west coast of Sumatra is administered upon lines somewhat approaching those of the east coast. There is a government in the north adjoining that of Acheen, and comprising the two residencies of Padang, the Highlands residency and the Lowlands residency; further, the residency of Tapanuly. All have several assistant-residencies. The residency of Benkulen is interposed between the west coast government and the residency of the Lampongs above mentioned. Of the recent history of the former, all that need be stated here is that the settlement of the Padang highlands and of Tapanuly, which, from the point of view of the picturesque alone, are among the most beautiful upland countries anywhere to be found, is of much later date than that of the Padang lowlands. Still, up to 1900 a great deal had been done to develop the long-neglected interior, a development to which the geological survey expeditions, under the lead of that eminent engineer, Mr Verbeek, to whom we owe not only the best maps of Sumatra but also the most comprehensive study of the Krakatao cataclysm, have so powerfully contributed. A state railway now runs from Padang town into the interior as far as the immense Ombilin coalfields, which are worked by a private company.

A brief mention should be made of the island of Nias, which forms a political division of the residency of Tapanuly on the west coast. Nias has excited a good deal of interest among scientists on account of its remarkable population, whose origin is still in doubt, Junghuhn's surmise that they are Battaks not having met with general acceptance. The Nias natives are a distinct race. Cannibalism seems unknown among them, but slavery is still rampant, and especially head-hunting, despite the persistent efforts against it made by the Dutch and German missionary societies, which are strongly represented in Nias. A peculiar feature of the population is the large number of albinos which it comprises.

From the above outlines it would appear that the government of Sumatra was still in 1902 in an essentially transitory condition. For recent literature consult the works mentioned under JAVA and MALAY ARCHIPELAGO; also Schuiling's *Nederland tusschen de Tropen* ("Tropical Holland," 1889), and Prof. VAN DER LITH's *Netherlands-India* (2nd edition, 1892). (H. TI.)

Sumbawa, one of the Little Sunda islands in the East Indian Archipelago east of Lombok, measuring, according to Zollinger, 4300 square miles, or, including the neighbouring islands, 5240 square miles. Four mountain chains cross the island in common with the Western Sunda islands in a west to east direction. The northern, as in Bali and Lombok, is of volcanic origin. In the southern chain is found a limestone formation analogous to that in Bali, Lombok, and Java. Between these two chains are round hills consisting of lavas, sometimes of volcanic tuffs, covered with the silvery and long grass which also clothes vast prairies in Java and Sumatra. The natives live solely by agriculture. But out of a total population of about 75,000 there are 11,000 foreigners, living mostly by trade and navigation (Ligtvoet). Politically, Sumbawa, with its four independent states, belongs to the confederated states of the "Government of Celebes and its dependencies" (see

Celebes), a situation to be explained by the fact of the old supremacy of the Makassaresi over Sumbawa, Flores, and Sumba.

Zollinger. "Soembawa," in *Verhandelingen van het Batav. Genootschap*, xxiii.—Ligtvoet. "Anteekeningen betreffende den Economischen Toestand en de Ethnographie van Soembawa," in *Tijdschr. Bat. Gen.* xxiii.

Summit, a city of Union county, New Jersey, U.S.A. It is on the Delaware, Lackawanna, and Western railroad, in the north-eastern part of the state. It was formerly Summit township. Population (1900), 5302, of whom 1397 were foreign-born and 129 negroes.

Sumter, a city of South Carolina, U.S.A., the capital of Sumter county. It is a little east of the centre of the state, on the Atlantic Coast Line and the Southern railway, and is an important shipping point for the products of the surrounding agricultural region. Population (1890), 3865; (1900), 5673, of whom 58 were foreign-born and 3160 negroes.

Sun.—The sun may be described in the most comprehensive way as a globe of matter so intensely hot that all the substances composing its interior are vaporized and dissociated, so that any chemical combination is prevented among them, and so massive that the gases which form it are compressed by the mutual attraction of their parts to a density exceeding in the mean that of water, and possibly, near the centre, as great as that of metals. The following numerical particulars will be convenient for reference. The bases of some of them will be found in Part II. of the article Astronomy in vol. xxv. of this work:—

Angular semi-diameter at mean distance	959·63″
Density (earth's density=1)	0·25538
,, (water=1)	1·41151

The value of the equatorial horizontal parallax of the sun at the earth's mean distance, as now adopted in all the astronomical ephemerides, is 8·80″, but the most recent investigations indicate a somewhat smaller value, probably 8·78″, and a correspondingly greater distance. The distance, linear diameter, mass, and attraction depend in their determination upon the parallax, and are therefore given for the two values of this quantity just mentioned:—

Equatorial horizontal parallax	8·80″	8·78″
Mean distance (kilometres)	149,501,000	149,841,000
,, (miles)	92,896,000	93,108,000
Linear diameter (kilometres)	1,391,080	1,394,240
,, (miles)	864,372	866,340
,, (earth's eq. diam.=1)	109·05	109·30
Mass (earth's mass=1)	332,297	334,512
Gravity at surface (metres)	273·82	274·42
,, ,, (⊕ gr=1)	27·88	27·95

According to Spörer's determinations from 1861 to 1866, the position of the solar equator referred to the ecliptic is

Longitude of ascending node	74·2°
Inclination to the ecliptic	6·6

The most recent determination of the period of the solar spots is $11^{y}\cdot13\pm0^{y}\cdot02$.

A fundamental constant of solar physics is the rate at which the sun radiates heat. The measure of this radiation, called the solar constant, is the amount by which a sheet of water 1 centimetre thick, exposed perpendicularly to the sun's rays at the earth's mean distance, would rise in temperature in one minute if it absorbed all the rays and lost no heat. The determination, being necessarily made at the earth's surface, requires a knowledge of the absorption of the sun's heat in passing through our atmosphere. The selective character of this absorption renders its determination difficult, and, as was pointed out by Langley, has led to the result being much too small. The most elaborate determination at command is that of Langley, made on the summit of Mount Whitney, at an elevation of about 14,000 feet. The value which he reached was 3·0° C. per minute, with a fair probability of its being as great as 3·5°. Ångstrom places the value at the yet higher point of 4°. We may assume the most probable value to lie between 3·0° and 3·5°. This result may be expressed by saying that if the sun were surrounded by a spherical shell of water 1 centimetre thick, having a radius equal to that of the earth's orbit, the heat radiated would raise its temperature at the rate of about 3·0° or 3·5° C. per minute (5·4° to 6·3° Fahr.). Computing the volume and mass of this shell, we may determine the number of units of heat necessary to warm it at this rate, which would be the rate at which the sun lost energy. The following are the common logarithms of the amount of energy radiated per minute and per day, assuming the two values just given for the constant. We remark that the C.G.S. unit of heat is that which will raise the temperature of 1 cubic centimetre of water 1° C.; the calorie is the amount which would raise one kilogramme 1°, while the erg is the C.G.S. unit of mechanical work.

	Per Minute.		Per Day.	
Constant	3·0	3·5	3·0	3·5
Log C.G.S.	27·927	27·994	31·086	31·153
,, Calories	24·927	24·994	28·086	28·153
,, Ergs	35·560	35·627	38·718	38·785

Assuming the mean specific heat of the materials composing the sun to be the same as that of water, the loss of energy would be equivalent to a lowering of the temperature at the rate of about 4° Fahr. per annum. Assuming the sun to be of uniform density in its interior, and to contract uniformly throughout its mass when cooling, the number of ergs of work done by a contraction of this mass through u centimetres is, when a coefficient is expressed by its logarithm, $(37\cdot515)u$. The annual contraction which would then generate an energy equal to that radiated is 6790 centimetres or 225 feet. In deriving this result no allowance is made for the rise of temperature produced by the contraction. The result of this rise would be a yet more rapid contraction, since the latter must suffice not only to produce the energy radiated, but the additional energy required to raise the temperature.

The interior of the solar globe is invisible to us, so that its constitution must be entirely a matter of inference. Its surface, the photosphere, is all we see under ordinary circumstances. Immediately outside of it, and lying upon it, is a layer of self-luminous gases, red in colour, forming the chromosphere. Outside of this is an irregular collection of matter of extreme tenuity, the corona. Both chromosphere and corona are, under ordinary circumstances, invisible to direct vision; the chromosphere can be detected by the aid of the spectroscope, but the corona is visible only during total eclipses of the sun.

The number of terrestrial elements whose spectral lines can be detected in the solar spectrum has been increased by Rowland's researches with the aid of photography. The question whether oxygen is in the list has long been an open one, and cannot yet be regarded as decisively settled. Its difficulty arises largely from the fact that we necessarily see the solar spectrum after the light has passed through the oxygen of the earth's atmosphere. Investigations by Runge make it at least highly probable that a triplet of lines in the extreme red, W. L. 7772·2, 7774·4, and 7775·6, belong to the spectrum of oxygen, and are also true solar lines. This evidence will be the more easily accepted that the absence from the sun of an element so abundant on the earth does not seem probable.

That the photosphere cannot be a continuous solid or ordinary liquid, like molten metal, is shown by the fact that, if it were, its enormous radiation would result in its being cooled down almost instantly. Even were the

Photosphere.

liquid as transparent as water, all the heat radiated at any moment would come from within a few yards of its surface, which would cool down in a few minutes or hours. Indeed, whatever constitution we assign to the photosphere, the matter composing it would cool off at a rate of several thousand degrees in a day if it remained *in situ*. The radiating matter must therefore be continuously renewed by convection currents. Great mobility is therefore a necessary characteristic of its constitution. The combination of the required mobility and radiating power is best obtained by supposing that the more refractory substances in a rising mass of vapour, carbon for example, condense when they reach a certain level, and then fall rapidly back into the interior, to be there revaporized. But it does not seem absolutely necessary to suppose any condensation, because the principles of thermodynamics show that a stratum of gas so thick as to be opaque to radiation will radiate like a solid. Further inferences as to the nature of the photosphere may be drawn by starting from the envelope of hydrogen which rests upon it, and assuming that chromosphere and photosphere have a temperature corresponding to convective equilibrium. The latter will occur when the temperature in going downward increases at such a rate that a descending current, continually growing hotter by the work of compressing it, shall always have the same temperature as the surrounding mass. In this case the temperature will increase with the depth at a uniform rate, if the change in the gravity in going downward be neglected. In the case of hydrogen the rate is about 15° C. per kilometre, and in the case of air about twenty times more rapid. Assigning to the chromosphere a depth of 5000 kilometres, the temperature at the base would be some 75,000° higher than at the surface, whatever the temperature of the latter might be. This result, however, is excessive, because based on the hypothesis of no radiation. The effect of the radiation from the photosphere is to elevate the temperature of the outer parts of the chromosphere, the base of which must, under all circumstances, be at least as cool as the photosphere on which it rests. In the general average every concentric shell of the sun's mass must be hotter as we go downward, since below the region from which radiation is received a condition approaching to that of convective equilibrium must hold. The increase of temperature in this case would admit of being computed by the laws of Boyle and Gay-Lussac, did we know the physical constants of the vapours composing the sun. But we must speedily reach a point of temperature and condensation at which these laws cease to hold, and there is also a tendency towards equality of temperature through interior radiation. We cannot therefore say what either the temperature or density may be at a great depth.

Defining the photosphere as the totality of all matter which radiates an appreciable amount of energy into outer space, we see that it cannot be a surface, but rather a stratum, of which the probable depth is several hundred, and may be several thousand, kilometres. The best estimates of its temperature range from 5000° C. to ten, fifteen, or even twenty thousand. Really, however, no definite temperature can be assigned to it, owing to the rapid increase of temperature with the depth.

The reversing layer of Young may be regarded as connecting the chromosphere and photosphere, being at once the base of the former and the extreme outer surface of the latter. Its duration during total eclipses of the sun, and the circumstances of its visibility on such occasions, seem to show its thickness to be a considerable fraction of 1″, say 500 kilometres. Its bright line spectrum shows that a ray of light from the earth would pass through and through it and suffer only selective absorption. The path of such a ray within the layer would be some 30,000 kilometres if it went in a straight course, and yet more if it underwent refraction. Being transparent through such a length, the tenuity of the layer must be extreme. Were its density not much less than that of our atmosphere, a ray of light could not pass through it without being refracted from its course toward the interior, and no bright line spectrum would then be visible. This result is totally at variance with the inferences of Jewell and Humphreys from the character of the spectrum—that the pressure upon it is equal to several terrestrial atmospheres. But the writer considers that an inference from these data can be little more than a conjecture. The probable law of the increase of temperature from the inner regions of the sun outward is shown in Fig. 1. Here C is the centre of the sun; *p* is the region of the photosphere, a shell between the surface S S, which is the innermost one that radiates heat into outer space, and R R, the very thin shell of the reversing layer; *h*, between R R and T T, is the region of the chromosphere; ordinates parallel to C A, terminating in the upper curve of the figure, would represent the diminishing temperature. From the centre C A to the surface S S the law of diminution is that of convective equilibrium. The dotted curve outside of S is a continuation of this curve, showing the temperature as it would be were there no radiation. But owing to the radiation by the photosphere there is a rapid drop of temperature through the latter, while outside of it, the radiation being absorbed by the chromosphere increases the temperature of the outer surface of the latter. The result is a rapid fall through the photosphere, while in the chromosphere the change may be quite small, the whole being shown by the continuous curved line.

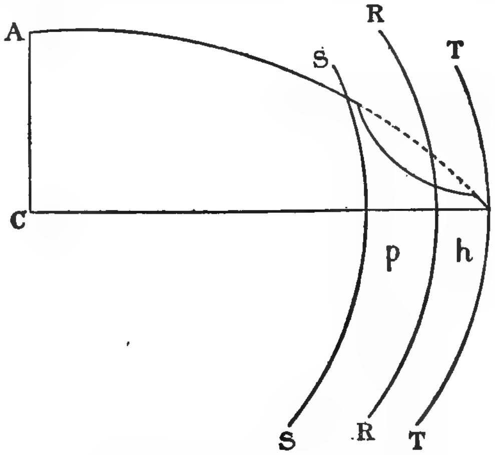

Fig. 1.—Temperature Gradient of the Sun.

Law of rotation.

One of the most curious phenomena connected with the sun is the rotation of its equatorial regions in less time than those nearer the pole, the difference being about $1^{d}{\cdot}5$ between the equator and the limits of the spotted zone. The question would naturally arise whether this might not be due to a motion of the spots in longitude unaccompanied by a motion of the matter of the photosphere around them, much as a whirlwind might change its position without a continuous translation of the air. On this supposition a spot would be in the nature of a disturbance, which might be propagated from point to point independent of the matter disturbed. There are, however, other tests. The motions of the faculæ admit of being followed like those of a spot, though not so easily. The results from faculæ have not been conclusive, but the preponderance of evidence is that they follow the same anomalous law as the spots. The most conclusive test is that afforded by the spectroscopic comparison of velocities to and from the earth at the opposite limbs of the sun. Very careful comparisons of this sort were made by Crew and Dunér, the latter of whom seems to have reached a high degree of precision in his work: his general conclusion is that the angular motion in question actually grows slower towards the poles not only within the zone of sun spots, but to at least ±60° of latitude. What makes the phenomenon seem anomalous is that, in the case of a revolving fluid body the particles of which constantly change their positions relatively to each other, the most rapid angular motion should be near the axis of rotation, where it might become so great that a vortex would form. Several recent writers have, however, constructed hydrodynamic theories of the processes going on in a rotating mass of gas at a high temperature, leading to a law of rotation similar to that observed in the present case. The subject is most thoroughly worked out in a memoir by Professor R. A. Sampson (*Mem. R.A.S.*, vol. li.), but it is impracticable to condense this or any other mathematical theory of the subject within our present limits. We must therefore confine ourselves to a brief statement of the probable conditions existing and processes going on in the sun's interior. The result of the convection currents must be a continuous increase in the angular speed of rotation from the surface towards the centre. The law of this increase cannot be rigorously determined. It seems to the writer that, passing inward from any point of the sun's equatorial region, there could at first be no diminution of the linear speed; that is, the angular speed should increase at least inversely as the distance from the centre. Sampson's theory, however, makes the increase in angular speed slower than this (*loc. cit.*, pp. 175, 176). The effect of the increasing pressure and temperature is to increase the viscosity towards the centre, so that the central core may behave like a solid. It would also have a higher angular speed of rotation than any point of the surface.

An important recent paper on the subject is by Emden (*Sitzungsber, Munich Akad.*, July 1901, pp. 339–363). The greater speed of the equatorial rotation is here connected with a theoretically higher temperature of the photosphere at the poles than at the equator, a condition not yet confirmed by observation.

Solar spots.

Several theories of their mode of production have been propounded, of which that of E. von Oppolzer (Vienna, *Schwingsbet.*, 3rd March 1893) has received most attention; but the conditions are not yet ripe for formulating any theory of the subject. We shall therefore confine ourselves to the general laws of the phenomenon brought out by recent investigations, and to deductions from observed facts.

In going through the eleven-year cycle of change the rise from minimum to maximum of spottedness takes place more rapidly than the reverse, the two partial periods being from minimum to maximum, 4^{y}·62, and from maximum to minimum, 6^{y}·51. The degree of spottedness at any one phase of the cycle is quite irregular, being sometimes greater or less than the average for a period of a year or more. The spots in one hemisphere sometimes reach a given phase, say that of maximum, a year or even more in advance of those in the other hemisphere. Spörer from a number of observations inferred that the southern cycle was generally in advance of the northern one; this, however, is not justified by more recent comparisons, which show that, in the general mean, the spottedness of the two solar hemispheres goes through its phases simultaneously. Accurate observations of the spottedness of the two hemispheres of the sun separately commenced with Carrington's work in 1856. During the four cycles which have since elapsed the spottedness of the southern hemisphere has in the general average exceeded that of the northern in a ratio of about 6:5. This excess is greater than the probable result of chance irregularities, but its permanence cannot yet be regarded as established.

A most important question connected with the length of the period is whether the cycle is fundamentally a perfectly regular one. Are the observed irregularities in the degree of spottedness superposed upon an invisible cycle of change of invariable length on which they fundamentally depend, or is the cycle itself an irregular one? In the former case the times of any one phase through long periods will, in the general average, be equidistant; in the latter case the irregularities will constantly tend to accumulate, so that the deviation from the results of uniformity may increase to any extent. Wolf, from records beginning with Galileo, derived the time of every maximum and minimum since 1610. Including the phases up to 1895, it is found that there is no evidence of any accumulated deviation, but the differences between the observed epochs and those computed on the supposition of a uniform period seem to be accidental all the way through. The probability is therefore that the unknown cycle of change in the interior of the sun on which the degree of spottedness depends is quite uniform. No cause external to the sun having the period in question is known to exist. The period of Jupiter, 11^{y}·86, comes nearest, but differs so much as to preclude the hypothesis of coincidence. E. W. Brown (*Mon. Not. R.A.S.*, October 1900) discusses the question whether the combined tide-producing forces of Jupiter and Saturn might not represent the changes in spottedness, but reaches no definite conclusion. We must therefore seek for the cause of the cycle in operations going on within the body of the sun itself. It is remarkable that the phases of increase and decrease during the cycle follow very different laws in different solar latitudes. About the time of maximum there is a fairly definite law of distribution of spots in latitude. There are very few at or near the solar equator. The number increases up to about 15° heliocentric latitude, where it reaches a maximum. From this point it falls off slowly at first, then more rapidly to 30° of latitude. Beyond this limit a spot is only occasionally seen. The number of spots in belts of latitude 5° wide during 1894, just after a maximum, was as follows:—

Mid. of belt + 30°	3 spots
25	13 ,,
20	36 ,,
15	51 ,,
10	75 ,,
5	41 ,,
0	11 ,,
− 5	46 ,,
− 10	75 ,,
− 15	88 ,,
− 20	49 ,,
− 25	16 ,,
− 30	5 ,,

The Wilsonian theory, that the spots are depressions in the photosphere, rested upon a supposed effect of perspective, the pneumbra which surrounds the dark nucleus of each spot being supposed to be broader on the exterior edge of the spot on the sun's limb than on the interior edge. But the breadth of the pneumbra is extremely irregular and variable, and it is now found that there is no such systematic difference, nor any other evidence of a depression. The question of the exact location of a sun spot is necessarily somewhat indefinite, because what we have to do with is a phenomenon, and not merely an object. It may be that the cause of the phenomenon extends through the entire thickness of the photospheric stratum.

The fundamental facts, relating to the radiation of the spots, which modern investigation has brought out are these:—By the aid of a thermopile it was long since found by Henry and Secchi that a spot radiates not only less light but less heat than the rest of the photosphere. The radiation from the photosphere is weaker the nearer we approach the limb of the sun. The question whether the radiation of the spot diminishes in the same degree has been investigated by Langley and Frost. It is found that this is not the case, and that in the general average the diminution of radiation from the spots is less than that from the photosphere as the latter approach the sun's limb. This lends colour to the view that the spot is high up in the photospheric stratum. The spectroscope shows that the darkness of the spots, especially of the umbra, is due entirely to an absorption of light by gases denser than those which produce the lines of the solar spectrum. The entire spectrum seems to be darkened to a greater or less extent, but in an irregular way. Young and Dunér have resolved the dark regions into great numbers of fine lines. Another remarkable phenomenon is the broadening of most of the spectral lines. In addition to this, a line is frequently reversed—that is, seen as bright instead of dark. Frequently a bright line appears without the broadened dark line having disappeared. The reversed line is also frequently curved or displaced, showing rapid vertical motion in the gases which produce it. The reversed lines are generally those of calcium, hydrogen, and iron. It is remarkable that the lines even of the same substance are not broadened equally. This, however, is only one of the many irregularities in the behaviour of the spectral lines of a substance under various conditions. The behaviour of the spectral lines seems best explained by supposing absorption by a dense layer of cool gases with another of hotter gases above it.

Faculæ and prominences.

Intimately associated with the spots are the faculæ and prominences. The former are subject to the same period as the spots and, like them, are mostly within 30° of the equator, but they are found occasionally, though rarely, even in the polar regions. The prominences are also found all over the sun, but are more frequent in the spotted latitudes. It is not established that the spots have any well marked motion in latitude, though a tendency has been suspected in those of high latitudes to move toward the pole.

The most hopeful source of conclusions respecting the surface of the sun seems to be offered by Hale's method of photographing it by monochromatic light, which is based on an idea originally suggested by Janssen. By it a photograph is made in which all the light but that of one particular spectral ray is cut off. The essential principle of the apparatus by which this is done is this. Let A be an image of the sun formed in the focus of a telescope. To fix the ideas, let us suppose this image formed of monochromatic light, that of the calcium line K for example. If this light is passed through a spectroscope, whether prism or grating, it, being monochromatic, suffers no dispersion. B may then represent the second image formed in the focus of the spectroscope. Then let S S be a slit through a frame which cuts off all the light but a narrow line. The image will then be reduced to the line S′ S′, which will simply be the spectral line K. Suppose S S to move vertically across the disc; the line S′ S′ will then seem to move in like manner across the image B, only instead of an actual motion of the spectrum it will be a moving impression of the K-light from the different parts of the sun. Actually, the light not being monochromatic, the entire spectrum of the sun will fall upon the plane of the image B. To obtain the photograph by the K-light an actual slit S′ S′ is made to move over the image B in coincidence with the K-image of the slit S S. Thus a photograph of the entire sun is obtained in which only K-light is allowed to fall on the plate. The most remarkable results obtained with this instrument concern the faculæ. The ordinary visual spectrum of these objects shows the H and K bands of calcium reversed by a thin bright line running down the middle of each, thus indicating the presence of calcium vapour at a higher temperature than the surface below. The reversal is often double, a very thin dark line running down the middle portions of the somewhat broader bright line. This indicates the presence of a stratum of cooler calcium vapour above the hotter one. In some cases the bright line on one side of the dark one disappears, showing the double reversal to be unsymmetrical. Distortions in these reversed lines are rare. The bright H line is sometimes accompanied by the neighbouring $H\epsilon$ line due to hydrogen. No bright lines more refrangible than those of calcium are ordinarily seen in either the faculæ or the spots. Photographs of the whole surface by the spectroheliograph show that this reversal of the K line is only an extreme case of a phenomenon present here and there over a large portion of the solar disc, especially the middle latitude belts of greatest spottedness, and comprising a regular gradation in the behaviour of the K line. Commencing at one extreme with the normal darkness usually shown in the visual spectrum of the sun, this line may, in special regions, be less dark to any extent, then gradually reversed, first by the narrowest possible line, and then by one of increasing brightness, which at length changes into a double reversal. Regions where this gradation is found to begin are irregularly scattered over a considerable portion of the sun's disc, but the brightening is farthest advanced in the two zones of greatest spot activity, where they sometimes cover widely extended regions, with scarcely a break, though with varying intensity. Besides these bright areas, the photographs show a fainter reticulated structure extending from pole to pole. The brighter regions increase and decrease in number and intensity with the spots, but the reticulation persists throughout the entire sun-spot period. On rare occasions the photographs show remarkable eruptive phenomena, which break out near sun spots and rise as immense clouds of calcium vapour, obscuring in the photographs the underlying regions of the photosphere. Such eruptions are, however, quite invisible either by direct vision or on photographs of the sun taken in the ordinary way. The photographs which may be taken with the instrument are not confined to the photosphere, but may include the chromosphere with its prominences. When taken by the light of the K line, these objects have the sharpness of outline of the best eclipse photographs.

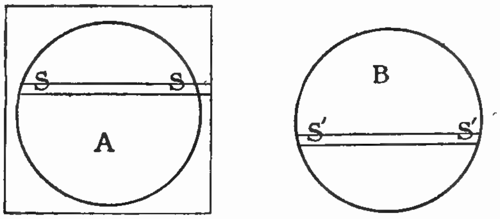

Fig. 2.—Principle of Hale's Spectroheliograph.

One of the most remarkable constituents of the chromosphere and protuberances is helium. When the spectrum of the objects in question was first studied, a bright line, W.L. 5876, was found to be present, not known to exist

Chromosphere.

among the dark lines of the solar spectrum. Being near the two D lines of sodium, it received the designation D_3. Its origin remained a mystery until it was found by Ramsay that this line was emitted by a hitherto unknown substance in clevite, a rare Norwegian mineral. To this new element the name helium was therefore given. Besides the helium line, the H and K lines of calcium are also found in the chromosphere. Hydrogen, helium, and calcium are therefore the three elements the evidence of whose existence is most uniformly shown. But besides these, the lines of many other metals, especially iron, magnesium, and sodium, are found, with greater or less frequency. It is curious that they are present mainly in the eruptive protūberances, never in the cloud-forms. This fact is susceptible of the very rational explanation, that after being thrown up from the sun, they rapidly condense and fall back, while the lighter gases of the other elements remain. At the station on Mount Sherman Young catalogued 273 lines which were seen with greater or less frequency in the spectrum of the chromosphere. This list has since been considerably extended.

Corona.

An outline of the observations made on the corona during total eclipses will be found in the article ECLIPSES (*Ency. Brit.*, vol. xxvii.). At present we confine ourselves to certain phenomena and conclusions of a general nature. In interpreting the apparent form of this curious effulgence, it must be remembered that we see only a projection, as it were, of the real corona. The latter surrounds the sun on all sides, towards us and away from us as well as laterally. What we really see at each apparent point is not the corona as it is at that point, but the combined effect of all the matter lying along the line of sight from our eye to the corona. This makes the seeming diversity of structure more remarkable, since the diversity must be lessened by the effect of perspective.

Considering, first, the visual aspect of the corona, the most striking feature is found to be its radial structure. It is not merely a soft effulgence, but a complex combination of rays, frequently with dark rifts between them. The appearance of these rays is much like what we should expect to see if the equatorial regions of the sun were dotted over with hundreds of search-lights sending out their light through a thin fog. Yet there can be nothing of this kind, because every point of the corona must be equally exposed to the light of the sun. There is a remarkable difference in the radial structure in the equatorial and polar regions. A peculiarity of the latter is the curved rays which bend away from the axial line on all sides. There is a curious resemblance between this curvature and that of the lines of magnetic force as they would be were the sun a magnet. This arrangement does not, however, extend around the equatorial region as it should, if the rays always coincided with lines of magnetic force.

The spectrum of the corona is found to be a faint, continuous one, crossed with a small number of bright lines, which form its characteristic spectrum. Of these lines the strongest is one in the green, long supposed to be identical with 1474 of Kirchhoff's scale, of which the wave-length is 5317. At recent eclipses Lockyer found the wave-length to be 5303, which does not coincide with any line present either in the spectrum of the sun or in that of any known substance. The lines next in brightness are near wave-lengths 4230 and 4290. A number of others have been recorded, some of which belong to hydrogen, calcium, and helium, but the existence of these as belonging to the corona has been questioned.

The question whether the continuous spectrum of the corona has any dark lines, as should be the case were it reflected sunlight, is still an open one, with a large preponderance of evidence in the negative. Only Janssen has ever been able to see such lines, and it seems likely that Campbell and others who have failed to see them enjoyed rather better conditions for doing so than did Janssen. However this may be, a rational interpretation of the spectrum seems easy. Scheiner has shown that any substance, especially if composed of solid particles, must in the neighbourhood of the sun be heated to incandescence by the sun's rays, and must therefore be self-luminous. In addition to this, it would reflect more or less sunlight, according to its degree of blackness. Only when perfectly black would it have no power to reflect; if belonging to the whiter class of substances, it might reflect more light than it emitted. Even if gaseous, a faint continuous spectrum formed by its own radiation would not be out of the question, because a gaseous body really emits light of all wave-lengths, though the quantity not belonging to its characteristic lines is extremely minute. We may therefore regard the light of the corona as a mixture of its own light with reflected sunlight, the latter being in an unknown but probably small proportion. The result of observations showing that the coronal matter is as bright in the rifts of the corona as in its brightest portions still lacks decisive confirmation. Granting it, the corona would seem to be in some sort duplex in structure, consisting of an extremely tenuous atmosphere of the unknown substance coronium surrounding the sun, in which are suspended minute particles partly or wholly vaporized by the sun's heat. All views of the corona as incandescent matter are at variance with the measures of its heat with the bolometer made by Abbot of the Smithsonian Institution during the eclipse of 1900. These, as interpreted by Abbot, would show that no obscure heat is radiated by the corona, a result which cannot be accepted without further investigation.

An interesting question is whether the coronal matter does or does not rotate with the sun. Three states of things are possible: it may remain at rest as the sun rotates, or rotate with the sun, or, like a mass of meteoric matter, might be revolving around the sun in orbits under the influences of gravitation. The latter would imply a vastly more rapid rotation than that of the sun itself. Campbell has investigated this question by comparing the spectra of the lines at the two edges of the sun. The result is conclusive against the motion of the coronal matter in an orbit around the sun, but is indicative of a motion corresponding to that of the sun's rotation. The effect is, however, too minute to be quite conclusive.

It has been shown by Arrhenius (*Physikalische Zeitschrift*, Nov. 1900) that a minute impulsive force of the sun's rays, pointed out by Maxwell in his development of the electromagnetic theory of light (*Electricity and Magnetism*, vol. ii.), affords a remarkably plausible explanation of the tails of comets, the floating prominences, and the solar corona. It results from this theory that this action upon particles of matter of dimensions of about 0·001 mm., and of density unity, will be equal to their gravity towards the sun. Particles smaller and rarer will be driven off against the sun's gravity. We have therefore only to suppose the solar corona to be composed of particles like this, to account for its seeming suspension about the sun. (S. N.)

Sunbury, a borough of Pennsylvania, U.S.A., the capital of Northumberland county. It is situated in lat. 40° 52′, long. 76° 47′, on the eastern bank of the Susquehanna river, at the junction of its north and west branches. Its site is level, and the borough is laid out with great regularity. It has three railways—the Pennsylvania, the Northern Central, and the Philadelphia and

Reading. Sunbury contains the repairing works of the Pennsylvania railroad, and varied manufactures. It was settled in 1772. Population (1880), 4077; (1890), 5930; (1900), 9810, of whom 1970 were foreign-born.

Sundarbans, The, a tract of waste country in British India, forming the seaward fringe of the Gangetic delta. It has never been surveyed, nor has the census been extended to it. It stretches for about 165 miles, from the mouth of the Hooghly to the mouth of the Meghna, and is bordered inland by the three settled districts of the Twenty-four Parganas, Khulna, and Backergunge. The total area (including water) is estimated at about 5500 square miles. The whole is a water-logged tract, overgrown with impenetrable jungle, in which tigers and other wild beasts abound. Attempts at reclamation have not been very successful. The forest department realized in 1897–98 a net revenue of Rs.4,00,000, chiefly by tolls on produce removed. The characteristic tree is the *sundri* (*Heritiera littoralis*), from which the name of the tract has been derived. It yields a hard wood, used for building purposes, and for making boats, furniture, &c. The Sundarbans are everywhere intersected by river channels and creeks, some of which afford the recognized means of water communication between Calcutta and the Brahmaputra valley, both for steamers and for native boats. Down to 1897–98 the total capital expenditure on the Calcutta and Eastern canal was Rs.63,00,000. The gross revenue from tolls in that year was Rs.4,26,203, and the net revenue Rs.2,24,798. The tonnage of boats was 1,016,657, with cargoes valued at Rs.5,90,14,426, or about four millions sterling.

Sunday.—There has not since 1887 been any legislation directly affecting the observance of Sunday in the United Kingdom, or the lawfulness of carrying on any trade on that day. But a good many Acts have been introduced with respect to Sunday trading. Most have been directed to the closing of public-houses on that day; but the Shop Hours Bills introduced in 1901 contained clauses for closing shops on Sunday, with the exception of certain specified trades. In the administration of the law, however, there has been a distinct disposition to refrain from enforcing the strict letter of the older law, and to permit the latitude of what is described as the "Continental Sunday," except in the case of businesses carried on so as to interfere with the public comfort.

The result of the Acts of 1871 and 1875 in London has been in substance to make the Lord's Day Acts a dead letter as to Sunday trading. The Commissioner of Police rarely if ever allows a prosecution for Sunday trading. Sunday markets are usual in all the poorer districts, and shopkeepers and hawkers are allowed freely to ply their trades for the sale of eatables, temperance drinks, and tobacco. But the conditions of licences for the sale of intoxicants and for refreshment houses are strictly enforced with respect to Sunday. In districts where the town councils have control of the police, prosecutions for Sunday trading are not infrequent; but they seem to be instituted rather from objection to the annoyance caused by street traders than from religious scruples. The limitation of the time for prosecution to ten days, and the necessity of the previous consent of the chief constable, have a great effect in restricting prosecutions. This liberality in administration has progressed *pari passu* with a change in public opinion as to the uses to which Sunday may properly be put; it is becoming less of a holy day and more of a holiday.

There has been great activity among those interested in different theories as to the proper use of Sundays. On the one side, Lord's Day observance societies and the organizations concerned in the promotion of "temperance" (or of abstinence from alcoholic drinks) have been extremely anxious to enforce the existing law against Sunday trading, and against the sale of intoxicants to persons other than *bonâ fide* travellers, and to obtain legislation against the sale of any alcohol on Sundays. On the other side, the Sunday League and other like organizations have been active to organize lectures and concerts and excursions on Sundays, and to promote so far as possible variety of recreation other than attendance at the exercises of any religious body. The lessees of certain places of public resort in London have in some cases obtained their licences from the London County Council on condition that they do not hold Sunday concerts, and the recent policy of the Council has been not to interfere with or restrict the giving of Sunday concerts unless they are given for private gain or by way of trade. The Council has no legal authority to dispense with observance of the Lord's Day Act of 1781 (21 Geo. III. c. 49), which enforces penalties on giving entertainments to which persons are admitted by payment of money or by tickets sold for money. The law has been judicially interpreted, however, to mean that charges for reserved seats are not incompatible with free admission. In consequence of this ruling Sunday concerts have been regularly given at the Albert Hall, which is not under the licensing jurisdiction of the London County Council, and at the Queen's Hall and other places within that jurisdiction. No charge is made for admission, but those who wish for seats must pay for them, and the proceeds of the concerts are not made the subject of profit. At the licensing sessions conflicts have annually arisen on this subject between the advocates and opponents of Sunday music.

Travelling and boating on Sunday are now freely resorted to, regardless of any restrictions in the old Acts, and railway companies run their trains at all hours, those in the metropolis, however, limiting their trains during the hours of morning service. The running of tramcars on Sundays has been recently introduced in Scotland, but its legality is the subject of litigation. Refreshment houses are freely open even in the Royal Gardens at Kew, and bands play in the public parks. An attempt was made in 1897 to enforce the Act 1 Chas. I. c. 1, forbidding the playing of Sunday games out of the player's parish, by prosecuting some lads for playing football in an adjoining parish, but the justices dismissed the charge, treating the Act as obsolete; and to a great extent the aim of the *Book of Sports* has, after two centuries, been attained.

The operation of the Lord's Day Acts has to some extent been restricted by two recent decisions. In 1900 it was decided that a barber was not a tradesman, artificer, workman, or labourer, or other person whatsoever within the Act of Charles II., and that he could lawfully shave his customers on Sunday. Under the Scots Act of 1579, c. 8, which prohibits "handy labouring or working" being used on Sunday, the House of Lords had in 1837 held that it was illegal for barbers to shave their customers on Sundays, although the deprivation of a shave might prevent decently disposed men from attending religious worship, or associating in a becoming manner with their families and friends through want of personal cleanliness.

British Colonies.—The English law as to Sunday observance was the original law of the colonies acquired by settlement, and in many of them is left to operate without colonial legislation. In other colonies it is supplemented or superseded by colonial Acts. Ontario has a law (Rev. Statutes, c. 246) which, besides the matters included in the Act of Charles II., prohibits political meetings, noisy games, shooting, fishing, and excursions, and to some extent the running of street railways. The

Indians of the province are exempt from the Act. In New Zealand an Act of 1884 (c. 24, § 16) prohibits the carrying on on Sunday of any trade or calling, but the exceptions are numerous, and, besides works of necessity or charity, include driving live stock, sale of medicines, sale or delivery of milk, hairdressing or shaving before 9 A.M., driving public or private carriages, keeping livery stables, working railways, ships and boats, and letting boats for hire, and work in connexion with post offices and telegraphs, and with daily newspapers.

United States.—The early legislation in the Eastern, and particularly in the New England states, prohibited business, travelling, and work of all kinds except of absolute necessity or of religious or charitable purpose. Unsuccessful attempts have been made to have the Sunday laws declared unconstitutional and invalid as interfering with the liberty of conscience and worship and the rights of property guaranteed by the Federal and State constitutions. But legislation has resulted in considerable relaxation from the old Puritan strictness. In Massachusetts, which may be fairly taken as representing the Eastern states, public service corporations, such as railway, street railway, steamboat, telegraph, telephone, electric lighting, water and gas companies, are permitted to serve the public in the usual manner. Public parks and baths are open. Tobacco may be sold by licensed innholders, common victuallers, druggists, and newsdealers. Bake shops may be open during certain hours. All other shops must be closed. Saloons are closed, and liquor can be served only to the guests of licensed innholders. Horses, carriages, boats, and yachts may be let for hire. All games and entertainments, except licensed sacred concerts, are prohibited. In Connecticut Sunday recreation is still prohibited, but electric and steam cars are now allowed to run. Sunday is a close time for game and birds (1899). In many of the Western states base-ball games and various entertainments for pay are permitted, and in some saloons are open. In many but not all the states such persons as by their religion are accustomed to observe Saturday are allowed to pursue their ordinary business on Sunday. In Delaware and Illinois barbers may not shave customers on Sundays; and in Georgia guns and pistols may not be fired (1898). In North Dakota the fines for Sabbath-breaking have been raised. Statutory provision has lately been made in Minnesota (1899) for investigation by the labour bureaux into Sunday labour; while in New York City the population of European origin have been much vexed by the enforcement of the Sunday laws.

Europe.—On the continent of Europe there is a distinct tendency to restrict Sunday labour, not on religious grounds, but in the interests of the industrial classes. In *France* a law of 13th June 1896 regulates *le repos hebdomadaire*, and M. Baudry d'Asson in that year introduced a Bill proposing to prohibit Sunday labour, but this was reported against and rejected. In *Austria* in the first half of the 19th century Sunday labour was prohibited on religious considerations. In 1884 legislation was passed with reference to factory workers, and after divers amendments and much discussion, comprehensive laws were passed in 1895. These laws prohibit factory work on Sundays, with certain specified exceptions corresponding to those of the English Factory Acts, and subject to the right of the Minister of Commerce to except works of a character which renders Sunday labour inevitable. Commercial enterprise or labour in shops, offices, &c., and hawking is allowed on Sundays for not more than six hours. The hours during which Sunday opening is permissible are settled by a form of local option. (W. F. C.)

Sunderland, a seaport and municipal (extended 1895), county (1888), and parliamentary borough, Durham county, England, at the mouth of the Wear, 269 miles north by west of London by rail. Recent buildings include the town hall, the museum and library, and other public institutions. Electric lighting is supplied by the corporation, which also owns a system of electric tramways. Two new piers, 2790 and 2844 feet long respectively, have been built, so as to form a harbour about 150 acres in area. There are two other piers at the south entrance to the south dock. The docks already opened accommodate many hundreds of vessels, and an undertaking is in hand to make the port adequate to the entry and exit of vessels of any size at any time. Besides the other docks there are two graving docks respectively 441 and 356 feet long. There are over a dozen shipbuilding yards. A large park at Roker and two smaller parks have been opened. In 1891, 6336 persons were employed in shipbuilding, 2057 in iron and steel manufactures, 2580 in the making of machines, and 1225 in mining. There are four daily newspapers. At this port 318 vessels of 229,081 tons were registered in 1888; in 1898, 252 of 266,211 tons. Vessels entered in 1888, 8473 of 2,719,256 tons; cleared, 8376 of 2,772,837 tons; in 1900, entered 6377 of 2,453,883 tons; cleared, 6487 of 2,559,025 tons. The value of the imports in 1900 was £695,350, against £583,561 in 1888. The value of the exports in 1900 was £2,320,200, against £583,561 in 1888. Area of municipal and county borough in 1891, 2868 acres; population in 1881, 116,526; in 1891, 131,015. The extended area (3739 acres) is coextensive with that of the newly-constituted parish of Sunderland, which includes the old parishes of Sunderland, Bishopwearmouth Panns, and almost the entire part of Bishopwearmouth on the south bank of the river; also Monkwearmouth and Monkwearmouth Shore on its north bank. The population on this area in 1891 was 131,686; in 1901, 146,565.

Sundsvall, a seaport town of Sweden, Vesternorrland county, on the east coast, on a wide bay of the Baltic, 117 miles north from Gefle, and connected by a branch line (70 miles) with the Stockholm–Trondhjem railway at Ånge (301 miles from Stockholm). Having been rebuilt in brick and stone since a destructive fire of 1888, it is one of the best built towns in Sweden, with a fine Gothic church, handsome schools, slöjd school, town hall, theatre (1894), &c. It possesses about forty steam saw-mills, besides wood-pulp factories, steel-works, brick-works, engineering shops, breweries, and joineries, but owes its chief importance to its export trade in timber (6 to 7 million cubic feet annually), the bulk of which goes to Germany, France, and Great Britain. It also exports wood-pulp, and a little iron and fish. There is a special trade with Finland. The harbour, which is usually closed by ice from about the middle of December to the second week in May, is sheltered against the east winds by a group of islands. In 1900 the port was cleared by 1033 vessels of 559,500 tons. Population (1900), 14,831.

Superior, a city of Wisconsin, U.S.A., the capital of Douglas county. It is situated in lat. 46° 42′, long. 92° 02′, at the head of Lake Superior, opposite Duluth, Minnesota, in the north-western part of the state, and at an altitude of 641 feet. The city is laid out with great regularity on a level plain, with broad streets, well paved mainly with wooden blocks, has an excellent water-supply drawn from Lake Superior, and is well sewered. It has an excellent harbour, shared with Duluth, and formed by Minnesota and Wisconsin Points, which, projecting at right angles from the north and south shores respectively, nearly close in the upper end of the lake. It has an immense lake traffic, consisting largely of wheat, coal, and lumber. It has four railways—the Chicago, St Paul, Minneapolis, and Omaha; the Duluth, South Shore, and Atlantic; the Great Northern; and the Northern Pacific, which add greatly to the city's traffic. The manufactures of the city are large and are rapidly increasing. They consist mainly of flour, lumber and lumber products, and iron and woollen goods. In 1900 the city contained 185 manufacturing establishments, with a capital of $5,882,562, employing 1958 hands and having a product valued at $7,527,703. There are many grain elevators, coal docks, and shipyards. The assessed valuation of real and personal property in 1899 was $10,604,151, the net debt of the city was $1,356,241, and the rate of taxation was $40·50 per $1000. The rate of assessment was very low. Superior was originally a trading post of the Hudson Bay Company. The city was founded in 1855, but no settlement followed, and it was not until 1885, thirty years later, that the present city commenced its rapid growth. Population (1890), 11,983; (1900), 31,091, of whom 11,419 were foreign-born and 186 negroes.

Suppé, Franz von (1820–1895), Austrian musical composer, whose real name was Francesco Ezechiele Ermenegildo Suppé-Demelli, was born at Spalato, in Dalmatia, in 1820, and died at Vienna in 1895. Originally he studied philosophy at the University of Padua, but on the death of his father devoted himself to music, studying at the Vienna Conservatoire under Sechter and Seyfried. He began his musical career as a conductor in one of the smaller Viennese theatres, and gradually worked his way up to be one of the most popular composers of light opera of the day. Outside Vienna his works have never won much success. Only two of his sixty comic operas have ever found their way to London. Of these *Fatinitza* (Vienna, 1876; London, 1878) was the most successful. *Boccaccio* (Vienna, 1879; London, 1882) only enjoyed a moderate amount of favour. It would be useless to attempt a catalogue of Suppé's comic operas, which are of the most ephemeral character, and only at their very best can pretend to something of the charm of Strauss. Suppé's overture to *Dichter und Bauer* is his most successful orchestral work. He also wrote some Church music.

Surat, a city and district of British India, in the Gujarat division of Bombay. The city is situated on the left bank of the river Tapti, 14 miles from its mouth; railway station, 167 miles north of Bombay. Population (1881), 109,844; (1891), 109,229; (1901), 118,364. The modern city is well laid out, with roads and markets. The most interesting monuments are the tombs of English and Dutch merchants of the 17th century. The military cantonment lies to the west. Surat is still a centre of trade and manufacture, though some of its former industries, such as shipbuilding, are now extinct. There are three cotton mills, with 181 looms and 45,000 spindles, employing 1550 hands; twenty factories for ginning and pressing cotton; a rice-cleaning mill; and a paper mill. Fine cotton goods are woven in handlooms, and there are special manufactures of silk brocade and embroidery. The chief trades are organized in guilds. There are many wealthy Parsi, Hindu, and Mahommedan merchants. There are three high schools, of which one is supported by the Government, one by a mission, and one by a Hindu association; total pupils (1896–97), 1124; also a municipal industrial school. The city has twelve printing-presses, issuing several vernacular newspapers.

The district has an area of 1662 square miles. Population (1881), 614,198; (1891), 649,989, showing an increase of 6 per cent.; average density, 391 persons per square mile, being the second highest in the province. In 1901 the population was 636,602, showing a decrease of 2 per cent. Land revenue and rates, Rs.29,76,000, the incidence of assessment being Rs.3–5–7 per acre. Cultivated area (1897–98), 481,531 acres, of which 10,256 were irrigated from wells, &c. Number of police, 833; children at school (1897–98), 25,306, being 4·4 per cent. of the total population; registered death-rate (1897), 33·48 per 1000. The principal crops are millet, rice, pulse, and cotton. After Surat city, the chief centre of trade is Bulsar. The district is traversed for 74 miles by the main line of the Bombay and Baroda Railway, with 15 stations; and a branch is now being constructed along the Tapti valley to join the Great Indian Peninsula in Khandeish.

The Surat Agency consists of three native states—Dharampur, Bansda, and Sachin. Total area, 1051 square miles; population (1891), 181,208; (1901), 161,010, showing a decrease of 11 per cent. Dharampur has an estimated revenue of Rs.4,13,000; tribute, Rs.9000. Bansda: revenue, Rs.3,33,000; tribute, Rs.154. Sachin: revenue, Rs.2,08,500; no tribute. The chiefs of the two former are Rajputs; the last is a Mahommedan.

Surbiton, a civil parish and town of England, on the Thames, in the ancient parish of Kingston, 12 miles south-west of London, and in the Kingston parliamentary division of Surrey. Station on the London and South-Western Railway. Population of urban district in 1881, 9406; in 1901, 15,019.

Surface.—Most of the results briefly outlined in the following article depend upon the method of treatment of the geometry of surfaces founded on the consideration of the expression of the lineal element in terms of two parameters, u, v,

$$ds^2 = \mathrm{E}du^2 + 2\mathrm{F}dudv + \mathrm{G}dv^2,$$

$u = \text{const}$, $v = \text{const}$, being thus systems of curves traced on the surface. This method has the great advantage of dealing in the most natural way with all questions connected with geodetics, geodetic curvature, geodetic circles, &c.—in fact, all relations of lines on a surface which can be formulated without reference to anything external to the surface. All such relations when deduced for any particular surface can be at once generalized in their application, holding good for any other surface which has the same expression for its lineal element; *e.g.*, relations involving great circles and small circles on a sphere furnish us with corresponding relations for geodetics and geodetic circles on any synclastic surface of constant specific curvature. The study of surfaces from this point of view may be said to have been inaugurated by Gauss in his classical paper published in 1828, *Disquisitiones generales circa superficies curvas.* He begins by introducing the conception of the integral curvature ("*curvatura integra*") of any portion of a surface. This he defines to be the area of the corresponding portion of a sphere of unit radius, traced out by a radius drawn parallel to the normal at each point of the surface; *i.e.*, it is $\iint \frac{ds}{\mathrm{RR}'}$, where R, R′ are the principal radii of curvature. The quotient obtained by dividing the integral curvature of a small portion of the surface round a point by the area of that portion, that is $\frac{1}{\mathrm{RR}'}$, he naturally calls the measure of curvature or the specific curvature at the point in question. He proceeds to establish his leading proposition, that this specific curvature at any point is expressible in terms of the E, F, and G which enter into the equation for the lineal element, together with their differential coefficients with respect to the variables, u and v.

It is desirable to make clear the exact significance of this theorem. Of course, for any particular surface, the curvature can be expressed in an indefinite variety of ways. The speciality of the Gaussian expression is that it is deduced in such a manner as to hold good for all surfaces which have the same expression for the lineal element. The expression for the specific curvature, which is in general somewhat elaborate, assumes a very simple form when a system of geodetics and the system of their orthogonal trajectories are chosen for the parameter curves, the parameter u being made the length of the arc of the geodetic, measured from the curve, $u=0$ selected as the standard. If this be done the equation for the lineal element becomes $ds^2=du^2+\mathrm{P}^2dv^2$, and that for the specific curvature $\frac{1}{\mathrm{RR}'}=-\frac{1}{\mathrm{P}}\frac{d^2\mathrm{P}}{du^2}$. By means of this last expression Gauss then proves that the integral curvature of a triangle formed by three geodetics on the surface can be expressed in terms of its angles, and is equal to $\mathrm{A}+\mathrm{B}+\mathrm{C}-\pi$, a theorem he, with natural satisfaction, calls "*elegantissimum.*"

This theorem may be more generally stated.

The integral curvature of any portion of a surface $=2\pi-\Sigma di$ round the contour of this portion . . . (A), where di denotes the angle of geodetic contingence of the boundary curve. The angle of geodetic contingence of a curve traced on a surface may be defined as the angle of intersection of two geodetic tangents drawn at the extremities of an element of arc, an angle which may be easily proved to be the same as the projection on the tangent plane of the ordinary angle of contingence. The geodetic curvature, which we shall denote by $\frac{1}{\rho}$, is thus equal to the ordinary curvature multiplied by cos ϕ, ϕ being the angle the osculating plane of the curve makes with the tangent plane.

The theorem (A), discovered by Gauss by his E, F, G analysis, may be established geometrically in the following simple manner:—

If we draw successive tangent planes along the curve, these will intersect in a system of lines, termed the *conjugate* tangents, forming a developable surface. If we unroll this developable it appears at once that $di=d\theta-d\psi$, where di is the angle of geodetic contingence, $d\theta$ the angle between two consecutive conjugate tangents, ψ the angle the conjugate tangent makes with the curve. Therefore, as ψ returns to its original value when we integrate round the curve, we have $\Sigma di=\Sigma d\theta$. This equation holds for both the curve on the given surface and the representative curve on the sphere. But the tangent planes along these curves being always parallel, their successive intersections are so also; therefore $\Sigma d\theta$ is the same for both; consequently Σdi for the curve on the surface $=\Sigma di$ for the representative curve on the sphere. Hence integral curvature of curve of surface $=$ area of representative curve on sphere,

$$\begin{aligned}&=2\pi-\Sigma di \text{ on sphere by spherical geometry,}\\ &=2\pi-\Sigma di \text{ for curve on surface.}\end{aligned}$$

A useful expression for the geodetic curvature of one of the curves, $v=$const, can be obtained. If a curve receive a small displacement on any surface, so that the displacements of its two extremities are normal to the curve, it follows, from the Calculus of Variations, that the variation of the length of the curve $=\int\frac{\delta n}{\rho}\,ds$ where $\frac{1}{\rho}$ is the geodetic curvature, and δn the normal component of the displacement at each point. Applying this formula to one of the v curves, we find

$$\delta\int \mathrm{P}dv=\int\frac{d\mathrm{P}}{du}\,\delta u dv=\delta \text{ length of curve}=\int\frac{1}{\rho}\,\delta u\mathrm{P}dv,$$

and as δu is the same for all points of the curve, $\frac{1}{\rho}=\frac{1}{\mathrm{P}}\frac{d\mathrm{P}}{du}$.

We can deduce immediately from this expression Gauss's value for the specific curvature. For applying theorem (A) to the quadrilateral formed by the curves u, u_1, v, v_1, and remembering that Σdi along a geodetic vanishes, we have

$$\begin{aligned}\iint\frac{\mathrm{P}dudv}{\mathrm{RR}'}&=-\Sigma di \text{ for curve BC}-\Sigma di \text{ for curve DA,}\\ &=-\Sigma\frac{1}{\rho}ds \text{ for curve BC}+\Sigma\frac{1}{\rho}ds \text{ for curve AD,}\\ &=-\int\frac{1}{\mathrm{P}}\frac{d\mathrm{P}}{du}\mathrm{P}dv \text{ for curve BC}+\int\frac{1}{\mathrm{P}}\frac{d\mathrm{P}}{du}\mathrm{P}dv \text{ for curve AD,}\\ &=-\int\left\{\left(\frac{d\mathrm{P}}{du}\right)_{u_1}-\left(\frac{d\mathrm{P}}{du}\right)_{u}\right\}dv,\end{aligned}$$

therefore passing to the limit $\frac{\mathrm{P}}{\mathrm{RR}'}=-\frac{d^2\mathrm{P}}{du^2}$.

Gauss then proceeds to consider what the result will be if a surface be deformed in such a way that no lineal element is altered. It is easily seen that this involves that the angle at which two curves on the surface intersect is unaltered by this deformation; and since obviously geodetics remain geodetics, the angle of geodetic contingence and consequently the geodetic curvature are also unaltered. It therefore follows from theorem (A) that the integral curvature of any portion of a surface and the specific curvature at any point are unaltered by non-extensional deformation.

Geodetics and Geodetic Circles.

For the definition of a geodetic and its fundamental properties see article SURFACE, vol. xxii. It is also explained in that article within what range a geodetic possesses the property of being the shortest path between two of its points. The determination of the geodetics on a given surface depends upon the solution of a differential equation of the second order. The first integral of this equation when it can be found for any given class of surfaces gives us the characteristic property of the geodetics on such surfaces. The following are some of the well-known classes for which this integral has been obtained: 1. Quadrics; 2. Developable surfaces; 3. Surfaces of revolution.

1. *Quadrics.*—Several leading mathematicians about the middle of last century made a special study of the geometry of the lines of curvature and the geodetics on quadrics, and were rewarded by the discovery of many wonderfully simple and elegant analogies between their properties and those of a system of confocal conics and their tangents *in plano.* As explained in the article on SURFACES, the lines of curvature on a quadric are the systems of orthogonal curves formed by its intersection with the two systems of confocal quadrics. Joachimstal showed that the interpretation of the first integral of the equation for geodetics on a central quadric is, that along a geodetic $p\mathrm{D}=$ constant (C), p denoting the perpendicular let fall from the centre on the tangent plane, and D the semidiameter drawn parallel to the element of the geodetic, the envelope of all geodetics having the same C being a line of curvature. In particular, all geodetics passing through one of the real umbilics (the four points where the indicatrix is a circle) have the same C.

Michael Roberts pointed out that it is an immediate consequence of the equation $p\mathrm{D}=\mathrm{C}$, that if two umbilics, A and B (selecting two not diametrically opposite), be joined by geodetics to any point P on a given line of curvature, they make equal angles with such line of curvature, and consequently that, as P moves along a line of curvature, either PA + PB or PA − PB remains constant. Or, conversely, that the locus of a point P on the surface, for which the sum or difference of the geodetic distances PA and PB is constant, is a line of curvature. It follows that if the ends of a string be fastened at the two umbilics of a central quadric, and a style move over the surface keeping the string always stretched, it will describe a line of curvature.

Another striking analogue is the following :—

As *plano*, if a variable point or an ellipse be joined to the two foci S and H, tan $\frac{1}{2}$PSH tan $\frac{1}{2}$PHS = const, and for the hyperbola tan $\frac{1}{2}$PSH/ tan $\frac{1}{2}$PHS = const, so for a line of curvature on a central quadric, if P be joined to two umbilics S and H by geodetics, either the product or the ratio of the tangents of $\frac{1}{2}$PSH and $\frac{1}{2}$PHS will be const.

Chasles proved that if an ellipse be intersected in the point A by a confocal hyperbola, and from any point P on the hyperbola tangents PT, PT′ be drawn to the ellipse, then the difference of the arcs of the ellipse TA, T′A = the difference of the tangents PT, PT′; and subsequently, Graves showed that if from any point P on the outer of two confocal ellipses tangents be drawn to the inner, then the excess of the sum of the tangents PT, PT′ over the intercepted arc TT′ is constant. Precisely the same theorems hold for a quadric replacing the confocals by lines of curvature and the rectilineal tangents by geodetic tangents. Hart still further developed the analogies with confocal conics, and established the following :—If a geodetic polygon circumscribe a line of curvature, and all its vertices but one move on lines of curvature, this vertex will also describe a line of curvature, and when the lines of curvature all belong to the same system, the perimeter of the polygon will be constant.

2. *Geodetics on Developable Surfaces.*—On these the geodetics are the curves which become right lines when the surface is unrolled into a plane. From this property a first integral can be immediately deduced.

3. *Geodetics on Surfaces of Revolution.*—In all such the geodetics are the curves given by the equation, $r \sin \phi =$ const, r being the perpendicular on the axis of revolution, ϕ the angle at which the curve crosses the meridian.

The general problem of the determination of geodetics on any surface may be advantageously treated in connexion with that of "parallel" curves. By "parallel" curves are meant curves whose geodetic distances from one another are constant—in other words, the orthogonal trajectories of a system of geodetics. In applying this method the determination of a system of parallel curves comes first, and the determination of the geodetics to which they are orthogonal follows as a deduction. If $\phi(u, v) =$ const be a system of parallel curves, it is shown that ϕ must satisfy the partial differential equation

$$\mathrm{E}\left(\frac{d\phi}{dv}\right)^2 - 2\mathrm{F}\left(\frac{d\phi}{du}\right)\left(\frac{d\phi}{dv}\right) + \mathrm{G}\left(\frac{d\phi}{dv}\right)^2 = \mathrm{EG} - \mathrm{F}^2.$$

If $\phi\ (u,\ v,\ a) =$ const be a system of parallel curves satisfying this equation, then $\left(\frac{d\phi}{da}\right) =$ const is proved to represent the orthogonal geodetics. The same method enables us to establish a result first arrived at by Jacobi, that whenever a first integral of the differential equation for geodetics can be found, the final integral is always reducible to quadratures. In this method ϕ corresponds to the characteristic function in the Hamiltonian dynamics, the geodetics being the paths of a particle confined to the surface when no extraneous forces are in action. See MECHANICS.

The expression for the lineal element on a quadric in elliptic co-ordinates suggested to Liouville the consideration of the class of surfaces for which this equation takes the more general form $ds^2 = (\mathrm{U} - \mathrm{V})(\mathrm{U}_1{}^2du^2 + \mathrm{V}_1{}^2dv^2)$, where U, U_1 are functions of u, and V, V_1 functions of v, and shows that, for this class, the first integral of the equation of the parallels is immediately obtainable, and hence that of the corresponding geodetics. It is to be remarked that for this more general class of surfaces the theorems of Chasles and Graves given above will also hold good.

Geodetics on a surface corresponding to right lines on a plane, the question arises what curves on a surface should be considered to correspond to plane circles. There are two claimants for the position: first, the curves described by a point whose geodetic distance from a given point is constant; and, second, the curves of constant geodetic curvature.

On certain surfaces the curves which satisfy one of these conditions also satisfy the other, but in general the two curves must be carefully distinguished. The property involved in the second definition is more intrinsic, and we shall therefore, following Liouville, call the curves possessing it geodetic circles. It may be noted that geodetic circles, except on surfaces of constant specific curvature, do not return back upon themselves like circles *in plano.* As a particular instance, a geodetic on an ellipsoid (which is, of course, a geodetic circle of zero curvature), starting from an umbilic, when it returns again, as it does to that umbilic, makes a finite angle with its original starting position. As to the curve described by a point whose geodetic distance from a given centre is constant, Gauss showed from the fundamental property of a geodetic that this curve resembles the plane circle in being everywhere perpendicular to its radius. In the same way it holds that the curve described by a point the sum (or difference) of whose geodetic distances from two given points (foci) is constant, resembles the plane ellipse (or hyperbola) in the property that it bisects at every point the external (or internal) angle between the geodetic focal radii, and, as a consequence, that the curves on any surface answering to confocal ellipses and hyperbolas intersect at right angles. The equation for the lineal element enables us to discuss geodetic circles on surfaces of constant specific curvature; for we have seen that if we choose as parameters, geodetics and their orthogonal trajectories, the equation becomes $ds^2 = du^2 + \mathrm{P}^2du^2$; and since $\frac{1}{\mathrm{RR}^1} = -\frac{1}{\mathrm{P}}\frac{d^2\mathrm{P}}{du^2}$, and here $\frac{1}{\mathrm{RR}^1} = \pm\frac{1}{a^2}$, it follows $\mathrm{P} = \mathrm{A}\cos\frac{u}{a} + \mathrm{B}\sin\frac{u}{a}$, or $\mathrm{P} = \mathrm{A}\cosh\frac{u}{a} + \mathrm{B}\sinh\frac{u}{a}$, according as the surface is synclastic or anticlastic. If a geodetic circle (curvature $\frac{1}{k}$) be chosen for the starting curve $u = 0$, and if v be made the length of the arc OY, intercepted on this circle by the curve $v =$ const (see Fig. 1), then A and B can be proved to be independent of u and $\mathrm{P} = \cos\frac{u}{a} + \frac{a}{k}\sin\frac{u}{a}$ for a synclastic surface, $\mathrm{P} = \cosh\frac{u}{a} + \frac{a}{k}\sinh\frac{u}{a}$ for an anticlastic surface. It follows from the expression for the geodetic curvature $\frac{1}{\rho} = \frac{1}{\mathrm{P}} \cdot \frac{d\mathrm{P}}{du}$ that in both classes of surfaces all the other orthogonal curves $u =$ const will be

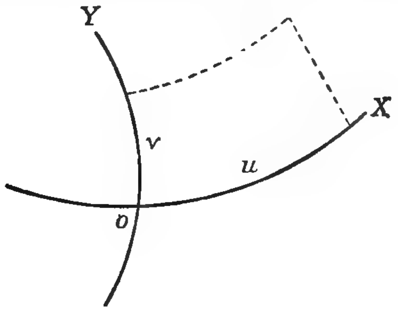

Fig. 1.

geodetic circles. It also appears that on a synclastic surface of constant specific curvature all the geodetics normal to a geodetic circle converge to a point on either

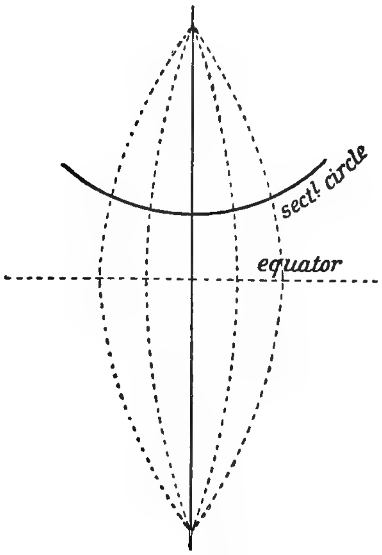

Fig. 2.

side as on a sphere, and can be described with a stretched string taking either of these points as centre, the length of the string being $a \tan^{-1}\left(\frac{a}{k}\right)$ (see Fig. 2). These normals will be all cut orthogonally by an equator, that is, by a geodetic circle of zero curvature.

For anticlastic surfaces, however, we must distinguish two cases. If the curvature $\frac{1}{k}$ of the geodetic circle $> \frac{1}{a}$ the geodetic normals meet in a point on the concave side of the geodetic circle, and can be described as on the synclastic by a stretched string, the length of the string being $a \tanh^{-1}\left(\frac{a}{k}\right)$, but in this case the geodetic normals have no equator (see Fig. 3). If on the other hand the curvature of the geodetic circle be $< \frac{1}{a}$ the normals do not meet on either side, but do possess an equator, and at this equator the geodetic normals come nearer together than they do anywhere else (see Fig. 4).

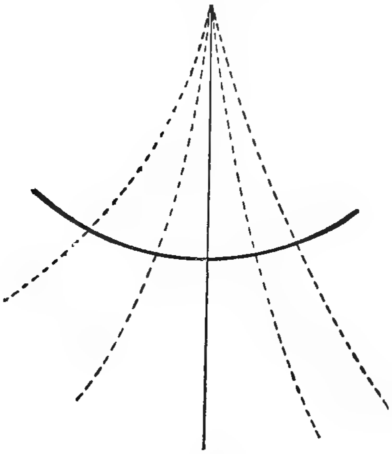

Fig. 3.

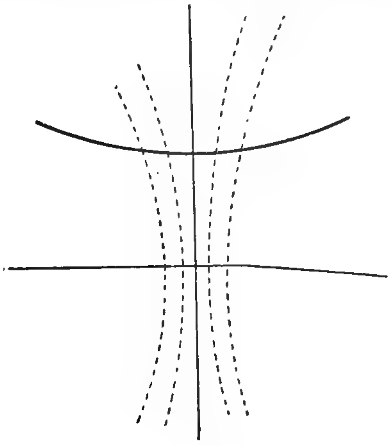

Fig. 4.

On a synclastic surface of constant specific curvature $\frac{1}{a^2}$ two near geodetics proceeding from a point always meet again at the geodetic distance πa; and more generally for any synclastic surface whose specific curvature at every point lies between the limits $\frac{1}{a^2}$ and $\frac{1}{b^2}$, two near geodetics proceeding from a point always meet again at a geodetic distance intermediate in value between πa and πb. On an anticlastic surface two near geodetics proceeding from a point never meet again.

Representation of Figures on a Surface by Corresponding Figures on a Plane; Theory of Maps.

The most valuable methods of effecting such representation are those in which small figures are identical in shape with the figures which they represent. This property is known to belong to the representation of a spherical surface by Mercator's method as well as to the representation by stereographic projection. The problem of effecting this "conformable" representation is easily seen to be equivalent to that of throwing the expression for the lineal element into what is known in the theory of heat-conduction as the isothermal form $ds^2 = \lambda(du^2 + dv^2)$, for we have then only to choose for the representative point on the plane that whose rectangular co-ordinates are $x = u$, $y = v$. A curious investigation has been made by Beltrami—when is it possible to represent a surface on a plane in such a way that the geodetics on the surface shall correspond to the right lines on the plane (as, for example, holds true when a spherical surface is projected on a plane by lines through its centre)? He has proved that the only class of surface for which such representation is possible is the class of uniform specific curvature.

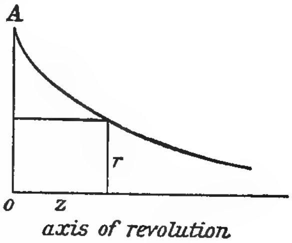

Fig. 5.

Just as the intrinsic properties of a synclastic surface of uniform specific curvature are reducible to those of a particular surface of this type, *i.e.*, the sphere, so we can deal with an anticlastic surface of constant specific curvature, and reduce its properties to a particular anticlastic surface. A convenient surface to study for this purpose is that known as the *Pseudosphere*, formed by the revolution of the tractrix (an involute of the catenary) round its base (see Fig. 5). Its equations are $r = a \sin\phi$, $z = a\left(\cos\phi + \log\tan\frac{\phi}{2}\right)$. This surface can be conformably represented as a plane map by choosing $x' = \omega$ where ω is the longitude of the point and $y' = \frac{a}{\sin\phi}$. It will then be found that $ds = \frac{a\,ds'}{y'}$, where ds = lineal element on the surface, ds' = same on the map. It easily appears that geodetic circles on the surface are represented by circles on the map, the angle ψ at which these circles cut the base depending only upon the curvature of the geodetic circle, $\cos\psi$ being equal to $\frac{1}{\rho}$. As a particular case it follows that the geodetics on the surface are represented by those special circles on the map whose centres lie on the base (see Fig. 6). The geodetic distance between two points P and Q on the surface is represented by the logarithm of the anharmonic function AP′BQ′, where P′Q′ are the representing points on the map, A B the points in which the circle on the map which passes through P′ and Q′ and has its centre on the base cuts the base. The perimeter (l) of a geodetic circle of curvature $\frac{1}{\rho}$ turns out to be $\frac{2\pi a\rho}{\sqrt{a^2-\rho^2}}$, and its area $\left(\frac{l}{\rho} - 2\pi\right)a^2$. The geometry of coaxal circles *in plano* accordingly enables us to demonstrate anew by means of the pseudosphere the properties which we have shown to hold good in all anticlastic surfaces of constant curvature. Thus the system of geodetics cutting orthogonally a geodetic circle C will be represented on the map by circles having their centres on the base, and cutting a given circle C′ orthogonally, *i.e.*, by a coaxal system of circles. We know that the other orthogonal trajectories of this last system are another coaxal system, and therefore, going back to the pseudosphere, we learn that if a system of geodetics be drawn normal to a geodetic circle, all the orthogonals to this system are geodetic circles. It is to be noted that while every point on the surface has its representative on the map, the converse does not hold. It is only points lying above the line $y' = a$ which have their prototypes on the surface, the portion of the plane below this line not answering to any real part of the surface. If we take any curve C′ on the map crossing this line, the part of the curve above this line has as its prototype a curve on the surface. When C′ reaches this line, C reaches the circular base of the pseudosphere, and there terminates abruptly. The distinction between the two cases of a geodetic circle with curvature greater and one with curvature less than $\frac{1}{a}$ also comes out clearly. For if curvature of $C > \frac{1}{a}$ the map circle C′ lies entirely above the base, and the coaxal system cutting C′ orthogonally passes through a real point; therefore C has a centre. If curvature of $C < \frac{1}{a}$ the map circle C′ intersects the base, the coaxal system cutting C′ orthogonally does not intersect in a real point, and C has accordingly no centre. It is of interest to examine in what way a pseudosphere differs from a plane as regards the behaviour of parallel lines. If on a plane a geodetic AB (*i.e.*, a right line) be taken, and another geodetic constantly pass through a point P and revolve round P, it will always meet AB in the point except in the particular position. On the pseudosphere, if we carry out the corresponding construction, the position of the non-intersecting geodetic is not unique, but all geodetics drawn within a certain angle fail to meet the geodetic AB. See GEOMETRY, NON-EUCLIDEAN.

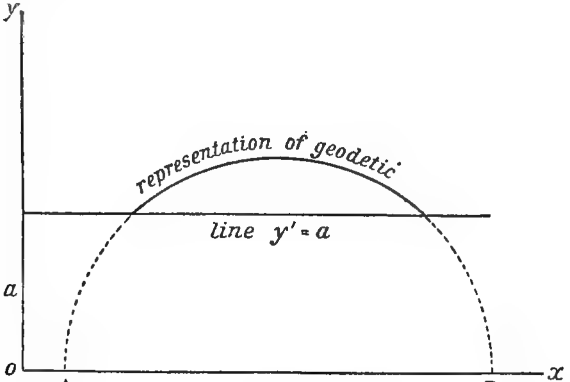

Fig. 6.

Minimal Surfaces.

For the definition of these surfaces and their partial differential equations, see SURFACES. From this definition readily follows the well-known property of these surfaces—that the two principal curvatures are at every point of such a surface equal and opposite. For familiar instances of the class we have the surface formed by the revolution of a catenary round its base called by French mathematicians the alysséide, and the right conoid, $z = a \tan^{-1}\frac{y}{x}$, formed by the successive edges of the steps of a spiral staircase. Monge succeeded in expressing the co-ordinates of the most general minimal surface in two parameters, and in a form in which the variables are separated. The separation of the variables in the expression signifies that every minimal surface belongs to the class of surfaces which can be generated by a movement of translation of a curve. Enneper has thrown the expression for the co-ordinates into the following convenient forms—

$$x = \frac{1}{2}\int(1-u^2)f(u)du + \frac{1}{2}\int(1-v^2)\phi(v)dv,$$
$$y = \frac{i}{2}\int(1+u^2)f(u)du - \frac{i}{2}\int(1+v^2)\phi(v)dv,$$
$$z = \int uf(u)du + \int v\phi(v)dv.$$

It is noteworthy that the expression for the lineal element on a minimal surface assumes the isothermal form $ds^2 = \lambda(du^2 + dv^2)$, (1) when the curves u = const, v = const are so chosen as to be the lines of curvature; and (2) when they are chosen to be the lines in which the surface is intersected by a system of parallel planes and the orthogonal trajectories of these lines. It is easily proved that a minimal surface possesses the property of being conformable to its spherical representation. For since the indicatrix at every point is a rectangular hyperbola, the angle between the elements of two intersecting curves = angle between their conjugate tangents; but this = angle between conjugate tangents to representative curves on sphere = angle between these curves themselves.

The problem of finding a minimal surface to pass through a given curve in space, known as Plateau's problem, possesses an exceptional interest from the circumstance that it can be always exhibited to the eye in the following way by an actual physical experiment. Dip a wire having the form of the given curve in a soap-bubble solution, and the film adhering to the wire when it is withdrawn is the surface required. This is evident, since from the theory of surface-tension we know that a very thin film must assume that form for which the area of its surface is the least possible. The same theory also furnishes us with an elementary proof of the characteristic property that the sum of the curvatures is everywhere zero, inasmuch as the normal pressure on the film, here zero, is known to be proportional to the surface-tension multiplied by the sum of the curvatures.

Riemann, adopting a method depending upon the use of the complex variable, has succeeded in solving Plateau's problem for several interesting cases, *e.g.*, 1° when the contour consists of three infinite right lines; 2° when it consists of a gauche quadrilateral; and 3° when it consists of any two circles situated in parallel planes. For Lie's investigations in this domain, see GROUPS, THEORY OF CONTINUOUS.

Non-extensional Deformation.

We have already explained what is meant by this term. It is a subject to which much study has been devoted, connecting itself, as it does, with the work of Gauss in pure geometry on the one hand, and with the theory of elasticity on the other. Several questions have been opened up:—(1) What are the conditions which must be fulfilled by two surfaces such that one can be "deformed" so as to fit on the other? (2) What instances have we of known surfaces applicable to one another? (3) What surfaces are applicable to themselves? (4) In regard to infinitely small deformations, what are the differential equations which must be satisfied by the displacements? (5) Under what circumstances can a surface not be deformed? Can a closed surface ever be deformed?

1. Of course if two surfaces are applicable, we must be able to get two systems of parameter curves $u = \text{const}$, $v = \text{const}$, on the first surface, and two systems on the second, such that the equation for the lineal element, when referred to these, may have an identical form for the two surfaces. The problem is now to select these corresponding systems. We may conveniently take for the co-ordinate u the specific curvature on each surface, and choose for v the function $\frac{du}{dn}$ which denotes the rate of increase of u along a direction normal to the curve $u = \text{const}$. Then, since at corresponding points both u and v will be the same for one surface as for the other, if the surfaces are applicable, E, F, and G, in the equation, $ds^2 = \mathrm{E}du^2 + 2\mathrm{F}dudv + \mathrm{G}dv^2$ must be identical for the two surfaces. Clerk-Maxwell has put the geometrical relation which exists between two applicable surfaces in the following way:—If we take any two corresponding points P and P′ on two such surfaces, it is always possible to draw two elements through P parallel to conjugate semi-diameters of the indicatrix at P, such that the corresponding elements through P′ shall be parallel to conjugate semi-diameters of the indicatrix at P′. The curves made up of all these elements will divide the two surfaces into small parallelograms, the four parallelograms having P as common vertex being identical in size and shape with the four having P′ as vertex. Maxwell regards the surfaces as made up in the limit of these small parallelograms. Now, in order to render these surfaces ready for application, the first step would be to alter the angle between two of the planes of the parallelograms at P, so as to make it equal to that between the corresponding planes at P′. If this be done it is readily seen that all the angles between the other planes at P and P′, and at all other corresponding points, will become equal also. The curves which thus belong to the conjugate systems common to the two surfaces may be regarded as *lines of bending*.

2. Any surface of uniform specific curvature, whether positive or negative, is applicable to another surface of the same uniform specific curvature, in an infinite variety of ways. For if we arbitrarily choose two points, O and O′, one on each surface, and two elements, one through each point, we can apply the surfaces, making O and O′ corresponding points and the elements corresponding elements. This follows from the form of the equation of the lineal element, which is for synclastic surfaces $ds^2 = du^2 + a^2 \sin^2\left(\frac{u}{a}\right)dv^2$, and for anticlastic, $ds^2 = du^2 + a^2 \sinh^2\left(\frac{u}{a}\right)dv^2$, and is therefore identical for the two surfaces in question. Again, a ruled surface may evidently be deformed by first rotating round a generator, the portion of the surface lying to one side of this generator, then round the consecutive generator, the portion of the surface lying beyond this again, and so on. It is clear that in such deformation the rectilinear generators in the old surface remain the rectilinear generators in the new; but it is interesting to note that two ruled surfaces can be constructed which shall be applicable, yet so that the generators will not correspond. For, deform a hyperboloid of one sheet in the manner described, turning the portions of the surface round the consecutive generators of one system, and then deform the hyperboloid, using the generators of the other system. The two surfaces so obtained are, of course, applicable to one another, yet so that their generators do not now correspond. Conversely Bonnet has shown that, whenever two ruled surfaces are thus applicable, without correspondence of generators, they must be both applicable to the same hyperboloid of one sheet. The alysséide is a good example of a surface of revolution applicable to a ruled surface, in this case the right circular conoid, the generators of the conoid coinciding with the meridians of the alysséide.

3. As instances of surfaces applicable to themselves, we may take surfaces of uniform specific curvature, as obviously follows from the reasoning already given; also surfaces of revolution, inasmuch as any such surface can be turned round its axis and still fit upon its old position. Again, helicoidal surfaces possess this property. A helicoidal surface means that traced out by a rigid wire, which is given a screw motion round a fixed axis, or, which comes to the same thing, the surface made up of a system of helices starting from the points of a given curve, all having the same axis and the same interval between the successive threads. The applicability of such a surface to itself if given a screw motion round the axis, is evident from the law of its formation.

4. The possible small variations ξ, η, ζ of the points of a surface when it is subject to a small inextensional deformation are conditioned by the equation $dxd\xi + dyd\eta + dzd\zeta = 0$, or making x and y the independent variables,

$$dx^2\left(\frac{d\xi}{dx} + p\frac{d\zeta}{dx}\right) + dxdy\left(\frac{d\xi}{dy} + \frac{d\eta}{dx} + p\frac{d\zeta}{dy} + q\frac{d\zeta}{dx}\right) + dy^2\left(\frac{d\eta}{dy} + q\frac{d\zeta}{dy}\right) = 0.$$

From this it follows that the three equations must separately hold

$$\frac{d\xi}{dx} + p\frac{d\zeta}{dx} = 0,\ \frac{d\xi}{dy} + \frac{d\eta}{dx} + p\frac{d\zeta}{dy} + q\frac{d\zeta}{dx} = 0,\ \frac{d\eta}{dy} + q\frac{d\zeta}{dy} = 0.$$

Accordingly, the determination of a possible small deformation of a given surface is reduced to the analytical problem of finding three functions ξ, η, ζ of the variables x and y to satisfy these equations. Changing the co-ordinates to α and β where $\alpha = \text{const}$, $\beta = \text{const}$, are the curves of inflexion on the surface, the solution of the equations can be shown to depend upon that of the equation $\frac{d^2w}{d\alpha d\beta} = \lambda w$, where λ is a function of α and β depending on the form of the surface. The last equation can be integrated, and the possible deformation determined in the case of a spherical surface, or of any surface of uniform specific curvature. It is easily shown that if we have determined the displacements for any surface S we can do so for any surface obtained from S by a linear transformation of the variables.

For let

$$x' = a_1x + b_1y + c_1z + d_1,\quad y = a_2x + b_2y + c_2z + d_2,$$
$$z' = a_3x + b_3y + c_3z + d_3,$$

then the displacements

$$\xi' = A_1\xi + B_1\eta + C_1\zeta,\ \eta' = A_2\xi + B_2\eta + C_2\zeta,\ \zeta' = A_3\xi + B_3\eta + C_3\zeta,$$

where A_1 B_1 &c. are the minors of the determinant $[a_1 b_2 c_3]$, will evidently satisfy the equation

$$dx'd\xi' + dy'd\eta' + dz'd\zeta' = 0.$$

Accordingly the known solution for a sphere furnishes us with a solution for any quadric. M. Moutard has pointed out a curious connexion between the problem of small deformation and that of the applicability of two finitely different surfaces.

For if $dxd\xi + dyd\eta + dzd\zeta = 0$, it follows that if k be any constant,

$$\{d(x+k\xi)\}^2 + \{d(y+k\eta)\}^2 + \{d(z+k\zeta)\}^2$$
$$= \{d(x-k\xi)\}^2 + \{d(y-k\eta)\}^2 + \{d(z-k\zeta)\}^2.$$

Consequently, if we take two surfaces such that for the first

$$X = x + k\xi,\ Y = y + k\eta,\ Z = z + k\zeta,$$

and for the second

$$X' = x - k\xi,\ Y' = y - k\eta,\ Z' = z - k\zeta,$$

then

$$dX^2 + dY^2 + dZ^2 = dX'^2 + dY'^2 + dZ'^2,$$

and therefore the new surfaces are applicable.

5. Jellett and Clerk-Maxwell have shown by different methods that, if a curve on a surface be held fixed, there can be no small deformation, except this curve be a curve of inflexion. This may be also proved thus:—There can be no displacement of the tangent planes along the fixed curve, for, at any point of the curve the geodetic curvature cannot alter; but in present case the ordinary curvature of the curve is also fixed, therefore their ratio is constant, so that $\delta(\cos\theta) = -\sin\theta\delta\theta = 0$, where θ is the angle which the osculating plane makes with the tangent plane; therefore unless $\sin\theta = 0$, as it is along a curve of inflexion, $\delta\theta = 0$, and therefore the tangent plane at each point is unaltered. Hence it can be shown that along the given curve not only ξ, η, ζ vanish, but also their differential coefficients of all orders, and therefore no displacement is possible.

The question has been much discussed, Can a closed synclastic surface be deformed? There seems to be a prevalent opinion amongst mathematicians that such deformation is always impossible, but we do not think any unimpeachable demonstration of this has yet been given. It is certain that a complete spherical surface does not admit of inextensive deformation, for if it did it would follow from Gauss's theorem that the new surface would have a uniform specific curvature. Now, it is not difficult to prove that the only closed surface possessing this property is the sphere itself, provided that the surfaces in question be such that all their tangent planes lie entirely outside them. We can then, by the method of linear transformation already given, extend the theorem of the impossibility of deformation to any ellipsoid.

The theorem, that a sphere is the only closed surface of constant specific curvature, may, we suggest, be established by means of the following two propositions, which hold for integration on any closed surface, p being the perpendicular from the origin on the tangent plane—

$$\iint\left(\frac{1}{R}+\frac{1}{R'}\right)dS = 2\iint\frac{pdS}{RR'}\ .\qquad .\qquad .\qquad (1)$$

$$2\iint dS = \iint p\left(\frac{1}{R}+\frac{1}{R'}\right)dS.\ .\qquad .\qquad .\qquad (2)$$

Now multiply both sides of the first equation by the constant $\sqrt{RR'}$, and subtract the second, and we get—

$$\iint\left\{\left(\frac{R'}{R}\right)^{\frac{1}{4}}-\left(\frac{R}{R'}\right)^{\frac{1}{4}}\right\}^2 dS + \iint p\left(\frac{1}{R^{\frac{1}{2}}}-\frac{1}{R'^{\frac{1}{2}}}\right)^2 dS = 0,$$

which is impossible unless $R' = R$ everywhere, since in accordance with the proviso p is everywhere positive.

Theorems (1) and (2) are deduced by Jellett by means of the Calculus of Variations in his treatise on that subject. They may also be very simply proved thus: Draw normals to the surface along the contours of the small squares formed by lines of curvature, and let these meet successive parallel surfaces at distances dn, then the volume bounded by two parallel surfaces

$$= \iint dS\int_0^n dn\left(1+\frac{n}{R}\right)\left(1+\frac{n}{R'}\right)$$
$$= \iint dS\left(n + \frac{n^2}{2}\left(\frac{1}{R}+\frac{1}{R'}\right)+\frac{n^3}{3}\frac{1}{RR'}\right);$$

but taking origin inside, the perpendiculars let fall from 0 on a tangent plane to the outer surface $= p + n$ on account of the parallelism of the surfaces. Also dS for outer surface $= dS\left(1+\frac{n}{R}\right)\left(1+\frac{n}{R'}\right)$; therefore volume in question

$$= \frac{1}{3}\iint(p+n)\left(1+\frac{n}{R}\right)\left(1+\frac{n}{R'}\right)dS - \frac{1}{3}\iint pdS$$
$$= \frac{n}{3}\iint\left(1+\frac{p}{R}+\frac{p}{R'}\right)dS + \frac{n^2}{3}\iint\left(\frac{p}{RR'}+\frac{1}{R}+\frac{1}{R'}\right)dS + \frac{n^3}{3}\iint\frac{1}{RR'}dS.$$

Hence equating coefficients of the powers of n—

$$\iint p\left(\frac{1}{R}+\frac{1}{R'}\right)dS = 2\iint dS,$$

and

$$\iint\frac{2p}{RR'}dS = \iint\left(\frac{1}{R}+\frac{1}{R'}\right)dS.$$

References to the original memoirs will be found in SALMON'S *Analytical Geometry of Three Dimensions*, FROST'S *Solid Geometry*, and, more completely, in DARBOUX'S *Leçons sur la theorie générale des surfaces*. (J. PU.; F. PU.)

SURGERY.

SINCE the year 1887, when the earlier volume of this Encyclopædia was published, the science and practice of surgery have been steadily advancing. It is the object of this article to show in what respects the advances have been most marked. Surgical explorers and pioneers have been bold and enterprising to an extraordinary extent, so that regions and tracts which hitherto had only by accident or good fortune, as it were, been entered, have now been systematically surveyed and annexed. But notwithstanding the extraordinary aggressiveness of modern surgery, the results and statistics of operative work are steadily improving, and it has been truly said that the mortality from surgical operations has been reduced to a point never dreamt of by the last generations of surgeons.[1] Surgery is every day becoming more successful and more responsible, but it is not, nor can it ever be, an exact science, for no two cases are ever precisely alike. The surgeon of to-day deems it an essential part of his duties to study the general condition of his patient, and, so far as practicable, his moral and physical environment, before urging the performance of a serious operation. The dashing operator who played so bold and useful a part before the days of anæsthetics and of asepticism would at the present time be hopelessly out of place, when each of the many details of the preparation for the operation, of the operation itself, and of the after-treatment, has to be a matter of the most careful consideration.

Antiseptic surgery.

When the ninth edition of this Encyclopædia was going through the press, the carbolic acid spray, which to some practitioners had apparently been the embodiment of the Listerian theory and practice, was beginning to pass into desuetude, though for a good many years after that time certain surgeons continued to employ it during operation and during the subsequent dressings of the wound. Surgeons who, having had practical experience of the unhappy course which their operation cases had been apt to run in the pre-Listerian days, and of the vast improvements which ensued on their adoption of the spray-and-gauze treatment in its entirety, were, not unnaturally, reluctant to operate except in a cloud of carbolic vapour. So, even after Lister himself had given up the spray, its use was continued by many of his disciples. It was in the course of 1888 that operating surgeons began to neglect the letter of the antiseptic treatment and to bring themselves more under the broadening influence of its spirit. Certain adventurous and partially unconvinced surgeons began to give up the carbolic spray gradually, by imparting a smaller percentage of carbolic acid to the vapour, until at last the antiseptic disappeared altogether, apparently without detriment to the excellence of the results obtained. But while some surgeons were thus ceasing to apply the antiseptic spray to the wound during operation, others were pouring mild carbolic lotion, or a very weak solution of corrosive sublimate (an extremely potent germicide) over the freshly-cut surfaces. These measures were in turn given up, to the advantage of the patient; for it was hardly to be expected that a chemical agent which was strong enough to destroy or render inert septic micro-organisms in and about a wound, would fail to injure exposed and living tissues. Eventually it became generally admitted that if a surgeon was going to operate upon the depths of an open abdomen for an hour or more, the chilling and the chemical influences of the spray must certainly lower the vitality of the parts exposed, as well as interfere with the prompt healing of the wounded surfaces. With the spray went also the "protective," the paraffin gauze, and the mackintosh sheeting which enveloped the bulky dressing.

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[1] *The Lancet*, 1891, vol. ii. p. 1447.

Aseptic surgery.

Years before this happened, in the address on Surgery given at the Cork meeting of the British Medical Association, Sir William (then Mr) Savory had somewhat severely criticized the rigid exclusiveness of the members of the spray-and-gauze school: the sum and substance of the address was that every careful surgeon was an antiseptic surgeon, and that the success of the Listerian surgeon did not depend upon the spray or the gauze, or the two together, but upon cleanliness—that the surgeon's fingers and instruments and the area operated on must be surgically *clean.* Though careful experiment shows that it is impossible for the surgeon to remove every trace of septicity from his own hands and from the skin of his patient, still with nail-brush, soap, and water, and alcohol or turpentine, with possibly the help of some mercuric germicide, he can, for all practical purposes, render his hands safe. Recognizing this difficulty, some surgeons prefer to operate in thin rubber or white cotton gloves which can, for certain, by boiling, be rendered free of all germs; but this refinement does not seem to be generally acceptable, whilst the results of practice show that it is by no means necessary. The careful, the antiseptic surgeon of 1885 is to-day represented by the careful, the *aseptic* surgeon. The *antiseptic* surgeon was waging a constant warfare against germs which his creed told him were on his hands, in the wound, in the air, everywhere; and these he attacked with potent chemicals which beyond question often did real damage to the healthy tissues laid bare during the operation. If, as was frequently the case, his own hands became sore and rough from contact with the antiseptics he employed, it is not to be wondered at if a peritoneal surface or an incised tissue became more seriously affected. The surgeon of to-day has much less commerce with antiseptics: he operates with hands which, for all practical purposes, may be considered as germless; he uses instruments which are certainly germless, for they have just been boiled for twenty minutes in water, to which a little common soda has been added to prevent tarnishing of the steel, and he operates on tissues which have been duly made clean in a surgical sense. If he were asked what he considers the chief essentials for securing success in his operative practice, he would probably reply, "Soap and water and a nail-brush." He uses no antiseptics during the operations, he keeps the wound dry by gently swabbing it with aseptic, absorbent cotton-wool, and he dresses it with a pad of aseptic gauze. This is the simple aseptic method which has been gradually evolved from the Listerian antiseptic system.

Drainage-tubes.

A great change has taken place in connexion with the use of soft indiarubber drainage-tubes. In former years most surgeons placed one or more of these in the dependent parts of the area of operation, so that the blood or serum oozing from the injured tissues might find a ready escape. But to-day, except in dealing with a large abscess or some other septic cavity, many surgeons make no provision for drainage, but, bandaging the part beneath a pad of aseptic wool, put on so much pressure that any little leakage into the tissues is quickly absorbed. If a drainage-tube can be dispensed with, so much the better, for if it is not actually needed its presence keeps up irritation and delays prompt healing. But inasmuch as a tube if rightly placed in a deep wound is an insurance against the occurrence of "tension," and as it can easily be withdrawn at the end of twenty-four hours (even if it has served no useful purpose), it is improbable that the practice of drainage of freshly made cavities will ever be entirely given up. If the tube is removed after twenty-four hours its presence can have done no harm, and sometimes the large amount of fluid which it has drained from the wound affords clear evidence that its use has saved the patient much discomfort, and has probably expedited his recovery. For septic cavities drainage-tubes are still used, but it must be remembered that they cannot remain long in position without causing and keeping up irritation; hence, even in septic cases, the modern surgeon discards the tube at the earliest possible moment. If after he has taken it out septic fluids collect, and the patient's temperature rises, it can easily be reinserted. But it is better to take out the tube too soon than to leave it in too long: this remark applies with special force to the treatment of abscess of the pleural cavity (empyema), in the treatment of which a drainage-tube has been resorted to.

Poultices are now never used: they were apt to be foul and offensive, and were certainly septic and dangerous. If moisture and warmth are needed for a wound they can be obtained by the use of a fold of clean lint, or by some aseptic wool which has been wrung out in a hot solution of boracic or carbolic acid, and applied under some waterproof material, which effectually prevents evaporation and chilling. There was no special virtue in poultices made of linseed meal or even of scraped carrot: they simply stored up the moisture and heat. They possessed no possible advantage over the modern boracic fomentation under oil-silk.

Shock.

A severe surgical or other serious injury, or a furious attack of bleeding, produces a lowered condition of the individual which is known as shock or collapse, the heart being unable to pump blood to the brain in sufficient amount. In recent years many individuals have been saved from a fatal collapse by the timely injection into their veins (or even into the loose tissue of the body) of several pints of boiled water which has been cooled to 105° F., and made somewhat to resemble blood-serum by having dissolved in each pint 60 grains of table salt. Other measures which are now also resorted to for warding off shock are the injection deeply into the tissues of brandy, ether, or of a solution of strychnia.

Much less is heard now of so-called "bloodless" operations.

Bloodless operations.

The bloodlessness was secured by the part to be operated on—an arm, for instance—being raised and compressed from the fingers to the shoulder by successive turns of an indiarubber roller-bandage (Esmarch's), the main artery of the limb being then compressed by the application of an elastic cord above the highest turn of the bandage. The bandage being removed, the operation was performed through bloodless tissues. But when it was completed and the elastic cord removed from around the upper part of the limb, a reactionary flow of blood took place into every small vessel which had been previously squeezed empty, so that though the operation itself had actually been bloodless, the wound could not be closed because of the occurrence of unusually free hæmorrhage or troublesome oozing. A still further objection to the application of such an elastic roller-bandage was that septic or tuberculous material might by chance be squeezed from the tissues in which it was perhaps harmlessly lying, forced into the blood-vessels, and so widely disseminated through the body. Esmarch's bandage is therefore but little used now in operative surgery. Instead each bleeding point at an operation is promptly secured by a small pair of nickel-plated clip-forceps, which generally have the effect, after being left on for a few minutes, of completely and permanently arresting the bleeding. These clips were specially introduced into practice by Sir Spencer Wells, and it is no unusual thing for a surgeon to have twenty or thirty pairs of them at hand during an extensive operation. Seeing how convenient, not to say indispensable, they are in such circumstances, the surgeon of to-day wonders how he formerly managed to get on at all without them.

Röntgen rays.

By means of the Röntgen or X-rays the surgeon is able to procure a distinct shadow-portrait of deeply-placed bones, so that he can be assured as to the presence or absence of fracture or dislocation, or of outgrowth of bone, or of bone-containing tumours. By this means also he is able to locate with absolute precision the situation of a foreign body in the tissues—of a coin in the windpipe or gullet, of a broken piece of a needle in the hand, of a splinter of glass in the foot, or of a bullet deeply embedded in soft tissues or bone. This effect may be obtained upon a fluorescent screen, or printed in a permanent form upon glass or paper. The shadow is cast by a 10- or 12-inch spark from a Crookes vacuum tube. The rays of Röntgen find their way through dead and living tissues which are far beyond the reach of the rays of ordinary light, and they are thus able even to reveal changes in the deeply placed hip-joint which have been produced by tuberculous disease. In examining an injured limb it is not necessary to take off wooden splints or bandages except in cases where the latter have been treated with plaster-of-Paris, lime-salts obstructing the rays and throwing a shadow. Thus the rays pass through an ordinary uric acid calculus in the kidney or bladder; but if it contain salts of lime, as does the mulberry calculus (oxalate of lime), a definite shadow is cast upon the screen. The value of the X-rays is not limited to the elucidation of obscure problems such as those just indicated: they are also of therapeutic value; for example, in the treatment of certain forms of skin disease, as well as of cancer.

Injection Treatment of Sarcoma.—Sarcomata are growths of new tissue of an embryonic type; the more elementary the cells of which they are built up the more rapid their growth and the greater their malignancy. In inoperable cases a treatment has recently been introduced by Coley, which consists of repeated injections of a sterilized culture of septic micro-organisms. The injections, though not necessarily made into the tumour itself, are supposed to act through the blood, causing fatty degeneration and absorption of the ill-organized cells of the tumour. The injection of such a potent fluid should not be undertaken without a clear appreciation of the risks run, nor must too much be expected of it. It is supposed to be most efficacious in those tumours in which the cellular elements are spindle-shaped; but at the time of writing there is no clear evidence that, in England at least, any unmistakably sarcomatous tumour has been cured by the treatment.

Carbuncle has been shown to be an intense local inflammation caused by septic germs which have in some manner found their way to the part. The attack ends in mortification of the affected tissue, and, after much suffering, the "core" or mortified part slowly comes away. The modern treatment consists in cutting into the inflamed area, scraping out the germ-laden core at the earliest possible moment, and applying germicides. This method relieves the pain at once, materially diminishes the risk of blood-poisoning, and hastens convalescence.

Aneurysms are now being dealt with in a more direct manner. Without resorting to the speculative and somewhat dangerous method of treatment by compression, or to the application of an indiarubber bandage, the surgeon now without loss of time cuts down upon the artery, and applies an aseptic ligature close above the dilatation. Experience has shown that this method of treatment possesses many advantages, and that (provided the wound be kept aseptic) it has none of the disadvantages which only recently were generally supposed to attend it. Saccular dilatations of arteries which are the result of cuts or other injuries are treated by legation of the vessel above and below, and by dissecting out the aneurysm. Popliteal, carotid, and other aneurysms, which are not of traumatic origin, are sometimes most successfully dealt with on this plan, which is the old "Method of Antyllus" under the influence of asepticism.

Treatment of Tuberculous Lesions.—It has now been settled beyond dispute that tuberculous lesions are due to the growth in the affected tissue of specific micro-organisms which, from their resemblance to minute rods, are called *bacilli.* They seize upon a tissue the vitality of which has been lowered by malnutrition, injury, or some such cause, and, undergoing proliferation, determine the growth of an unhealthy material which rapidly breaks down. Tuberculous lesions may be found in many other tissues than the lungs, where it is called *phthisis.* It is specially prone to attack the spongy bone-tissue, joints, skin (*lupus*), and lymphatic glands—especially those of the neck. Recognizing the infective nature of the disease, and knowing that from one focus the germs may be taken by the blood-stream to other parts of the body, and so cause a general tuberculosis, the surgeon is anxious, by removing the primary lesion, to cut short the disease and promote immediate and permanent convalescence. Experience has shown him that medicines and sea-air cannot be depended upon to cure the disease, any more than could the much-vaunted and disappointing injection of Koch's *tuberculin.* Cod-liver oil and sea-air are useful only in so far as they improve the general health and nutrition of the individual, and enable his tissues to wage a more successful warfare against the bacilli. Thus, in the early stage of tuberculous disease of the glands of the neck, for instance, these measures may render excellent service, but when the disease has got a firm hold, nothing short of removal of the glands by surgical operation is likely to be of any avail. The results of this modern treatment of tuberculous disease of the skin, and of the lymphatic glands, has been highly gratifying, for not only has the infected tissue been completely removed, but the resulting scars have been far less noticeable than they would have been had less radical measures been employed. One rarely sees now a network of scars down the neck of a child, showing how a chain of tuberculous glands had been allowed to work out their own cure. A few years ago, however, such conditions were by no means unusual.

Cancer of the Tongue is now operated on in advanced cases such as in former years would scarcely have been dealt with by a radical operation. An incision is made beneath the jaw and through the floor of the mouth, by which the tongue is drawn out and rendered easily accessible, the arteries being leisurely secured as the tissues are cut across. The upper part of the gullet is plugged by a sponge so that no bleeding can enter the lungs, and unimpeded respiration is provided for by the preliminary introduction of a tube into the windpipe. Through the incision which is made below the jaw the infected lymphatic glands are removed. To Dr Kocher of Berne the profession and the public are indebted for this important advance in the treatment of this disease.

Intra-Cranial Surgery.—Chronic discharge of matter from the external ear is associated with septic disease of the middle ear, or drum, and as the inflammation is liable to spread to the adjacent structures, abscess is very likely to form in or about the contiguous part of the brain, and a foul clot is apt to plug the large venous channel inside the skull and at its base. If these conditions are allowed to run their course uninterfered with, fatal consequences, chiefly from blood-poisoning, not infrequently ensue. Amongst the most important advances of modern surgery is that of making an aperture into the skull behind the ear and opening up, gently irrigating, and draining an intra-cranial abscess. The septic clot is also turned out from the (lateral) venous sinus, and if the large vein of the neck (internal jugular) is found also to be plugged, it is exposed and tied in the neck, cleaned of its clot, and, together with the lateral sinus (which communicates with it), is syringed out with an antiseptic lotion. The result of this treatment is often extremely gratifying. The situation of tumours inside the skull can now be defined with precision, and their removal is sometimes effected with complete success. But inasmuch as such growths are often of a malignant nature, the successful accomplishment of their extirpation is not seldom impracticable. In certain cases of intractable neuralgia of the face the skull is now opened for the removal of a large ganglionic swelling (Gasserian ganglion) through which courses the trunk of the fifth, the tri-facial nerve. The results of this formidable operation are sometimes most successful.

Surgery of the Spine.—Being deeply placed amongst the mass of the muscles of the back, and, moreover, being jealously locked within the bony canal of the vertebral column, the spinal marrow or spinal cord was, until the last few years, generally considered to be beyond the reach even of the most enterprising surgeon. Still, like other tissues, it was liable to diseases and injuries. The exact situation of a tumour pressing upon the spinal cord can be located with great precision by noting the areas of pain and numbness, and the height in the limbs or trunk to which loss of power of voluntary movement ascends, and by noting also whether these effects are symmetrical upon the two sides or appear more upon one side than on the other. By cutting away the posterior parts of certain segments of the vertebral column, tumours of various sorts have been successfully removed from the interior of the canal. Displaced fragments of bone in tuberculous affection of the spine, abscess-contents, and inflammatory tissue have also been similarly dealt with. Macewen of Glasgow and Horsley of London have been pioneers in this development of surgery. In cases of fracture of the spine, with displacement of the vertebræ and compression of the spinal cord, surgeons have also been trying what relief can be afforded by the adoption of bold operative measures, but as in most of these cases of fracture-dislocation the spinal cord is torn right across or crushed beyond hope of repair, active measures cannot be undertaken with much prospect of success.

In the last few years the treatment of spinal abscess has undergone a great improvement. In the first place, surgeons have recognized the fact that the collection of broken-down tuberculous material or fluid is not an *abscess* in the usual sense, for it does not contain "pus" or "matter." A spinal abscess is therefore no longer drained: it is incised, scraped, washed out, and swabbed dry, the opening being carefully and permanently sewn up. In this way septic germs are effectually excluded from the cavity, and the patient is spared the depressing and tedious discharging of the cavity which so often followed the old methods of treatment. It must be clearly understood, however, that every spinal abscess does not undergo cure after being subjected to the evacuation and closure treatment mentioned above, but that the surgeon is sometimes compelled to use irrigation and drainage.

In the year 1897 Dr Calot of Berk-sur-Mer introduced the method of straightening out the hump of the back, so often left after disease of the spine, by stretching the child on a flat table and dealing with the hump, under chloroform, with what is commonly known as "brute force." A considerable number of hump-backed children on the Continent as well as in England and America were thus dealt with, but it is doubtful whether the records of those cases, could they all be collected and published, would be found entirely to justify the enthusiasm and publicity with which the method was inaugurated and its details were spread abroad. It is scarcely necessary to say that the forcible straightening of a spine which has developed a hump because tuberculous disease has wrecked the front of the vertebral segments is in no sense a *curative* operation. Diminishing the size of the projection does not cure the tuberculous ulceration of the bones; indeed, it may increase the ulcerative process or determine a scattering of the germs of tubercle throughout the body. Still there may be a certain small proportion of cases in which a resort to such rough and speculative measures may possibly be deemed expedient. The operation has not been generally accepted by British and American surgeons. In the practice of the foreign surgeon death ensued in three cases out of thirteen that were operated on, and an English surgeon reported fourteen cases "in all of which the deformity had recurred although the spines had been fixed in plaster-of-Paris after the straightening." At present the method—which is not a new one—is on its trial, but it does not look as if it would come through it with triumph.

In cases of advanced tuberculous disease of the spine, in which the spinal cord is compressed within its bony canal either by the posterior parts of the vertebral bodies or by inflammatory products, or in which, after severe injury, the cord is pressed upon by a displaced piece of bone, the surgeon may think it expedient to open the spinal canal from behind, removing in the procedure the posterior arches (laminæ) of the vertebræ. The operation is called by the hybrid word *laminectomy*. Sometimes in the case of tuberculous disease, where the propriety of resorting to the operation is being discussed, the symptoms of the compression begin to clear off and the child makes a complete recovery without being operated on. When the operation is performed for a crushed cord, the outlook is, as might be expected, very cheerless. Still, there are a certain small number of cases in which it may be given a trial.

Adenoids ; Post-Nasal Vegetations.—A general impression exists that in the last few years a new disease has been invented by surgeons; the fact is that, thanks to the teaching of Meyer of Copenhagen, surgeons have somewhat recently been shown how they may recognize the existence of a mass of soft spongy tissue between the back of the nose and throat, which, blocking the air-way, prevents the due inflation of the lungs and the proper development of the chest. The growths are apt to keep up a constant catarrh near the orifice of the tubes which pass from the throat to the ear, and so render the child dull of hearing or even deaf. They also give rise to asthma, and, like enlarged tonsils—with which they are often associated—they impart to the child a vacant expression, and hinder his physical and intellectual development. Though, except in the case of a cleft palate, they cannot be seen with the naked eye, they are often accompanied by a very visible and suggestive granular condition of the wall of the back of the throat. Their presence may easily and confidently be determined by gently hooking the end of the index-finger round the back of the soft palate. Though the disease is a comparatively recent discovery, it has probably existed as long as tuberculosis itself, with which affection it is somewhat distantly connected. In the unenlightened days many children must have got well of adenoids without operation, and even at the present time it by no means follows that because a child has these vegetations he must forthwith be operated on. The condition is very similar to that of enlarged tonsils, where with time, patience, and attention to general measures, operation is often rendered unnecessary. But if the child continues to breathe with his mouth open and to snore at night, if he remains deaf and dull and is troubled with a chronic "cold in his head," the question of thorough exploration of the naso-pharynx and of operation should be most certainly considered.

Cleft Palate.—Operations for closing a congenital cleft in the roof of the mouth are now performed much earlier than was customary a few years ago. If the infant be in a satisfactory state of health, the operation may be undertaken within a few weeks of birth. However wide a cleft of the hard and soft palate may be, it is now the custom to deal with it in its entirety at the one operation, rather than to divide the operation into two parts—one for closing the cleft in the soft, and the other for closing that in the hard, palate. In many cases it is better to operate on the cleft palate before dealing with an accompanying hare-lip, and even a few weeks after birth the infant bears the shock of the operation extremely well.

Abscesses in the Lungs are treated by resection of a piece of rib, stitching the lung to the opening in the chest thus made, and, after a few days, when adhesions have formed, opening and draining the cavity. So, also, suppurating bronchiectatic cavities are dealt with, to the great relief of the patient. Portions of the lungs, especially the apex, have been removed by operation in the hope of curing malignant or tuberculous disease, but the treatment has not met, nor is likely to meet, with much success, for if a part of a lung is affected with malignant disease an attempted removal of the implicated tissue is almost certain to leave some outlying patches of disease, whilst if a tuberculous inflammatory patch is so limited in extent as to lend itself to incision, it is more than likely that the area would completely clear up under medical and general treatment without operation. If *foreign bodies* which have been carried in by the air-stream—such as beads, buttons, or fragments of bone—can be located by the Röntgen rays, they should be removed, if be need by operation through the side of the chest, for if they are allowed to remain embedded in the lung they are very likely to set up inflammatory changes ending in abscess, blood-poisoning, or phthisis.

Affections of the Heart.—It has somewhat recently been proved that incised wounds of the heart may be successfully dealt with by cutting through the ribs and turning up a large flap of the chest wall so as to make a window through which effused blood may be wiped out and the wound of the heart deliberately stitched up. When the presence of abscess in the pericardium has been demonstrated by aspiration, modern experience has shown that the most successful treatment consists in dividing the fourth and fifth costal cartilages of the left side, and incising and draining the suppurating heart-sac.

Cancer of the Breast.—Highly important advances have been made in connexion with the operative treatment of cancer of the breast, and the results of this radical treatment have emboldened surgeons to undertake the removal of cancerous masses which a few years ago they would have considered to be hopelessly beyond their reach. The advances consist in a free and fearless attack, the skin being widely removed with the cancer, and the large muscles of the side of the chest stripped bare of fascia as the mass is lifted up. The latter is a very important matter, as the lymphatic ducts from the breast are now known to be in communication with lymph-spaces over the muscle. The lymphatic ducts running from the breast to the glands in the arm-pit are also taken away, together with the infected glands in the arm-pit. Inasmuch as the operator cannot know what glands are actually infected, he takes them all away so as to make his operation secure. If the muscles of the chest are invaded, he removes them also. In cases where a considerable amount of integument is taken away with the breast, he endeavours to bring the edges of the wound together by freely detaching the skin from the side of the chest so as to obtain loose available flaps whose edges can be adjusted and secured by sutures without tension. Experience has shown that in the case of return of cancerous growth, repeated operations may be advantageously resorted to. The surgeon therefore keeps the patient under regular supervision, and on the appearance of any fresh nodules of cancer at or near the scar, promptly and thoroughly removes them. In the meanwhile the health and comfort of the patient have often greatly improved, and the secondary operations being, as a rule, far from serious, are submitted to cheerfully and hopefully. Lastly, in those sad cases in which, from obstruction of the lymph-channels and veins in the neighbourhood of the arm-pit, the hand and arm are swollen, heavy, and useless, and cancerous pressure on the nerves is causing terrible neuralgias, which dart down to the elbow or even into the fingers, the expediency of resorting to Paul Berger's operation may be considered. This operation consists in the removal of the outer part of the collar-bone, the entire shoulder-blade, and the whole of the upper extremity, together with tissue of doubtful integrity in the arm-pit and on the upper part of the chest. Though obviously a very severe undertaking, Berger's operation does not, as a rule, cause a large amount of shock, whilst the relief which the unhappy patient experiences from it may be lasting and immense. In the case of inoperable cancer of the breast the administration of thyroid extract sometimes proves helpful, but experience does not seem to show that the removal of the ovaries has much influence in checking the growth of the disease. Nevertheless, so many cases have been reported in which real improvement has followed their removal, that the method may still be regarded as worthy of favourable consideration.

Exploratory Laparotomy.—In many cases of serious intra-abdominal disease it is impossible for the surgeon to say exactly what is wrong without making an incision and introducing his finger, or, if need be, his hand among the intestines. With due care this is not a perilous or serious procedure, and the great advantage appertaining to it is daily being more fully recognized. It was Dr Oliver Wendell Holmes, the American physiologist and poet, who remarked that one cannot say of what wood a table is made without lifting up the cloth; so also it is often impossible to say what is wrong inside the abdomen without making an opening into it. When an opening is made in such circumstances—provided only it is done soon enough—the successful treatment of the case often becomes a simple matter. An exploratory operation, therefore, should be promptly resorted to as a means of diagnosis, and not left as a last resource till the outlook is well-nigh hopeless.

A great impetus was given to the surgery of severed intestines by the introduction from Chicago of an ingenious contrivance named, after the inventor, *Murphy's button.* This consists of a short nickel-plated tube in two pieces which are rapidly secured in the divided ends of the bowel, and in such a manner that when the pieces are subsequently "married" the adjusted ends of the bowel are securely fixed together and the canal rendered practicable. In the course of time the button loosens itself into the interior of the bowel and comes away with the alvine evacuation. In many other cases the use of the button has proved convenient and successful, as in the establishment of a permanent communication between the stomach and the small intestine when the ordinary gateway between these parts of the alimentary canal is obstructed by an irremovable malignant growth; between two parts of the small intestine so that some obstruction may be passed; or between small and large intestine. The operative procedure goes by the name of *short-circuiting;* it enables the contents of the bowel to get beyond an obstruction. In this way also a permanent working communication can be set up between the gall-bladder, or a dilated bile-duct, and the neighbouring small intestine—the last-named operation bears the precise but impossible name of *choledocoduodenostomy.* By the use of Murphy's ingenious apparatus the communication of two parts can be secured in the shortest possible space of time, and this, in many of the circumstances in which it is resorted to, is of the greatest importance. But there is this against the method—that sometimes ulceration occurs around the rim of the metal button, whilst at others the loosened metal causes annoyance in its passage along the alimentary canal. Some surgeons therefore prefer to use a bobbin of decalcified bone or similar soft material, while others rely upon direct suturing of the parts. The last-named method is gradually increasing in popularity, and of course, when time and circumstances permit, it is the ideal method of treatment. The cause of death in the case of intestinal obstruction is usually poisoning by the absorption of the products of decomposition of the fluid contents of the bowel above the obstruction. It is now becoming the custom, therefore, for the surgeon to complete his operation for the relief of obstruction by drawing out a loop of the distended bowel, incising and evacuating it, and then carefully suturing and returning it.

Gunshot Wounds and Stabs of the Abdomen.—If a revolver bullet passes through the abdomen, the coils of intestine are likely to be traversed by it in several places. If the bullet be small and, by chance, surgically clean, it is possible that the openings may tightly close up behind it so that no leakage takes place into the general peritoneal cavity. If increasing collapse suggests that serious bleeding is taking place within the abdomen, the cavity should be opened forthwith and a thorough exploration made. When it is uncertain if the bowel has been traversed or not, it is well to wait before opening the abdomen, due preparation being made for performing that operation on the first appearance of symptoms indicative of perforation having occurred. Small perforating wounds of the bowel are treated by such suturing as the circumstances may suggest, the interior of the abdominal cavity being rendered as free from septic micro-organisms as possible, for it is by the malign influence of such germs that a fatal issue is determined in the case of an abdominal wound, whether inflicted by firearms or by a pointed weapon. If aseptic procedure can be promptly resorted to and thoroughly carried out, abdominal wounds do well, but the recent campaign in South Africa showed that these essentials cannot be obtained upon the field of battle. When after an action wounded men come pouring into the field-hospital, the many cannot be kept waiting whilst preparations are being made for the thorough carrying out of a prolonged aseptic abdominal operation upon a solitary case. Experience showed that Mauser bullets could pierce coils of intestine and leave the unfortunate soldiers in such a condition that, if treated by mere "expectancy," more than 50 per cent. of them recovered, whereas if operations were resorted to fatal septic peritonitis was likely to ensue. From a surgical point of view, this was the great lesson of the Boer war, and probably in all future wars experience will show that in the close proximity of the fight, where time, assistants, pure water, towels, lotions, and others necessaries for carrying out a thoroughly aseptic operation cannot be forthcoming, gunshot wounds of the abdomen had best not be interfered with.

Gastric Ulcer.—Among the complications of the chronic forms of dyspepsia met with, especially in youngish women, is an inflamed spot upon the wall of the stomach, which ulcerates, and not infrequently perforates, the wall, allowing the contents of the stomach to escape into the abdominal cavity. Without operation, such cases almost invariably end fatally, but in recent years it has become a matter of custom for the physician to call in the aid of a surgeon the instant that pain and collapse indicate that perforation has taken place. The abdomen being promptly opened, the ulcer excised, and the inflamed area turned into the stomach and secured by suturing, the surgeon cleans out the abdomen and puts in a gauze drain. A large proportion of cases of perforated gastric ulcer thus treated recover. Sometimes the physician and surgeon arrange to deal with the ulcerated patch of the stomach before perforation has taken place—a plan of treatment which gives still better results. Reports are accumulating of cases of typhoid fever with perforation of the bowel, which have been successfully dealt with by opening the abdomen, stitching up the ulcer, and washing out or merely wiping out the abdominal cavity.

Tuberculous Peritonitis.—It has long been known that inflammation of the peritoneal cavity is frequently met with in tuberculous subjects, and especially amongst children and young adults, and that medical and general treatment is incapable of diverting its downward course. Almost by accident it was discovered, however, that if an incision be made into the abdomen and the tension be relieved by the letting out of some of the tuberculous fluid, the remainder is likely to undergo spontaneous absorption and the peritonitis entirely to clear away. The surgical treatment of tuberculous peritonitis has thus become one of the most remarkable advances of late years; but the explanation of the improvement which follows the simple operation has yet to be discovered.

Liver and Gall-bladder.—Much advance has been made in the treatment of injuries and diseases of the liver and gall-bladder. The liver being a large and friable gland, is not seldom ruptured in the case of severe blows upon the abdomen. Collapse of the patient, and other signs of rupture and hæmorrhage, are now taken by the surgeon as a clear indication that the abdomen should be immediately opened and the liver examined and dealt with; by this means patients have been snatched from death. Liver abscesses are also successfully evacuated by direct incision (through the chest, if need be) instead of by blind and speculative exploration through the abdominal wall. Gall-stones lodged in the gall-bladder, impacted in the biliary ducts or, as sometimes happens, obstructing the small intestine, are successfully operated on through an abdominal incision. Rupture of the gall-bladder has been happily dealt with by opening the abdomen, suturing the rent, and cleansing the peritoneal cavity. Cases of rupture of the liver, spleen, intestine, and kidney which have been successfully treated by bold operative measures are of diminishing rarity.

Pyloroplasty.—Simple fibrous narrowing of the gateway of the stomach or of the intestine is dealt with by dividing it longitudinally and then suturing the edges of the wound transversely. This ingenious operation widens the track at the expense of an unimportant fraction of its length. In cases of great dilatation of the stomach with no obstruction to the outlet the slack of the walls may be gathered up by pleating, and so permanently secured by suturing. Loreta's operation for dilatation of the outlet of the stomach is now rarely performed.

Intussusception.—That terribly fatal disease of infants and children, in which a piece of bowel slips into a piece next below it, is being dealt with on more progressive lines, and therefore is giving promise of a diminished mortality. Hitherto it had generally been the custom to endeavour to reduce the invagination by passing air or water up the rectum under pressure—a speculative method of treatment which sometimes ended in a fatal rupture of the distended bowel, and often—one might almost say *generally*—failed to do what was expected of it. The teaching of modern surgery is that a small incision into the abdomen and a prompt withdrawal of the invaginated piece of bowel can be trusted to do all that, and more than, injection can effect, without blindly risking a rupture of the bowel. It is certain that when the surgeon is unable to unravel the bowel with his fingers gently applied to the parts themselves, no speculative distention of the bowel could have been effective. But the outlook in these distressing cases, even when the operation is promptly resorted to, is extremely grave, because of the intensity of the shock which the intussusception and resulting strangulation entail.

Cancer of the Stomach.—In more than one instance the entire stomach has been successfully removed for cancer, the end of the gullet being "married" to the beginning of the small intestine. Partial resection of the stomach is also resorted to from time to time. When the ninth edition of this work was in preparation the operative treatment for cancer of the large intestine chiefly consisted in arranging for the escape of the fæces which had accumulated above the obstruction by making an opening in the right or left loin, as the case might demand. The great advantage of this operation was that the interior of the bowel was reached without traversing, and without risking injury to, the peritoneum. But with the introduction of aseptic methods of operating it was found that the surgeon could reach the bowel through the peritoneum easily and safely. With the peritoneum opened, moreover, the surgeon can explore the diseased bowel and deal with it as circumstances suggest. If the cancerous mass is fairly movable the affected piece of bowel is excised and the cut ends are spliced together, and the continuity of the alimentary canal is permanently re-established. Thus in the case of cancer of the large intestine which is not too far advanced, the surgeon expects to be able not only to relieve the obstruction of the bowel, but actually to cure the patient of his disease. When the lowest part of the bowel was found to be occupied by a cancerous obstruction, the surgeon, as already remarked, used formerly to secure an easy escape for the contents of the bowel by making an opening into the colon in the left loin. But in recent years this operation of lumbar colotomy has been almost entirely replaced by opening the colon in the left groin. This operation of *inguinal colotomy* is usually divided into two stages: a loop of the large intestine is first drawn out through the abdominal wound and secured by stitches, and a few days afterwards, when it is firmly glued in place by adhesive inflammation, it is cut across, so that subsequently none of the motions find their way into the bowel below the artificial anus. If at the first stage of the operation symptoms of obstruction are urgent, one of the ingenious glass tubes which Mr Paul has recently invented may be forthwith introduced into the distended bowel, so that the contents may be allowed to escape without fear of soiling the peritoneum or even the surface-wound.

Cases of *malignant disease of the rectum* are now radically and successfully dealt with, which, a few years ago, no surgeon would have felt justified in attacking. For this important advance surgeons are indebted to Professor Kraske of Freiburg. In order to secure the entire removal of the cancerous piece of bowel, the coccyx and a considerable portion of the sacrum may have to be removed; and the rapid and complete recovery of the patient after so serious an operation is often a matter of surprise even to the surgeon.

Inflammation of the Appendix.—Attached to the large intestine (near the right groin) is a slender, worm-like process about as large in circumference as an ordinary penholder, and 3 or 4 inches long. It is hollow, and it communicates with the interior of the bowel by a small valvular opening. When the secretion of this vermiform process, or appendix, is prevented from finding its way into the intestine by a kink, or by any other form of obstruction, local pain and tenderness and great constitutional disturbance are apt to result. Inflammation of the appendix has been compared to the behaviour of the obsolete percussion-cap under the hammer of the gun: sometimes the hammer striking the cap gave absolutely no result, sometimes it merely "snapped" the cap, and sometimes it exploded the charge of powder. Sometimes the attack of inflammation of the appendix is slight and transitory, sometimes it passes off after giving rise to considerable local and general disturbance, and sometimes it determines the formation of an acute septic abscess, which suddenly and without definite warning bursts into the general peritoneal cavity with, probably, a fatal result.

In recent years surgeons have fully recognized the advantage of interfering in the course of a large proportion of these cases, rather than allowing them to drift on as blind chance may direct. It is a feature of the disease that though it may subside after running a subacute course, it is apt to recur, especially after severe exercise, or cold, or after an indigestible meal. These recurrent attacks are often met with in young adults who, but for this weakness, are in perfect health, but who during the attacks are compelled to lead a life of helpless inactivity or invalidism. Modern surgery has shown that on the subsidence of one of these attacks the appendix can be safely removed, and the individual restored to robust and permanent health. During the progress of an acute attack of appendicular inflammation, when the local tension and pain are great, and the patient is disturbed by the absorption of septic material which is set free in the formation of a local abscess, the surgeon cuts down into the inflamed mass of tissues so as to provide for the easy escape of matter to the surface which might otherwise burst into the general peritoneal cavity. By this rational treatment many a life is saved. If in the course of the operation the inflamed appendix presents itself in the abscess-cavity the surgeon does well to resect it, but otherwise it is not always advisable for him to disturb the tissues in searching for it, lest by breaking down barriers of adhesions he should render the abscess diffuse. Lastly, in those sad cases in which an inflamed appendix has suddenly burst into the peritoneum and amongst the coils of intestine, the patient being in a state of serious collapse, the surgeon hastens to offer the only chance left, by opening the abdominal cavity, wiping out the interior, and affording full provision for drainage.

Hernia.—Great advance has been made and success secured in the treatment of reducible hernia. Without tiresome delay, and the tedious and sometimes disappointing application of trusses, the weak spot in the abdominal wall is exposed, the sac of the hernia tied and removed, and the canal by which the rupture descended blockaded by buried suturus. Thus the patient's worries become a thing of the past, and he is rendered a fit and normal member of society. The results of the treatment of strangulated hernia also show steady improvement, for the simple reason that the condition is now more promptly dealt with by operation, "radical cure" being aimed at at the same time.

Surgery of the Kidney.—During the past decade the surgery of the kidney has been steadily advancing: movable kidneys are now stitched securely in their bed, with great relief to the patients; the presence of a renal calculus is sometimes clearly located by the Röntgen-rays and the stone extracted; abscesses are drained, and kidneys hopelessly diseased are removed with the greatest possible advantage. Calculi which have become impacted in their course down to the bladder are also searched for and extracted.

To Brigade-Surgeon Lieutenant-Colonel Keegan, of the Indian Medical Service, is due the fact that the operation of crushing and promptly removing all fragments of a vesical calculus—*litholapaxy*—is as well suited for boys as for men. In entire opposition to old European prejudices, Keegan's operation is now firmly and permanently established. The old operation (Cheselden's) of cutting a stone out through the bottom of a boy's bladder is now very rarely resorted to, and if a stone in a boy is found too large or too hard to lend itself to Keegan's crushing operation, it is now removed by a vertical incision through the lower part of the anterior wall of the abdomen. For the successful performance of the crushing operation in a boy a small lithotrite has, of course, to be used, and it must be of the very best English make: the bending of a "cheap" lithotrite in a boy's bladder would be a terrible predicament. The operation has to be done with the utmost gentleness and thoroughness, not a particle of the crushed stone being left in the bladder.

Ligation of Iliac Arteries.—In the case of aneurysmal or other pulsating tumour of the buttock, or of iliac aneurysm in which it is desirable to place a ligature upon the internal or upon the common iliac artery, the surgeon now finds it convenient and expedient to expose the main trunk by cutting across the peritoneal cavity. In the pre-aseptic days such an operation could scarcely have been thought of, as the risk of the patient dying from infective peritonitis would have been very great.

Senile Enlargement of the Prostate.—Enlargement of the prostate gland in old men is being somewhat widely treated by removal of the testes, or by the enucleation of the masses themselves through a supra-pubic incision, after the manner of McGill of Leeds or Fuller of New York.

Fractures.—The treatment of fractures has undergone considerable improvement of late. Simple fractures are not kept so long at rest fixed in splints, but are constantly "taken down" in order that massage and passive movements of the limb may be resorted to. This, of course, is done with the utmost gentleness, and with the result that swelling, pain, and other evidences of the serious injury quickly disappear, whilst a more rapid and complete recovery is insured. Stiff hands and feet after fracture are very much less constantly met with. By the aid of the X-rays it is now easy for the surgeon to assure himself that fractured surfaces have been well adjusted and are in close apposition. But if they are not well in position, and it be found impracticable to assure their close adjustment by ordinary methods, the surgeon now, without undue loss of time, cuts down upon the broken ends and fixes them together by a strong wire suture, which remains permanently in the tissues. If the fracture be associated with an open wound of the part (compound fracture), and the broken ends are found incapable of easy adjustment, immediate wiring together of the fragments is now considered to be a necessary part of the primary treatment.

Congenital Dislocation at the Hip.—Possibly as the result of faulty position of the subject during intra-uterine life, the head of the thigh-bone leaves, or fails throughout to occupy, its normal situation on the haunch-bone. The defect, which is a very serious one, is probably not discovered until the child begins to walk, when its peculiar rolling gait attracts attention. The want of fixation at the joint permits of the surgeon thrusting up the thigh-bone, or drawing it down in a painless, characteristic manner.

The first thing to be done is to find out by means of the X-rays whether a socket exists into which, under an anæsthetic, the surgeon may fortunately be enabled to lodge the end of the thigh-bone. If this offers no prospect of success, there are three courses open: First, to try under an anæsthetic to manipulate the limb until the head of the thigh-bone rests in its normal position, and then to endeavour to fix it there by splints, weights, and bandaging until a new joint is formed; second, to cut down upon the site of the joint, to scoop out a new socket in the haunch-bone, and thrust the end of the thigh-bone into it, keeping it fixed there as just described; and third, to allow the child to run about as it pleases, merely raising the sole of the foot of the short leg by a thick boot, so as to keep the lower part of the trunk fairly level, lest secondary curvature of the spine ensue. The first and second methods demand many months of careful treatment in bed, and the ultimate result of the second is so often disappointing that, except in certain rare instances, the surgeon is loth to recommend it.

Fracture of Patella.—There is still a great difference of opinion as to the most satisfactory method of treating a recent fracture of the patella. Some surgeons are still content to follow the old plan of fixing the limb on a back-splint, or in plaster-of-Paris splints, and awaiting the result.

It is beyond question that a large percentage of these cases recovered with a useful limb—especially if the fibrous bond of union between the pieces of the broken knee-cap was not stretched, by bending the leg, at too early a date. But a certain proportion of the cases gave a very imperfect result, the fragments remaining permanently wide apart, and the patient being left with a more or less enfeebled limb. Still, at any rate, this line of treatment was unassociated with risk. But after Lister showed (1883) that with due care and cleanliness the knee-joint could be opened, and the fragments of the broken patella secured in close apposition by a stout wire suture, the treatment of the injury underwent considerable change. The great advantage of Lister's treatment was that the fragments, being fixed close together by the wire stitch, became solidly united by bone, and the joint became as sound as it was before. Some surgeons, however, objected to the operation—in spite of the excellence of the results obtainable by it—because of the risk which it entailed of the joint becoming invaded by septic micro-organisms. As a sort of compromise, Barker introduced the method of holding the fragments close together by means of a strong silver wire which he passed round them vertically by a large needle without laying open the joint. But experience has shown that in the hands of skilful surgeons Lister's operation of openly wiring the fragments gives a perfect result with a comparatively small amount of risk. Other surgeons secure the fragments in close contact for bony union by passing a silk or metal suture around them circumferentially. Many years ago Lister remarked that the careful selection of one's patients is an antiseptic measure—by which he meant that if a surgeon intended to get the most perfect results for his operative work, he must carefully consider whether any individual patient is physically adapted for the performance upon him of any particular operation. From this aphorism it is evident that not every patient with a broken knee-cap is suited for the opening of his knee-joint, or even for the subcutaneous adjustment of the broken fragments. An operative procedure which is admirably suited for one patient might result in disaster when adopted in another case, and it is an important part of the surgeon's business to know exactly what to advise in an individual case.

Infantile Paralysis.—In cases of infantile paralysis of the leg and foot, groups of muscles supplied by certain nerves are left seriously affected, and in many instances great improvement results from grafting the tendons of the paralysed muscles upon the tendons of muscles which remain strong and vigorous. The operation, which was recently designed by Dr Nicoladoni, is a very ingenious one, and it is steadily making its way into general recognition. In cases in which the paralysis has left a useless flail-joint in a limb, considerable strength may be imparted to the limb by opening the joint and scraping it out so as to render it permanently rigid.

Club-foot.—In the treatment of congenital club-foot great advances have been made. Parents as well as surgeons have come to recognize the value of the adoption of corrective measures in the very earliest days of infancy. The monthly nurse is now instructed in the art of manipulating the deformed foot and of gently but firmly holding it in the corrected position; and in slight cases these simple measures when begun thus early are sufficient. At any rate, they are to have a fair trial, and should they fail, a simple subcutaneous division of tendon or tendons, in the earliest weeks of infancy, may suffice. Much of the great advance which has recently been made in dealing with obstinate cases of deformity has been the result of Phelps's teaching. Dr Phelps is an orthopædic surgeon of New York, and he has shown that in cases which are not remediable by simple measures, an immediate correction of the deformity may safely be obtained by freely dividing the skin and all the resisting tissues by a vertical incision straight across the middle of the foot. By this "open method" the surgeon sees exactly what structures are at fault and in need of division—skin, fasciæ, tendons, ligaments; everything, in short, which prevented the easy rectification of the deformity. After the operation, the foot is fixed, without any strain in an over-corrected position, between plaster-of-Paris splints. By the adoption of this method the old instrument of torture known as "Scarpa's shoe" has become obsolete, as have also some of those operations which effected improvement of the foot by the removal of portions of the bony arch. Phelps's operation removes the deformity by increasing the length of the concave border of the foot rather than by shortening the convex borders; it is a levelling up, not a levelling down.

Morton's Disease.—There is a painful neuralgic condition of flat feet which has recently been described by Dr Morton and named after him. It is apparently due to the nerves of the toes (which come from the sole of the foot) being pressed upon by the rounded ends of the long bones of the foot near the web of the toes. It does not generally yield to palliative measures (though rest of the foot is helpful), and the only effectual remedy for it seems to be resection of the head of one of the metatarsal bones.

Hammer-toe.—That painful condition in which a toe is rigidly bent and the salient angle on its upper aspect is constantly irritated by the boot, is no longer treated by amputation of the toe, but the toe is made permanently to lie flat by the simple excision of the small digital joint. Even in extremely bad cases of hammer-toe the operation of resection of the head of the metatarsal phalanx is to be recommended rather than amputation. (E. O*.)

Surgical Instruments and Appliances.—The purpose of this article is to give an account of the more important surgical instruments that are at this time in general use, and to show by what modifications, and from what discoveries in science, the present methods of an operation have come to be what they are. A new catalogue of surgical instruments suggests at first sight that the surgeon must be hindered rather than helped by the bewildering number and variety of instruments that he is supposed to use, one and all of them, with equal ease and familiarity. The array of instruments is of amazing length: for example, in one instance the list of needle-holders extends from No. 845 to No. 887, with twenty-five illustrations. Yet in many cases the finger and thumb are a sufficient needle-holder, and for cases where the depth of the tissues, or the special nature of the operation, require a needle-holder, there are a few simple forms of the instrument, and no need for these many sub-species. The good surgeon is careful to use the right sort and pattern of instrument, but is not concerned to try all the twenty-five different kinds of needle-holder; one might as well expect an artist to have twenty-five palettes. But, though the mere multiplicity of catalogued instruments is not an exact measure of the excellence of surgery, yet the chief fact about the surgery of the present day, that it is aseptic or antiseptic, is recorded in the make of surgical instruments and in all the installation of an operating-theatre. Take, for instance, a scalpel and a saw that are figured in Ambroise Paré's (1510–1590) surgical writings. The scalpel folds into a handle like an ordinary pocket-knife, which alone was enough in those days to keep it from being aseptic. The handle is most elegantly adorned with a little winged female figure, but it does not commend itself as likely to be surgically clean. The saw, after the same fashion, has a richly-chased metal frame, and, at the end of the handle, a lion's head in bold relief, with a ring through its mouth to hang it up by. It may be admirable art, but it would harbour all sorts of germs. If one contrasts with these artistic weapons the instruments of 1850, one finds no such adornment, and for general finish Savigny's instruments would be hard to beat; but the wooden or ivory handles, cut with finely scored lines like the cross-hatching of an engraving, are not more likely to be aseptic than the handles of Paré's instruments. At the present time, instead of such handles as these, with blades riveted into them, scalpels are forged out of one piece of steel, their handles are nickel-plated and perfectly smooth, that they may afford no crevices, and may be boiled and immersed in carbolic lotion without tarnishing or rusting; the scalpel has become just a single, smooth, plain piece of metal, having this one purpose, that it shall make an aseptic wound. In the same way the saw is made in one piece, if this be possible; anyhow, it must be, so far as possible, a simple, smooth, unrusting metal instrument, that can be boiled and laid in lotion; it is a foreign body that must be introduced into tissues susceptible of infection, and it must not carry infection with it.

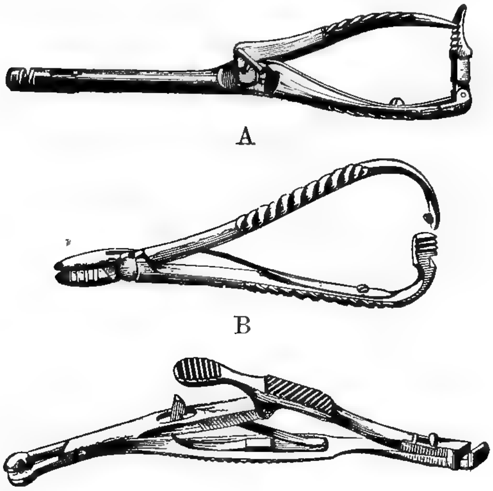

Fig. 1.—Needle-holders—A, Hagedorn's; B, Macphail's; and C, Allen and Hanburys', for Hagedorn or ordinary needles.

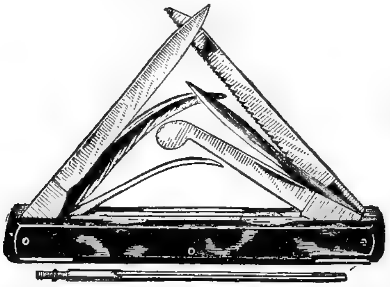

Fig. 2.—Combination knife containing finger-knife, finger-saw, gum lancet, Liston's naevus needle, Syme's abscess knife, tenotomy knife, probe and grooved director.

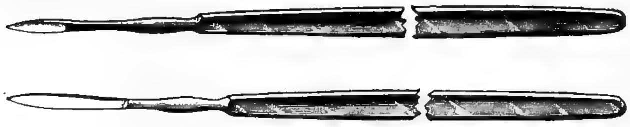

Fig. 3.—Tenotomy knives forged in one piece.

Or we may take, at different periods of surgery, the various kinds of ligature for the arrest of bleeding from a divided blood-vessel. In Paré's time (he was the first to use the ligature in amputation, but the existence of some sort of ligature is as old as Galen) the ligature was a double thread, *bon fil qui soit en double;* and he employed a forceps to draw forward the cut end of the vessel to be ligatured. From the time of Ambroise Paré to the time of Lord Lister no great improvement was made. In the middle of last century it was no uncommon thing for the house-surgeon at an operation to hang a leash of waxed threads, silk or flax, through his button-hole, that they might be handy during the operation. Then came Lord Lister's work on the absorbable ligature; and out of this and much other experimental work has come the present use of the ligature in its utmost perfection—a thread that can be tied, cut short, and left in the depth of the wound, with absolute certainty that the wound may at once be closed from end to end and nothing more will ever be heard of the ligatures left buried in the tissues. The choice of materials for the ligature is wide. Some surgeons prefer catgut, variously prepared; others prefer silk; for certain purposes, as for the obliteration of a vessel not divided but tied in its course for the cure of aneurysm, use is made of kangaroo-tendon, or some other animal substance. But whatever is chosen, is made aseptic by boiling, and is guarded vigilantly from contamination on its way from the sterilizer into the body of the patient. The old ligatures were a common cause of suppuration. Therefore the wound was not closed along its whole length, but the ligatures were left long, hanging out of one end of the wound, and from day to day were gently pulled until they came away. Certainly they served thus to drain the wound, but they were themselves a chief cause of the suppuration that required drainage.

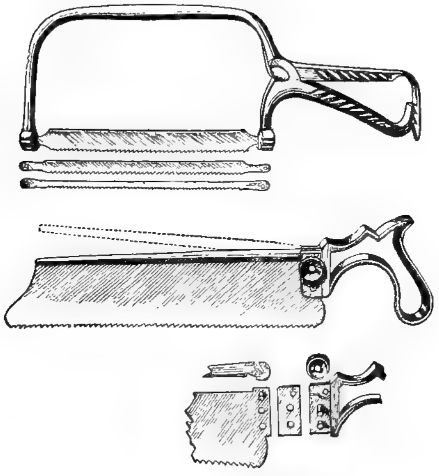

Fig. 4.—Amputating saws.

Sutures, like ligatures, were a common cause of suppuration in or around the edges of the wound. Therefore, in the hope of avoiding this trouble, they were made of silver wire, which was inconvenient to handle, and gave pain at the time of removal of the sutures. At the present time they are of silkworm-gut, catgut, silk, or horsehair; they are made aseptic by boiling, and can be left any number of days without causing suppuration, and can then be removed without pain.

Next may come the consideration of surgical dressings. In the days when inflammation and suppuration were almost inevitable, the dressings were usually something very simple, that could be easily and frequently changed—ointment, or wet compresses, to begin with, and poultices when suppuration was established. It is reported of the great Sir William Fergusson that he once told his students, "You may say what you like, gentlemen, but after all, there's no better dressing than cold water." This is not the place to try to tell the long history of the quest after a perfect surgical dressing, and the advance that was begun when Lord Lister invented his carbolic paste. The work was done slowly in the international unity of science during many years. The perfect antiseptic dressing must fulfil many requirements: it must be absorbent, yet not let its medicament be too quickly soaked out of it; and it must be antiseptic, yet not virulent or poisonous. Of the many gauzes now available, that which is chiefly used is one impregnated with a double cyanide of zinc and mercury. Its pleasant amethystine tint has no healing virtue, but is used to distinguish it from other gauzes—carbolized gauze, tinted straw-colour; iodoform gauze, tinted yellow; sublimate, blue; chinosol, green. The chinosol gauze is especially used in ophthalmic surgery; for general surgery the cyanide gauze is chiefly employed. The various preparations of absorbent wool (*i.e.*, wool that has been freed of its grease, so that it readily takes up moisture) are used not only for outside dressings, but also as sponges at the time of operation, and have to a great extent done away with the use of real sponges. The gauzes in most cases are used not dry, but just wrung out of carbolic lotion, that their antiseptic influence may act at once.

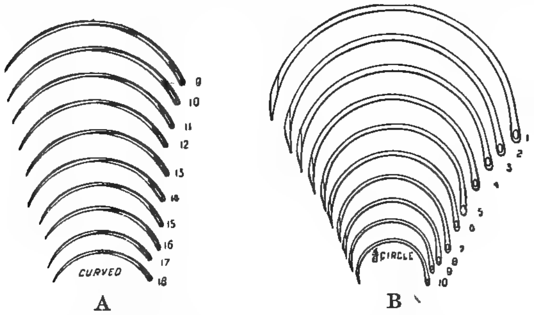

FIG. 5.—Surgical needles—A, ordinary; B, Hagedorn's.

The whole subject of surgical instruments may be considered in more ways than one. It may be well, for the sake of clearing the ground, to take first some of the more common instruments of general surgery, and then to note the working out, in the operations of surgery, of the three great principles—the use of anæsthetics, the use of antiseptic or aseptic methods, and the surgical uses of electricity.

Of the essential instruments that are common to all operations, we may well believe that they have now become, by gradual development, perfect. Take, for instance, the ordinary surgical needle. In the older forms the eye was slit-shaped, not easily threaded, and the needle was often made of a triangular outline, like a miniature bayonet. At the present time the needles used in general surgery are mostly Hagedorn's, which have a full-sized round eye, easy for threading, are flat for their whole length, and have a fine cutting edge on one side, near the point. Thus they enter the skin very easily, like a miniature knife, and the minute wound they make is not a hole, but a tiny slit that is at once drawn together and, as it were, obliterated by the tying of the suture. Or, for another simple instrument in universal use, take the catch-forceps that is used for taking hold of a bleeding point till it is ligatured. This forceps is as old as the time of Paré, but he made use of a very heavy and clumsy pattern. Up to the last few years, the artery-forceps was made with broad, curved, fenestrated blades, with the catch set close to the blades. At the present time the forceps in general use, named after Dr Péan in France and after Sir Spencer Wells in England, is made with very narrow grooved blades, and the catch is placed not near the blades, but near the handles: thus it takes a surer hold, and can be set free when the ligature is tied by a moment's extra pressure on the handles.

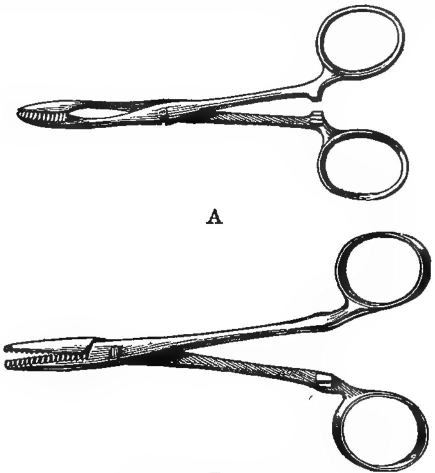

FIG. 6.—Artery-forceps—A, Péan's; B, Spencer Wells'.

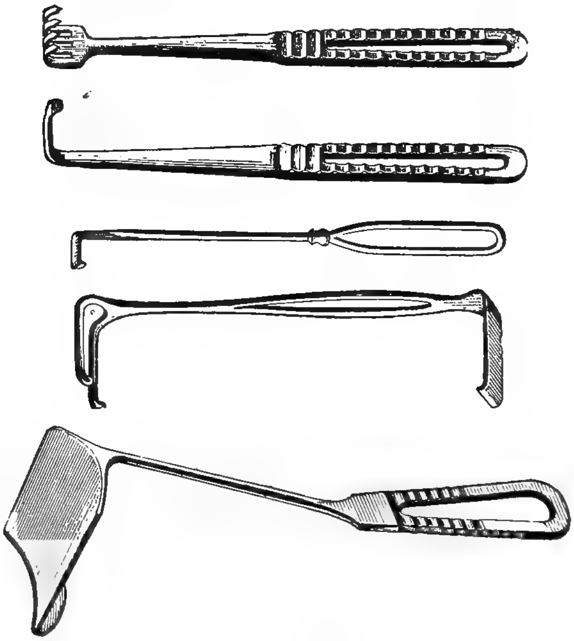

FIG. 7.—Retractors.

Among other instruments in universal use are divers forms of retractors, for holding gently the edges of a wound: the larger patterns are made with broad, slightly-concave, highly-polished surfaces, that they may, so far as possible, reflect light into the wound. Among tourniquets, the old and elaborate Petit's tourniquet, which was a band carrying a pad screwed down over the main artery of the limb, has given place to the elastic tourniquet with Esmarch's bandage. For example, in an amputation, or in an operation on a joint or on a vessel or a nerve in a limb, the limb is raised, and the Esmarch's elastic bandage is applied from below upward till it has reached a point well above the site of the operation; then an elastic tourniquet is wound round the limb at this point, the bandage is removed, and the limb is thus kept almost bloodless during the operation.

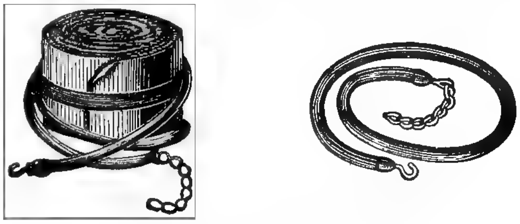
Fig. 8.—Tourniquet (Esmarch's).

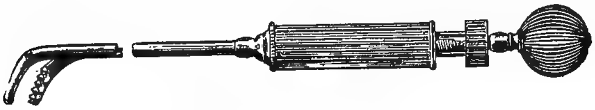
Fig. 9.—Lithotrite (Bigelow's).

It is not possible to describe here the many forms of other ordinary instruments of general surgery—probes, directors, scissors, forcipes, and many more—nor those that are used in operations on the bones. Nor again can the numerous instruments used in special departments of surgery be discussed in detail. But, with regard to the special surgery of the eye, and of the throat and ear, it is to be noted that the chief advance in treatment arose from the invention of the present instruments of diagnosis, and that these are of comparatively recent date. The *ophthalmoscope* was the work of Helmholtz. The inventor of the *laryngoscope*, Signor Manuel Garcia, was still living at the beginning of this century; and the use of a *frontal mirror*, for focussing a strong light on the membrana tympani, in the examination of the ear, was then scarcely fifty years old. Before the ophthalmoscope, it was impossible to study the internal diseases of the eye; before the laryngoscope, the diseases of the larynx were invisible, and were mainly a matter of guess-work, and of vague and often futile treatment. Before the use of the frontal mirror, the diseases of the ear were hardly studied, in that sense in which they are studied now. The wonderful advance of the special departments of surgery was, of course, the result of many forces, but one of the chief of these forces was the invention of proper instruments of diagnosis. The text-books that were written immediately before those instruments became available were not far in advance of Ambroise Paré, so far as these special departments are concerned.

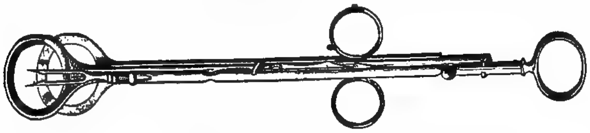
Fig. 10.—Tonsillotome (Mathieu's).

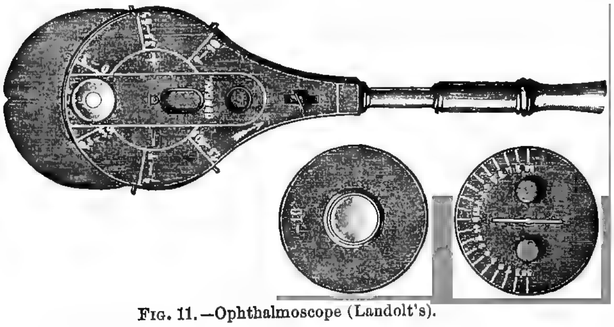
Fig. 11.—Ophthalmoscope (Landolt's).

It may be well next to consider in what ways the conduct of an operation is influenced by those two great discoveries, the discovery of anæsthetics, and the more gradual development of the principles of antiseptic and aseptic surgery; with especial reference to the use of the instruments of surgery. The jubilee year of anæsthesia was 1896; the first use of nitrous oxide was on 11th December 1844; the first operation under ether was on 30th September 1846; the first use of chloroform was on 4th November 1847. The choice of the anæsthetic, or of some combination of anæsthetics, that is best suited to each particular case, is a matter of careful consideration; but, on the whole, the tendency in England is to keep to the *via media* between the more general use of chloroform in Scotland and the more general use of ether in the United States. Of the methods of administering chloroform there is no need to say much; no instrument is used save a fold of lint or some such stuff, or a piece of flannel made into a sort of cone or mask. But, for operations on the face or on the mouth, where a piece of lint would be in the way, use is generally made of a "Junker's inhaler," whereby the vapour of chloroform is administered by means of a hand-ball through a fine, soft tube held at one corner of the mouth, out of the way of the surgeon. For the administration of ether, some form of Clover's inhaler is generally used, whereby the ether in a small metal chamber passes as vapour into an indiarubber bag, and there is combined with the patient's breath in proportions determined by the anæsthetist throughout the operation. The metal chamber is so designed that by turning it the exact proportion of ether

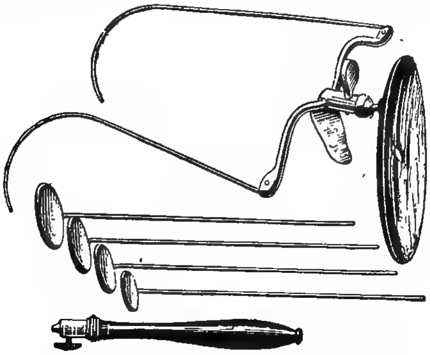
Fig. 12.—Laryngoscope (Lennox Browne's).

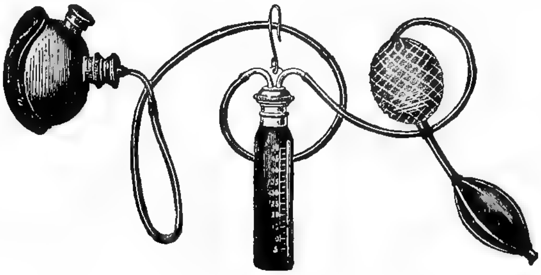
Fig. 13.—Inhaler (Junker's).

to air is fixed in accordance with the requirements of the case. Of late years, by the use of an iron cylinder of nitrous oxide, connected by a tube with a Clover's inhaler, it is possible to begin with nitrous oxide, and to go on, without interruption, with ether. More recently, an admirable method has been devised of administering nitrous oxide with the admixture of air or of oxygen in such a way that the anæsthesia produced by the gas may be maintained for time enough to allow of an operation of some length.

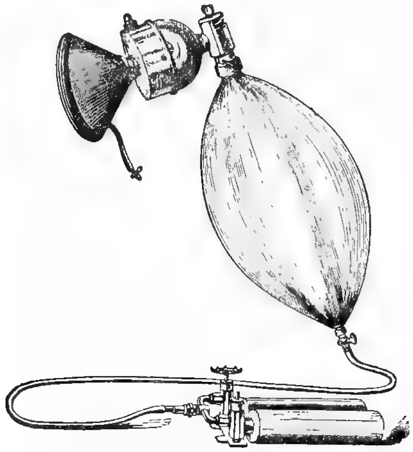

Fig. 14.—Gas and ether apparatus (Hewitt's).

The series of discoveries which, in its application to surgery, has brought about the present antiseptic and aseptic methods of operation, is concerned both with the shape or use of the instruments of surgery and with their preparation for use. The mere sterilization, by boiling or by steaming, of all instruments and dressings, is enough to ensure their freedom from the ordinary micro-organisms of suppuration; but the surgeon cannot boil or steam either himself or his patient. The preparation, therefore, of the surgeon's hands, and of the skin over the area of operation, is made not only by scrubbing with soap and hot water, but by careful use of antiseptic lotions. Again, ligatures and sutures, which must be kept in stock ready for use, are kept, after careful sterilization, in antiseptic lotion, or are again sterilized immediately before an operation. Again, all towels used at an operation must be prepared, either by sterilization or by immersion in antiseptic lotion.

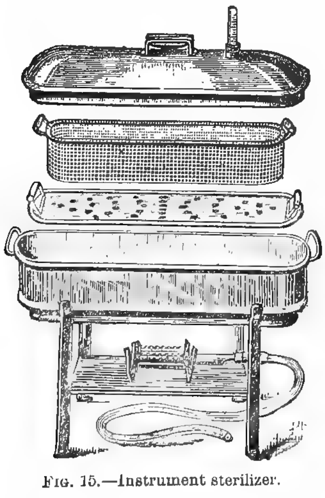

Fig. 15.—Instrument sterilizer.

The sterilization of all instruments and dressings is a simple matter: the usual sterilizer is a vessel like a fish-kettle, with a perforated metal tray in it, so that the instruments can be immersed in boiling water, and can be lifted on the tray and transferred straight from the sterilizer into vessels containing sterilized water or antiseptic lotion. For the sterilization of dressings, an upper vessel is fitted to the sterilizer, so that the steam may permeate the dressings placed in it. In hospital practice it is usual also to sterilize all towels, aprons, and the like in a large cylindrical vessel. Sterilization by boiling or steaming, together with the use of antiseptic lotions, or of water that has been boiled, for all such things as cannot be boiled or steamed, is the essential principle of the surgery of the present day; and practically the antiseptic method and the aseptic method have become one, varying a little this way or that according to the nature and circumstances of the case.

Beside anæsthetics and antiseptics, there is a third series of discoveries that has profoundly influenced surgery—the use of the forces of electricity. The uses of electricity are fivefold.

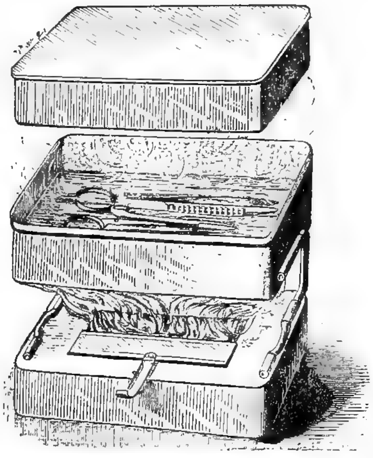

Fig. 16.—Portable sterilizer.

(1) *The Galvano-Cautery.*—The original form of the cautery, the *fer ardent* of Paré's time, for the arrest of hæmorrhage after amputation, was a terrible affair. Happily for mankind, his invention of the ligature put an end to this use of the cautery, but it was still used in a small number of other cases. Subsequently Paquelin invented a very ingenious form of cautery, a series of metal blades or points of different shapes and sizes, that could be fitted to a handle: these points were hollow inside, and were filled with fine platinum gauze, and, by means of a bottle and hand-bellows, they could be kept heated with benzine-vapour. Thus, when they had once been raised to a glowing heat by holding them over a spirit-lamp, they could be kept at any desired heat. This instrument is still in use for a few cases where very rapid and extensive cauterization is necessary. But for all finer use of actual heat the galvano-cautery alone is used—a series of very minute points of platinum, with a suitable trigger-handle, connected with a battery or (by means of a converter) with the ordinary house supply of electricity. In this way it is possible to apply a glowing point with a fineness and accuracy of adjustment that were wholly impossible with Paquelin's cautery.

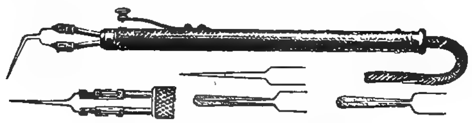

Fig. 17.—Galvano-cautery set.

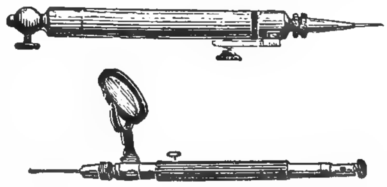

Fig. 18.—Electrolysis needle-holders.

(2) *Electrolysis.*—This method is of great value, in suitable cases, for the arrest or obliteration of small growths. The passage of the electric current between needles introduced into or under the skin brings about a gradual shrinking or cicatrization of the tissues subjected to it, without the production of any unsightly scar.

(3) *Electro-Motor Power.*—During the last few years the use of a small electro-motor machine has come into

the practice of surgery for certain operations on the bones; especially for the operation for disease involving the mastoid bone. It is, of course, a better method for the use of a fine drill or burr, for example, than the "dental engine," where the power is generated by a pedal turning a wheel, and it will probably come into wide use both for dental surgery and for those operations of general surgery that require very gradual and delicate removal of small circumscribed areas of bone, especially of the cranial bones.

(4) *The X-Rays.*—This, the most unexpected and, as it were, the most sensational discovery that has been bestowed on physicians and surgeons since the discovery of anæsthetics, is now used over a very wide and varied field of practice. Its value does not stop at the detection and localization of foreign bodies; indeed, this is but a small part of its work. It is used constantly for cases of actual or suspected fracture or dislocation; for cases of congenital or acquired deformity; for cases involving difficulties of diagnosis between a swelling of the bone due to inflammation and a swelling due to a tumour; and for obscure cases of spinal disease, hip-disease, and the like. Moreover, it has lately been found possible, by Dr Hugh Walsham and others, to obtain pictures of the thoracic organs that are a very valuable guide in many obscure cases of disease of the lungs or of the pleura, and in many cases of thoracic aneurysm or of intra-thoracic tumour. Every year the number and the range of the cases where the X-rays are helpful for diagnosis, and for treatment, become greater; and it is impossible to say at what point the surgical value of this discovery will find its limit. Beyond these uses, it is probable that the X-rays will maintain and extend the importance that they already have in the direct treatment of certain cases of disease of the skin.

Fig. 19.—Cystoscope (Nitze's).

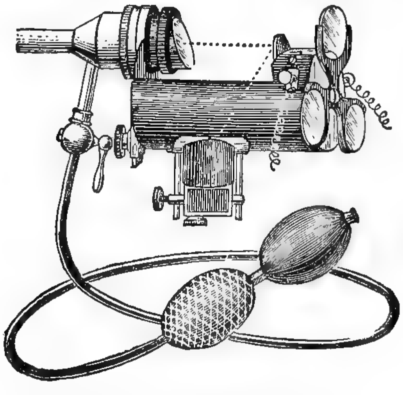

Fig. 20.—Urethroscope (Fenwick's), also used for ear, nose, throat, &c.

(5) *The Electric Light.*—Beside the general superiority of this light to other lights for the routine work of surgery, there are several special uses for it. Of these, the most important is the *cystoscope*, a long narrow tube, shaped and curved somewhat like a catheter, and having at its end a very minute glow-lamp and reflector, and a small window. Its other end is fitted with a lens, and is connected by a switch with the main current. With this instrument, in skilled hands, it is possible to inspect the interior of the bladder, and in many cases to make an exact diagnosis under circumstances where otherwise it would be impossible. Another instance of the value of the electric lamp in diagnosis is given by the trans-illumination of the facial bones in cases of suspected disease of the central cavity of the superior maxillary bone. A small glow-lamp is held in the closed mouth, in a darkened room, and by a comparison of the shadows on the two sides of the face, thus trans-illuminated, an exact diagnosis can often be obtained as to the presence or absence of pus in this central cavity. Again, a small glow-lamp, duly sterilized, is often of great value in deep operations on the abdominal cavity.

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Surrey, an inland county of England. It is bounded on the N. by the Thames, which separates it from Berks and Middlesex, on the E. by Kent, on the S. by Sussex, and on the W. by Hampshire.

Area and Population.—The area of the ancient county as given in the census returns is 485,128 acres, or 758 square miles, with a population in 1881 of 1,436,899, in 1891 of 1,731,343, and in 1901 of 2,008,923. In 1891, 820,993 were males and 910,350 females, the number of persons per square mile being 2284, and of acres to a person 0·28. The area of the administrative county, exclusive of the county borough of Croydon, is 452,218 acres, with a population of 418,856, and including the county borough the area is 461,230, with a population in 1901 of 653,406. Under the provisions of the Local Government Act, 1888, 23,898 acres of the ancient county were transferred to the county of London. The area of the registration county is 452,733 acres, with a population in 1891 of 572,092, of whom 175,307 were urban and 396,785 rural. Within this area the increase of population between 1881 and 1891 was 24·09 per cent. The excess of births over deaths between 1881 and 1891 was 67,873.

The following table gives the number of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1899:—

Year.	Marriages.	Births.	Deaths.	Illegitimate Births.	
				Males.	Females.
1880	2956	13,907	7,550	264	267
1890	3605	14,534	8,645	273	281
1899	5001	16,843	10,268	312	297

The following table shows the marriage-, birth-, and death-rates per 1000 of the population, with the percentage of illegitimate births, for a series of years:—

	1870–79.	1880.	1880–89.	1890.	1889–98.	1899.
Marriage-rate	12·7	13·0	12·5	12·8	13·0	14·7
Birth-rate .	31·5	30·6	29·2	25·8	25·3	24·8
Death-rate .	17·3	16·6	15·6	15·4	14·6	15·1
Illegitimate births .	3·8	3·8	4·1	3·8	4·0	3·6

Both the birth-rate and death-rate were below the average for England. The number of Scots in the county in 1891 was 4621, of Irish, 5291, and of foreigners 3388.

Administration.—The ancient county is divided into six parliamentary divisions, and it also includes the parliamentary borough of Croydon. The administrative county includes five municipal boroughs, exclusive of the county borough of Croydon (133,885), viz., Godalming (8748), Guildford (15,937), Kingston (34,375), Reigate (25,993), Richmond (31,677). The following are urban districts—Barnes (17,822), Carshalton (6745), Caterham (9486), Chertsey (12,762), Dorking (7670), East and West Molesey (5937), Epsom (10,915), Esher and The Dittons (9489), Farnham (6124), Frimley (8409), Ham (1460), Leatherhead (4694), Maldens (The) and Coombe (6232), Penge (22,468), Reigate (25,993), Surbiton (15,019), Sutton (17,224), Walton-on-Thames (10,329), Weybridge (5329), Wimbledon (41,604), Woking (16,223). Surrey is in the south-eastern or home circuit, and assizes are held at Guildford. The administrative county has one court of quarter sessions, and is divided into eleven petty sessional divisions. The boroughs of Croydon, Godalming, Guildford, Kingston-upon-Thames, and Reigate have separate commissions of the peace, and Croydon and Guildford have in addition separate courts of quarter sessions. The Central Criminal Court has jurisdiction over certain parishes adjacent to London. All those civil parishes within the county of Surrey, of which any part is within 12 miles of, or of which no part is more than 15 miles from, Charing Cross, are in the metropolitan police district. The administrative county contains 133 entire civil parishes, and the county borough of Croydon one entire civil parish. The ancient county of Surrey (exclusive of the parishes now in the county of London) contains 210 entire ecclesiastical parishes or districts, and parts of six others, situated in the dioceses of Rochester, Winchester, Canterbury, Oxford, and Chichester.

Education.—The number of elementary schools in the county on 31st August 1899 was 287, of which 67 were board and 220 were voluntary schools, the latter including 190 National Church of England schools, 3 Wesleyan, 13 Roman Catholic, and 14 "British and other." The average attendance at board schools was 16,645, and at voluntary schools 41,925. The total school board receipts for the year ended 29th September 1898 were over £135,392. The income under the Agricultural Rates Act was over £1303. The South-Eastern Agricultural College, Wye, Kent, is under the control of the county councils of Surrey and Kent. In 1899 there were three reformatory and industrial schools in the county.

Agriculture.—About two-thirds of the area of the county is under cultivation, and of this about five-ninths is in permanent pasture. In 1899, 1313 acres were devoted to the cultivation of hops, and 1537 acres to that of small fruit; 54,437 acres are under wood, and 11,221 acres are heathlands used for grazing. The following table gives the main divisions of the cultivated area at intervals from 1880:—

Year.	Total Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1880	299,315	86,649	42,528	28,848	122,793	16,169
1890	295,920	72,627	39,062	24,724	147,655	9,110
1899	280,027	57,128	34,364	23,305	155,948	6,578

The following table gives particulars regarding the principal live stock during the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in milk or in calf.	Sheep.	Pigs.
1880	13,947	45,475	23,286	79,848	25,937
1890	12,606	46,071	23,152	80,575	27,822
1899	12,535	45,021	22,633	72,630	21,943

Industries and Trade.—The total number of persons employed in factories and workshops in 1897 was 15,996, as compared with 13,701 in 1896. Textile factories employed only 82. In non-textile factories 9599 persons were employed, as compared with 8591 in 1896. Of the 6315 persons employed in workshops, 3081 were employed in the clothing industries. Gloves and hosiery are made at Godalming. Fuller's-earth is excavated at Nutfield and Reigate. There are oil, paper, and sheet-iron mills on the rivers Mole and Wandle. Other industries are brush and broom making, brick-making, glass-working, cement-working, and pottery.

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SURVEYING.

I. METHODS AND INSTRUMENTS.

SURVEYING is the art of determining the relative positions of prominent points and other objects on the surface of the ground, and recording them in such a manner that graphical determination of the included area may be made, and the areas of the whole, or of defined portions, may be calculated from the observed data. All surveys rest primarily on linear measurements, which are frequently, and when a long distance has to be covered invariably, supplemented by angular measurements. From the latter are formed triangles, whose sides can be calculated from the original measured base and whose apices are known and fixed points, from which other triangles may be observed and evaluated, and from which direct linear measurements may be made. The simplest form of surveying is that in which the chain, rod, and staff are the only instruments employed. The chain in use in England for land surveying is 66 feet long and is divided into 100 links. The length of 66 feet is arrived at by the relation of this unit of measurement to the mile and the acre, there being 80 chains in a mile of 1760 yards, and 10 square chains to one acre of 43,560 feet. With the metrical system the chains are 20 metres, or approximately 65·62 feet, in length. Until recently the chain was constructed of 100 short bars of iron or steel hooked at the ends and connected together by three rings between each pair of links, the end links being provided with brass handles and each ten links marked with a distinctive brass label. Such chains as these are heavy, and the hooks and intermediate links collect sticks, grass, weeds, and mud, and offer considerable resistance to traction, causing them to stretch, and necessitating frequent adjustment by reducing the length of the shorter links with the hammer or by the removal of one or more of the rings. In modern practice a continuous steel band of nearly oval section, about $\frac{3}{16}$ of an inch deep by $\frac{1}{8}$ of an inch thick, is substituted for the built-up chain. Such a band does not stretch in itself, does not offer much resistance to traction, and is of small weight; but the brass swivel handles used for dragging it are liable to extension, and the points of measurement should be marked on the band itself and should not include the handles. To obtain the most accurate measurements the steel band is suspended horizontally with a given tension, one end being made to coincide with a given mark, and the mark at the other end transferred to a nail driven into a peg or to some other record by means of a plumb-line, or, better, of the theodolite. When used in this manner the band must be 66 feet in length between marks; and as this is the case at one particular temperature only (generally 52° F.), temperature observations should be made simultaneously with each measurement, so that the true length passed over may be corrected by calculation. The rate of expansion of steel is 1 in 927, from 32° to 212° F., and is nearly constant within these limits.

Chain measurements.

In surveying with the chain, rod, and staff, straight lines are measured horizontally along the surface of the ground. The primary base line is of the greatest practicable length, and from it other lines are measured in such manner as to form triangles and polygons, each side of each figure being the subject of direct measurement, and the position of every three sides being further defined by a check measurement, generally made in a direction nearly perpendicular to the base of the particular figure under consideration to its apex. Where, as in European countries, the land is divided up into fields by walls, ditches, or hedges, the subsidiary figures are generally made to follow as closely as is convenient the lines of division between enclosures, and the distance of the boundary from the survey line is measured from recorded points on the chain by offsets or short lines drawn perpendicularly from the chain to the boundary. Where the length of the offset is short, the offset staff, a pole of ten links in length, can be used, and this rod may be laid at right angles to the chain by eye; but if the length of the offset is greater, its direction must be laid perpendicular to the chain by means of some instrument, such as the cross staff, the optical square, or the box sextant. Where offsets are greater than 50 links in length, they should be obtained by making two measurements from different points in the base line. Great care must be taken to ensure the straightness of each line, especially in the case of the primary or base line, which is probably that of greatest length. The success of the operation depends on placing poles in the ground one in front of another by eye; hence considerable care and judgment must be used, and before the survey is commenced it is necessary to traverse the greater part of the ground, selecting a route for the primary line that is not obstructed by some obstacle which would render the continuity of the base difficult or impossible. Obstacles—such as buildings, ponds, and rivers—have to be surmounted in most surveys. Where, as in the case of a building, the obstacle obstructs both the sight and the measurement, a common practice is to measure off in two places from the main line a distance sufficient to clear the obstacle, to run through the points measured a line parallel to the main line until the obstacle is passed, and to return into the main line again by a repetition of the former measurements (Fig. 1). When the line of sight is not obstructed, the survey line may be continued by methods such as are shown in Figs. 2 and 3. The whole of the measurements, the number of each line, its general direction with regard to the line from which it originates and to any other which it may cross or with which it may connect, its reference number and any measurements along it and from it which it is necessary to record, are entered in a field book, from which the survey may be transferred to paper and the areas of enclosures calculated.

The amount of error permissible in chaining with the link chain is 1 in 1000, and considerable care is necessary to secure this degree of accuracy: with the band chain used as an instrument of precision there is little difficulty, however, in measuring to 1 in 20,000; and if the measurement be of sufficient importance to warrant the delay, much greater accuracy than this, probably 1 in 60,000, may be obtained without any special apparatus beyond that already described. Although the use of the chain lies at the foundation of all surveying, the addition to the surveyor's apparatus of some optical instrument for measuring angles facilitates his operations greatly, and is recognizable in the use of the cross staff for setting offsets perpendicularly to the chain line. In the accurate survey of a long length of line or a considerable tract of country the use of an optical instrument becomes a necessity: the instrument best adapted for this purpose is the theodolite, although the work of the surveyor may be much assisted by the use of the prismatic compass and the pocket sextant, and either or both of these instruments may be used with advantage, in conjunction with the theodolite, for obtaining the direction of the less important and shorter lines.

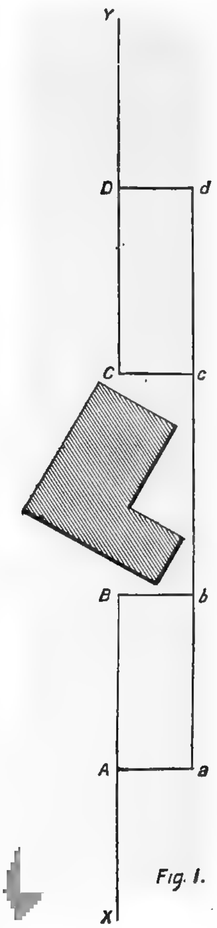

Fig. 1.

If to the chain, cross staff, tape, offset staff, and lining rods, which form the equipment of the surveyor under elementary conditions, some instrument for measuring angles, such as a prismatic compass, a more advanced form of cross staff, a box sextant, or (in large surveys) a theodolite, be added, and if the optical square be substituted for the cross staff, the rapidity of the survey may be increased. The direction of each survey line with reference to the primary or base line or to magnetic north can be recorded in the field book, and accuracy in the measurements of each triangle is secured apart from the tie line or fourth element, which is employed for this purpose in surveying with the chain alone, but which should not be omitted even when angular observations are made. In a survey with the chain alone it is possible to plot the triangle without any manifest error although the length of a side is inaccurately measured. The measurements must therefore be checked by a fourth dimension, generally drawn from the apex of the triangle perpendicularly, or nearly so, to the base. The triangle, however, may still be plotted with its apex in the wrong direction without falsifying any measurement. But none of these errors can take effect if the bearing or direction of each line with regard to magnetic north be recorded, as, should there be inaccuracy in reading the angles or in measuring the lengths of the sides, the triangle could not be constructed.

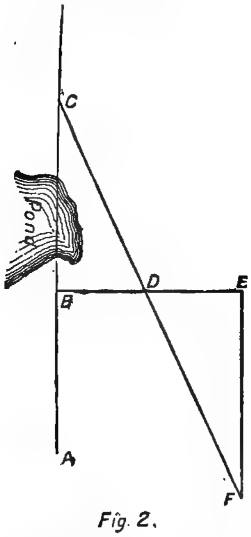

Fig. 2.

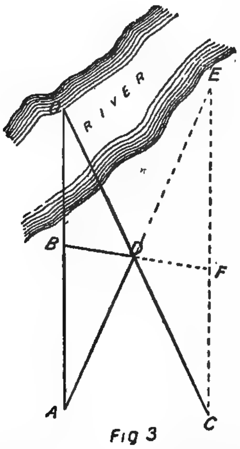

Fig 3

When no local attraction exists to affect the magnetic needle, the prismatic compass is the most convenient instrument for taking the bearings of the several survey lines and the direction of straight pieces of fencing, whereby the measurement of many offsets and frequently of subsidiary triangles rendered necessary in a chain survey in order to obtain short offset measurements may be avoided. Failing the prismatic compass, the cross staff is more convenient than the sextant, because its construction permits of angles the apices of which are at varying levels being read in the horizontal plane, and because it is free from parallax, except when the observed point is very close to the instrument. The cross staff can also be used to read bearings from magnetic north on the angle intercepted between two lines, but it is a heavier and more cumbersome instrument than either the prismatic compass or the pocket sextant. Owing, however, to the fact that it must be supported on a leg or staff forced into the ground, or on a tripod, the angles taken may be recorded to something like 10′ of arc, while neither the sextant nor the prismatic compass can be relied on to read more closely than to half degrees. In surveys of large extent it is preferable to lay out the main lines, and especially the base or primary line of the survey, with the theodolite. By this instrument a given straight line may be continued for any convenient distance with a degree of accuracy to be measured only by the care taken in observing, and the angles of the principal triangles can be read to any desired degree of nicety up to 1″ of arc. Minor triangles may be filled in with the prismatic compass, cross staff, or sextant. The length measurements may be made with the chain, the tacheometer (see TACHEOMETRY), or by means of a succession of triangles built up on the base line, the sides of which are calculated trigonometrically.

Traversing.

Traversing is a system of surveying dependent for its accuracy on an exact measurement of a system of main survey lines laid out in succession, and of the angle which each line makes with the last, with the primary line, with true meridian, or with magnetic north. Traverse surveys are of two kinds, closed and open. A closed traverse is one where the terminal point coincides with the commencing station on the survey, and the lines when drawn in plan form one or more polygons. In an open traverse the terminal station does not coincide with any other point on the survey; if it did, or if any line on the traverse intersected or coincided with any other line previously surveyed, the traverse would be partly closed and partly open. A traverse closed or open may be surveyed with the chain and poles only, in the following manner: The direction of the primary line having been poled out, its length is measured with the chain. Where it is desirable to deflect the survey from the original straight line, a line in a new direction is poled out, preferably from a chain end, so that the measurement may be continuous. A measurement of a convenient number of chains is then made in the reverse direction, and the distance which separates the terminal distance measured in a backward direction from the corresponding point on the primary line is measured as carefully as possible, not with the chain, but with a steel tape, or with a stick cut to the required length, preserved for reference and numbered; the traverse line is then continued forward until it is desired again to deflect its direction, when the same process is repeated. In plotting the survey lines it is desirable that the dimensions of the tie lines should be multiplied three or more times, or that the angle of deflection from the straight should be calculated in order to obtain greater accuracy. This system, which, however, is not to be recommended, may be used for recording the position of an outlying piece of property which is only conveniently accessible along a road, or for the delimitation of the boundaries of a wood through which it would be impossible to lay out lines without cutting the timber, when instruments for measuring angles are not available.

Traverse surveying by chain or tacheometric observations for length measurements with the assistance of an instrument for measuring angles is a most important branch of the art, and is particularly applicable to the delineation of the shore line of an island or lake when the traverse is closed, or to that of a length of coastline, a road, or railway, where the traverse is open. When, as in laying out roads or railways, the absolute direction of the several lines is a matter of minor importance, and it is sufficient as a rule to know that a line can be laid out with given radii of curves, the prismatic compass may be used; but much greater accuracy may be obtained by employing the theodolite to measure the angle which each line makes with the preceding one, or with a meridian. In a closed traverse (Fig. 4), the first lines AB, BC, being set out and measured, the theodolite may be placed at B with the verniers reading zero and the telescope directed to A and clamped. The upper circle is then unclamped, the telescope directed to C, the circle reclamped, and the angle ABC read by means of the verniers. In the same manner the sides CD, DE, EA may be set out and measured, and the angles BCD, CDE, DEA, and EAB read with the theodolite. The angles recorded being exterior angles, and the sum of the exterior angles of a polygon, diminished by four right angles, being equal to twice as many right angles as the figure has sides, in the five-sided figure illustrated they should be equal to 14 right angles or 1260°; and the interior angles, which can be found in each case by subtracting the observed angle from 360°, should be equal to six right angles or 540°. If the observed angles together differ from 1260° by more than the permissible error (which, for single observations with a small instrument, may be taken at 30'' for each angle), they should be observed a second time, the final error being evenly divided between them. Should the lines when plotted with a protractor fail to close, the measurements must be inaccurate and should be repeated. The polygon illustrated forms the base of the survey, and must be filled in with the chain and other instruments by the introduction of subsidiary lines or triangles with offsets in the manner described under the head of chain surveying.

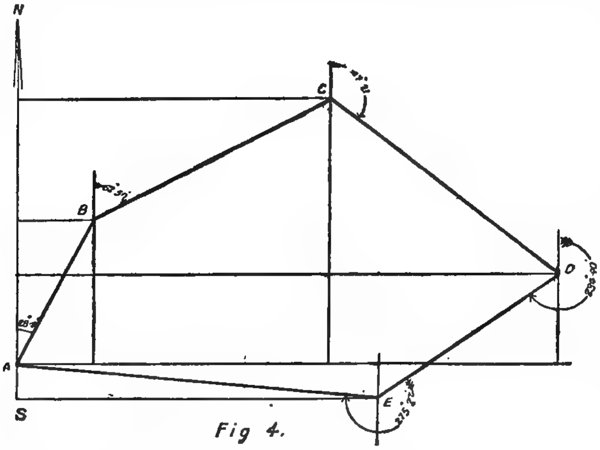

Fig 4.

Co-ordinates.

Plotting the polygon or other figure on paper with protractor and scale is an untrustworthy method. Hence, when the survey is of any considerable size, plotting by co-ordinates is preferable, and may even become obligatory. In this system every angle is referred, where the compass is used, to magnetic north and south, or in important surveys with the theodolite to a true meridian; and the position of each point is calculated trigonometrically with reference to its distance east or west, north or south, of the starting-point of the survey. The distance from point to point, measured along or parallel to the meridian, is called the difference of latitude of these two points, or northing or southing, and the distance from point to point in a direction perpendicular to the meridian is called the departure of these points, or easting or westing. In a closed traverse *the sum of the northings is equal to the sum of the southings, and the sum of the eastings is equal to the sum of the westings.* The angle which any line makes with a true meridian is called its "azimuth," with any other meridian its "bearing." The length of a line and its bearing being known, the difference of latitude of its extremities can be calculated trigonometrically. Thus in Fig. 5 the triangle ABC is right-angled, the angle at B being the right angle. Then AB, the difference of latitude between A and C, = AC x cos < BAC, and BC, the departure of C from A = AC x sin <BAC.

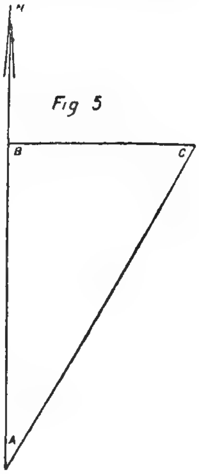

Fig 5

In modern theodolites the circle is divided from 0° to 360°, reading clockwise; the method of whole circle readings is therefore adopted, though reference is made to that of reading by quadrants which obtained in older instruments. The whole circle system agrees with the graduation of the compass, and the angle suffices to determine the bearing. Unfortunately, most trigonometrical tables only give functions of angles from 0° to 90°, Shortrede's tables (which are scarce) being, it is believed, the only ones which give augments from zero to 360°. Consequently, with ordinary tables, to obtain the sine or cosine of an angle greater than 90° a preliminary calculation has to be made, which is an objection to the use of whole circle readings. The arrangement of the first quadrant agrees with the whole circle readings; in the second quadrant, between east and south, 0° corresponds with 90°, and 90° with 180° on the whole circle; in the third, from south to west, 0° corresponds with 180°, and 90° with 270°; and in the fourth, from west to north, 90° corresponds with 270°, and 0° with 360°. When using ordinary trigonometrical tables for bearings less than 90°, enter tables with bearing direct; for bearings greater than 90° but less than 180°, with 180° − bearing; for those greater than 180° but less than 270°, with bearing − 180°; and for those greater than 270° but less than 360°, with 360° − bearing. The calculation of differences of latitude and departures greatly facilitates plotting; it obviates the use of the protractor, since the points can be projected with scale, T-square, and set-square, and the work can be set out more accurately than with any protractor.

Observation of angles.

In the observation of the angles it is desirable to follow a regular routine, in order that addition and subtraction of figures (especially the latter) in the field may be avoided as far as is possible. Several systems may be adopted, but the following seem to commend themselves most:—(1) Let the theodolite be set up at A (Fig. 4), the telescope being clamped at zero and directed along the meridian towards the north. Then, after reading and booking the bearing of the magnetic needle, unclamp the upper plate, direct the telescope to B, and read and book the angle NAB and the magnetic bearing. If the angle recorded is less than 90°, no correction is necessary; if it be larger, deduct it from 180° and book as a reduced angle; if larger than 180°, deduct 180° from it; if in excess of 270°, deduct it from 360° and book both the whole circle and the quadrant readings. The theodolite is next moved to B and the vernier set to the same number of degrees, minutes, and seconds as was observed for the last angle, but deducted from 360°; thus, when brought to zero the telescope should be parallel to the meridian, and the magnetic reading should be constant in this position, serving as a check throughout on the accuracy of the readings to the nearest degree. The telescope is then directed to C; the angle ABC and the magnetic bearing read and booked. The same process is repeated at D, E, and A. It is obvious that the same result may be obtained if the first position of the telescope be along the line AE or AB, the direction of the meridian being taken as an intermediate bearing, and the telescope at each setting up of the instrument being clamped at zero and directed backwards along the last line observed; but the number of the calculations to be made is greater and the automatic check on the accuracy of each reading less than where the telescope is made to stand parallel to the meridian when brought to zero. (2) The same process may be carried on automatically. Place the theodolite at A (Fig. 6), clamp the telescope at zero, direct it in a northerly direction along the meridian, and read the position of the magnetic needle. Then unclamp the telescope, direct it to B, and book the angle recorded and the bearing of the magnetic needle. Next, keeping the telescope clamped, remove the instrument to B, transit the telescope, unclamp the lower plate, and direct the telescope to A. Then retransit the telescope, reclamp the lower and unclamp the upper plate, and bring the telescope to zero; there it should be parallel to the meridian, the magnetic bearing being the same as for the previous reading at zero, and serving as a check on its position. Now direct the telescope to C and read.

With the telescope still clamped, but with the lower plate unclamped, remove the instrument to C, transit the telescope, direct it to B, retransit and bring the vernier to zero; then read the bearing of the magnetic needle and see that it remains the same, direct the telescope to D, and book both the angle and magnetic bearing. The process is to be repeated until the traverse is completed. By this method all the angles recorded are true bearings from the meridian used, and should differ by the same number of degrees in all cases from the magnetic bearings. The possible sources of error are two: the telescope may be slightly moved during transit of the instrument from one station to another, and the omission to transit the telescope may lead to there being a mistake of 180° in the readings. The first is easily obviated by checking the reading of the vernier at each change of position, and the second by comparing the readings with the magnetic bearings when the vernier is at zero. To facilitate accuracy the primary vernier should be marked A, and be under the eye-piece of the telescope when at zero.

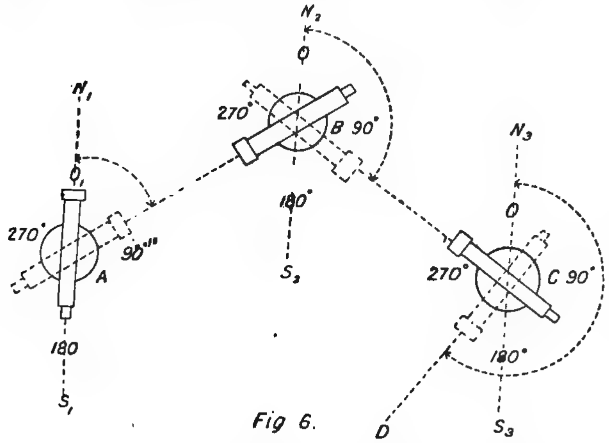

Fig 6.

The advantage of this system over others is that it is largely mechanical. It should be remembered that the surveyor is more usefully employed in selecting the best route for the survey, and in other matters in the field, than in attending to the instrument, which can be manipulated by almost any man who has had a moderate training in its use, and who can give his whole attention to accuracy of position, to careful reading, and booking; who, moreover, has no thought beyond his instrument, and is not distracted by the multifarious duties of the surveyor in charge of a large survey. Some surveyors prefer not to transit the telescope, but to read alternately the true bearing and the true bearing + 180°; the results obtained are the same, but the method is less mechanical than the other. The effect of defective centring of the instrument and incorrect bisection of the object viewed is common to all the systems referred to, which, however, eliminate graduation and reading errors to a great extent. These are limited to a single observation, whereas if each angle were read separately any error in reading would be carried forward and could not be located.

Plotting.

From the angles or bearings and the distances the traverse sheet is compiled, and the latitudes and departures are computed by multiplying the cosine of the reduced bearing by the distance for latitude, and by the sine of the distance for departure. In an ideal polygon the sum of the northings will equal the sum of the southings, and the sum of the eastings the sum of the westings. In an open traverse no such check on the accuracy of the readings and measurements can be obtained; the utmost care is therefore necessary both in observation and measurement, and angles should be taken to distant objects, which are visible from as many stations as may be, which will serve as checks on the accuracy of both the angular and linear measurements. The computation of latitudes and departures may be facilitated by the use of traverse tables, which are tables of natural sines and cosines multiplied by 10 or 100, addition being substituted for multiplication. Full directions for use are given in the introduction to these tables, and they need not be described. The most complete tables are, it is believed, made out for centesimal degrees. The next step is to calculate the co-ordinates or meridional distances and perpendiculars from a common point of origin, which in polygons is conveniently taken at some place approximating to the centre of the figure. Through A the point of origin in an open traverse, or through a point at some convenient distance from it near the centre of the figure in the case of a closed traverse, draw a vertical line, NS, to represent the meridian, or NS, a line parallel to the meridian, and through the same point draw a line at right angles to the meridian. On the second line the departures must be measured, and through each point so obtained a perpendicular should be drawn and the meridional distance measured along it. If the several points so obtained be connected by straight lines, then length measurements AB, BC, CD, &c. (Fig. 4) will agree approximately with the distances measured on the ground. As the paper on which the plot is drawn expands and contracts irregularly, it will be found, if the distances be continuously laid off by scale, that one sheet will not agree with another, nor the earlier measurements with the later. It is therefore desirable at the commencement of operations to draw a horizontal and a vertical scale on each sheet, and to divide the paper into squares not larger than about 3 inches across, the sides of which represent a given number of feet, links, or other unit, on the scale: in this way the measurements by scale can be limited to a length which cannot be greater than half the side of a single square, and the relation of every part of the plot to the scale inscribed on the paper is maintained throughout, notwithstanding a material alteration in the size and shape of the sheet. The squares must be set out with the greatest accuracy, their dimensions, parallelism, and verticality being checked with all care; they should be ruled in faint carmine in preference to pencil, any line which may be inaccurate being easily removed with chloride of lime. The deformation in each square is probably less than the smallest amount which can be measured with an ordinary scale, and is insignificant when compared with the distortion of the whole sheet. Should the sheet be exposed to the sun in the field, and become, from this or any other cause, seriously distorted, the squares can be accurately redrawn on a new sheet of paper, and the details filled in. By this system the measurement of the areas surveyed can be taken out with facility, and long distances determined by the addition of squares with greater accuracy than is possible with the short scale inscribed on the plan. To take out an area, count the number of squares which approximately coincide with the figure, measure the fractional parts of squares, add the excess and deduct the deficiency, and the desired area is then determined. The areas of the squares themselves are independent of contraction or expansion, and the only part liable to error is the small portion of the whole area comprised in the fractional parts of the squares.

Accuracy.

Absolute accuracy is unattainable, and the degree to be aimed at bears relation to the use to which the work when executed is to be put. Thus the accuracy to be aimed at in the measurement of a base line from which a large trigonometrical survey is to be laid out should be the greatest possible; but with regard to the work to which this article refers a lower standard may be adopted, which has direct reference, except where the measurements are to be used for the purpose of calculating the areas measured, to the scale to be used in plotting. It may be assumed that the limit of accuracy in plotting is $\frac{1}{100}$ of 1 inch. Taking the scales in most common use in England, $\frac{1}{100}$ of 1 inch is equal in each to the following dimensions, in feet or links:—

1 chain to	1 inch	$(\frac{1}{792})=1$ link.	10 feet to	1 inch	$(\frac{1}{120})=\frac{1}{10}$ ft.
2 chains to	1 ,,	$(\frac{1}{1584})=2$ links.	20 ,,	1 ,,	$(\frac{1}{240})=\frac{2}{10}$,,
3 ,,	1 ,,	$(\frac{1}{2376})=3$,,	30 ,,	1 ,,	$(\frac{1}{360})=\frac{3}{10}$,,
4 ,,	1 ,,	$(\frac{1}{3168})=4$,,	40 ,,	1 ,,	$(\frac{1}{480})=\frac{4}{10}$,,
5 ,,	1 ,,	$(\frac{1}{3960})=5$,,	100 ,,	1 ,,	$(\frac{1}{1200})=1$,,
6 ,,	1 ,,	$(\frac{1}{4752})=6$,,	200 ,,	1 ,,	$(\frac{1}{2400})=2$,,
8 ,,	1 ,,	$(\frac{1}{6336})=8$,,	400 ,,	1 ,,	$(\frac{1}{4800})=4$,,

Ordnance Scales.

1 mile to 1 inch or $\frac{1}{63360}=52{\cdot}8$ feet or 80 links.
$\frac{1}{6}$ mile to 1 inch or $\frac{1}{10560}=8{\cdot}8$ feet or 13·33 links.
1 mile to 2·112 feet or $\frac{1}{2500}=2{\cdot}0833$ feet or 3·15 links.
41·667 feet to 1 inch, $\frac{1}{500}={\cdot}41700$ or ·631 link.
40 feet to 1 inch, $\frac{1}{528}={\cdot}400$ or ·606 link.

Thus it appears that with a scale of 1 mile to 1 inch an error of 52·8 feet, $\frac{1}{100}$ of a mile, will leave no sign of its presence, while with a scale of 10 feet to 1 inch the permissible error is $\frac{1}{10}$ of a foot.

Traverse surveys may be plotted direct from the field book by means of a protractor. An efficient protractor is illustrated in Fig. 7, or one 18 inches in diameter made of clear parchment paper with the angles printed thereon may be used. When the former instrument is employed it is usual to lay the lower edge against a vertical or horizontal line, or against a parallel ruler placed parallel to one of these lines, to move the arm until the proper bearing is secured, and to draw a line along its bevelled edge. To use the second, or any other circular protractor, the line intersecting zero and 180° is laid on the meridian, or on a line parallel to it, and on the circle are marked off all the angles required for one sheet in direct bearing, and the same + 180°. The protractor is then removed, the marks joined, and the several lines transferred into their proper places on the plan with the parallel ruler. Cardboard protractors 12 inches in diameter internally, the interior portion being cut out, can be advantageously employed, especially where the traverse is a closed one: the survey is plotted to a small scale, so that the whole or the greater number of the survey lines fall within the 12-inch circle, and the lines can be laid down on the paper without moving the protractor. Cardboard protractors are generally accurate, and are little liable to distortion through changes of temperature and damp; this is not, however, invariably the case, and it is well to check a new cardboard protractor before using it. Good work can be done with the protractor in careful and competent hands, but it cannot be safely trusted to an ordinary draughtsman. Should any error occur, it can only be discovered by going over the whole work again. In extensive surveys, when really accurate work is desired, the method of co-ordinates is greatly to be preferred, as it admits of positive check at every stage of the work. Surveys should not be plotted on paper mounted on a board, but the sheets should, previously to use, be damped, mounted several together on a board, cut off before they are quite dry, and stacked together for some weeks in order that they may become flat and take up the surrounding hygrometric conditions. The filling in of subsidiary lines should be done with the protractor, which may also be used with advantage in laying out a preliminary plot of the work to a small scale.

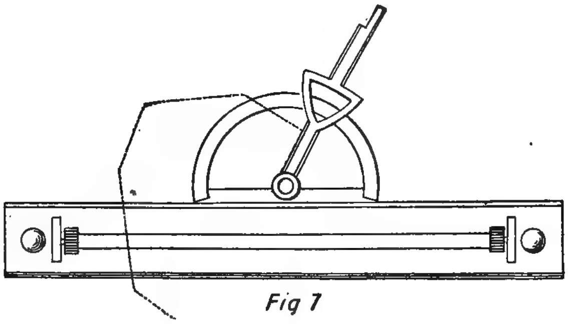

Fig 7

It being accepted that the permissible error in chaining between two points, the distance apart of which is known, is ± 1 per 1000, the permissible difference, *i.e.*, the difference between two measurements of the same distance with the same instruments, should not exceed half the above amount. In the same manner, it being accepted that, using a 5-inch theodolite and single readings, the total error, including those due to imperfect centring of the instrument and bisection of the object, does not exceed 30 seconds of arc (which is a very liberal allowance), the linear error will be ± ·29 foot per 1000. In other words, in a square the sides of which are 1000 feet in length the linear measurements at the first angle will be within a square the sides of which are 2 feet in length, and the angular measurement within a square the sides of which are ·58 foot in length. Neither the linear nor the angular errors are necessarily cumulative, but being some +, some −, they have a tendency to correct themselves. The linear and angular errors may be in the same or in opposite directions. Probably, as in other matters of measurement, the error will increase in proportion to the square root of the number of sides. Thus in a figure with nine sides, each 1000 feet in length, the closing error for linear measurements would amount to $12'' \times \sqrt{9} = 36''$, and the angular error to $30'' \times \sqrt{9} = 1'\ 30''$. The final error may be corrected by an addition to or deduction from the several sides of the figure, the corrections being proportioned to the length to which they apply. If greater accuracy is requisite, the following rule (due to Bowditch) may be observed: "As the sum of all the distances is to each distance, so is the total error in departure to the correction for the corresponding departure, each correction being applied so as to diminish the whole error or departure." The same procedure is applied for correction in latitude. In all surveys of importance, the principal stations should be permanently marked, preferably by pillars of stone or concrete, or by holes drilled in a rock, the actual position of the instrument being indicated by a copper bolt into which a centre punch mark is made, or on which intersecting lines are drawn.

In extensive surveys made with the chain and compass it is necessary to bear in mind that the direction of the magnetic needle is not constant, but varies throughout the globe, and from year to year, or even during one day, in the same locality. In 1663 the magnetic needle pointed due north in Paris, while in 1895 it was 15° west, decreasing about 7′ annually, while the needle pointed due north at St Petersburg. In a distance of 360 miles, from Dover to the west coast of Ireland, the compass varies from 16° to 23° west, or 7° in 360 miles, or at the rate of 1′ 10″ per nautical mile. Dr Carl Bamfried gives the following daily variations: St Helena, in summer, 0° 4·06′; winter, 0° 3·03′. At Greenwich, in summer, 0° 8·16′; in winter, 0° 7·02′. At Munich, in summer, 0° 10·77′; in winter, 0° 6·54′. The same authority states that near Munich the maximum deviation to the east occurs at 8 A.M., and the maximum westerly at 2 P.M. Lastly, the needle is affected by magnetic storms and by local attractions. It is clear, therefore, that the compass cannot be accepted as an instrument of precision; but for exploratory work, and for filling in details of surveys where only a moderate degree of accuracy is required, it is invaluable. If it should be desirable to determine the variation of the compass, this must be done by astronomical observations on the spot, and not by reference to any fixed north and south line, however accurate, situated at another place and observed only at a particular time, where the variation will almost certainly be different from what it is when used.

Although the effect of the spherical form of the earth is practically ignored in this article, it will not be out of place to introduce a few words indicating the point at which it becomes necessary to consider the earth as a sphere and to what extent a survey may be carried without consideration of the spherical form. In Rankine's *Civil Engineering* the following dimensions are given:—

Earth's mean radius	20,889,000 feet.
Arc subtended by 1° . . .	364,582 ,,
" " " 1′	6076·36 ,,

From these figures it may be deduced that in working from a fixed meridian, when the departures east or west have summed up to 6076 feet, or to a nautical mile, the direction of the meridian will be inaccurate to the extent of 1′, and ought to be inclined to the meridian of origin by that amount.

Minor triangulation.

In minor triangulation, which deals with triangles the sides of which are comparatively short, and which are used for the purpose of filling in between the sides of larger triangles, or as the bases of construction of independent surveys, an 8″ theodolite is as a rule the largest employed, and good results may be obtained with smaller instruments. The spherical form of the earth is neglected. Only one side of the triangle need be measured, although it is desirable to measure the side of some adjacent triangle as a check, since the lengths of the other sides are found by calculation. Although, if accuracy is required, the three angles of every triangle should be measured with the theodolite, if two be known the third can be found, since the three together are always equal to 180°. In a triangle ABC let the sides subtending the several angles be called *a*, *b*, *c*. If *c* be the base, the length of $a = \frac{c \sin A}{\sin C}$, and of $b = \frac{c \sin B}{\sin C}$. If, as should be done, all three angles are observed, they will not in all probability sum up to 180°; but the summation error should not exceed ±52″, even with the smallest instrument and without repetition. In a single triangle this error may be divided by 3; but when several triangles form part of the survey and together form a polygon, the corrections become much more difficult and tedious. In order to simplify the process as much as possible, it is desirable to correct the interior angles at the outside of the polygon first, remembering that their summation should be equal to twice as many right angles as the figure has sides, less four right angles, and to go on correcting towards the centre. It is assumed that the correction may be equally distributed between the several angles, although if the polygon be built up of many triangles this system is insufficient, as the surveyor would find out when, the outer angles being fixed, he approached the centre of the polygon and discovered, as he probably would, an ever-increasing distortion in a particular direction. A right angle is the angle least liable to error, but the error tends to increase slowly as the angle becomes more obtuse, and more rapidly as it becomes more acute. For this reason the angles of every triangle should be as regular as possible; none should be less than 30°, and each should approximate as nearly as may be to 60°. With angles ranging from 25° to 155°, the rate of error is always less than 1 per 1000, which may be taken as the error of good ordinary chaining. If only two angles be measured and the third calculated from the difference between the two which have been observed and 180°, the limiting error in the third will be 1′ instead of 30″.

In one or more polygons built up from several triangles (Fig. 8), if the interior angles at A, B, C, D, E, F, G, H, I, J, K, L, M, N, and O be added together, and the difference between the sum of these angles and 2340° be divided over all the angles, the form of the polygon will be fixed. As each of the interior angles of the polygon is made up of two or more angles, these must be made to agree with the interior angles, but should be corrected in proportion to the angle, the smaller angle receiving the larger correction. Thus the angles O A *a*, *a* A *b*, *b* A B, *b* B C, &c., will be fixed. By the same operation the angles A *b* B, B *b* C, C *c* D, &c., the apices of which are opposite to a side of the polygon, are also fixed, as is one angle of each of the triangles whose apices are towards the outside of the polygon. The polygon *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, may now be treated in the same way, except that the correction is made previously in the exterior angles, the interior angles being deduced from the corrected exterior ones. In the figures which go to make up the exterior angles of this polygon, the triangles A B *b*, B C *b*, C D *c*, D E *c*, E F *d*, F G *e*, G H *e*, H I *f*, I J *f*, J K *g*, K L *h*, L M *i*, M N *j*, N O *j*, O A *a*, are known and fixed, as are the angles *a* A *b*, *b* C *c*, *c* E *d*, *d* F *e*, *e* H *f*, *f* J *g*, *g* K *h*, *h* L *i*, *i* M *j*, *j* O *a*; and the whole of the correction must be divided between the remaining angles of the triangles of which the angles *a* A *b*, *b* C *c*, &c., form part. Should the result of these corrections be to distort the triangles *a* A *b*, *b* C *c*, &c., materially in one direction, it is desirable to correct the second polygon *a* to *j* in the same manner as the figure A to O, and then to redistribute the corrections backwards. If the angles have been carefully observed, no material distortion should be possible. When the exterior angles of the second polygon have been fixed, the interior angles are corrected from the exterior ones in the manner already described for the outer polygon. Alternately, the outer polygon may be treated as a traverse, and corrected by Bowditch's method. The subsequent procedure may be as before, or the following precept may be adopted: In any closed polygon, composed of triangles, the continued product of the log sines of the right-hand angles is equal to the continuous product of the log sines of the left-hand angles. When all the angles have been fixed, the remaining sides may be calculated from the side A B, or other known base, and should be invariable whether the calculations be made to the right or left, or through any other set of triangles.

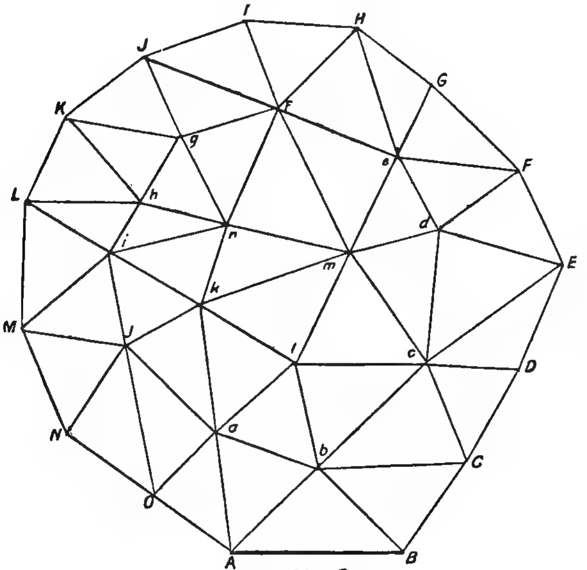

Fig 8.

Base line.

As the accuracy of the figure is dependent on the accuracy of the base, the latter must be carefully measured, if possible, on a flat and unbroken country. A base line may be measured with rapidity and fair accuracy along the rails of a straight portion of railway, and experience proves that it is better to use a short base line, carefully measured, than to employ a longer one which has to pass over broken country, and which may not be laid out with the same care. The base line may be extended in the direction required by the triangulation in the manner shown in Fig. 9, where A B is the measured and E F the extended base line. A system of comparatively small triangles is useful in surveying, as affording fixed points and measured bases from which chain measurements may be carried in any convenient direction; and should the error in the base line measurement be 1 in 2500—and it is not difficult to measure to 1 in 40,000—the survey will still be within the permissible limit of error. The selection of points, always laborious, on account of the difficulty of determining from one or two stations whether or no it is possible for all the other stations required for the triangulation to be seen, is a matter of such importance that it should be done by the chief surveyor. The observation of the angles, as has already been pointed out, may be reduced to a matter of routine. Survey points should, where possible, be marked in a permanent manner for future reference.

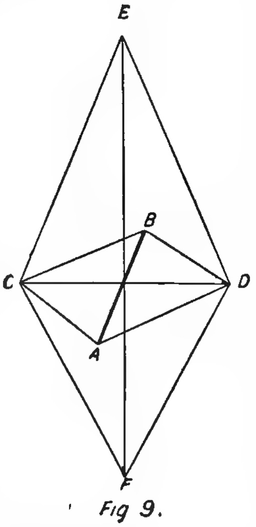

Fig 9.

The size of the triangles to be employed must depend on the scale and on plotting, the length measured with the chain not exceeding that which can be detected in plotting. With a scale of $\frac{1}{2500}$ it has already been shown that $2\frac{1}{2}$ feet is the smallest dimension which can be plotted, and as the probable chainage error is 1 per 1000, the length to be chained within any triangle should not exceed 2500 feet. With a scale of $\frac{1}{10000}$ the length to be chained might be increased to 10,000 feet without detectable error in plotting.

Observation of angles.

In order that the angles recorded may be observed with the greatest accuracy, it is necessary that a method of repetition or reiteration should be employed. With the upper plate and the theodolite clamped at zero, direct the telescope to the first object to be sighted, clamp the lower plate, and bisect the object by means of the lower tangent screw; read all the verniers, unclamp the upper plate, and bisect the right-hand signal. The reading of the verniers will give the desired angle. Next unclamp the lower plate and bisect the first object, unclamp the upper plate and direct the telescope to the right-hand station, bisect the signal, and again read the verniers, which should record twice the first angle. The operation should be repeated at least once around the circle. Then the telescope must be transited, and the whole operation gone over again. This system of repetition (invented by Borda) reduces the error of reading and bisection to some extent; it is, however, laborious and tedious. Reiteration, which, if carried to its fullest extent, is both laborious and tedious, consists in clamping the upper plate at zero of the A vernier, directing the telescope at a selected signal, bisecting it, reading all the verniers, unclamping the upper plate, bisecting each of the signals in succession, and returning to the selected signal, the angles recorded by each vernier being read in each case. Second, if there be two or four verniers make the A vernier read 90°, if three verniers make it read 120°, and repeat the operation; similarly with the A vernier at 180° and 270° when the instrument has two or four verniers, or at 240° when it has three. Next the telescope must be transited, and the whole process repeated. This system may be further elaborated by bringing each of the verniers to zero successively. Except in extreme cases, these methods for the purposes of a minor triangulation are unnecessary, and it is sufficient that two readings of each object should be recorded, one being taken "face right," that is to say with the vertical circle to the right of the observer, and one "face left," with the vertical circle to the left of the observer. It is well to turn the instrument to the right for one set of readings, and to the left for the other.

The Plane Table.—This instrument in its simple form consists of a board about 1 foot 6 inches or 2 feet square, supported on a light tripod stand, on which it can revolve in a horizontal plane, a central screw being provided to clamp it in any desired position. The paper on which the survey is to be drawn is laid on the top of the table and held in position by eight clamps. The adjuncts to the plane table are: a sighting rule, made in the form of a parallel ruler; a plumb line attached to a long clip, which can be passed over the edge of the board; a compass, generally of the box form; and a level. To use the instrument, set it up with the table horizontal, and bring the plumb line over the starting-point of the survey; direct the sighting rule along the line of survey, beginning over the plumb line measure the line with the chain, draw it in, and with a scale mark off its length; next, direct the rule to any prominent objects, and draw rays to them, marking each in succession. Before leaving the first station, place the compass on the paper, direct the needle to magnetic north, and draw a pencil line carefully round the compass box, indicating at the same time the northern direction. The table is now moved and set up over the second station. With the compass the table is brought into the same direction as at the previous station, and the plumb line moved to the end of the survey line is brought over the station, and the sighting rule is laid alongside the line drawn on the paper from station to station, and should, when sighted through, bisect the last station; if it does not do so, the magnetic needle must have deviated from its position or the line drawn round it must be inaccurate. A new line is now laid out and measured with the chain and on the paper, and rays are again drawn to the principal objects and numbered as before, the intersection of the rays giving the position of each object. Three rays from three separate stations should be drawn to each object in order to ensure accurate work. In this way the survey of a plot of ground, a traverse, or a triangulation may be drawn on the plane table. If to the instrument described above be added an arrangement for levelling the table and a slow-motion screw for turning it on its vertical axis, while for the simple sighting rule an alidade provided with a telescope fitted with subtense hairs for measuring distances by the interception of units on a staff, be substituted, the use of the chain becomes unnecessary; the staff may be held at any point the position of which it is desired to record, and the point at which it is held can be plotted directly on the sheet, and checked by a second and third observation from other stations, and by rays drawn through it. With these adjuncts and under suitable conditions of climate, the plane table becomes an instrument of precision, and extensive surveys can be carried out with it alone (Fig. 10). To the telescope of the alidade is attached a graduated circle for reading vertical angles (Fig. 11), the use of which is necessary for reducing the distance measured to the horizontal, and which enables the points observed to be levelled. Good millboard is preferable to paper for plotting, and should be pale drab, green, or pale slate colour, rather than white. The preliminary survey of the St Gothard railway was made with the plane table, and very extensive surveys have been made in America with this instrument alone; it must be remembered, however, that there is no record of the survey except that contained in the sheets of paper themselves.

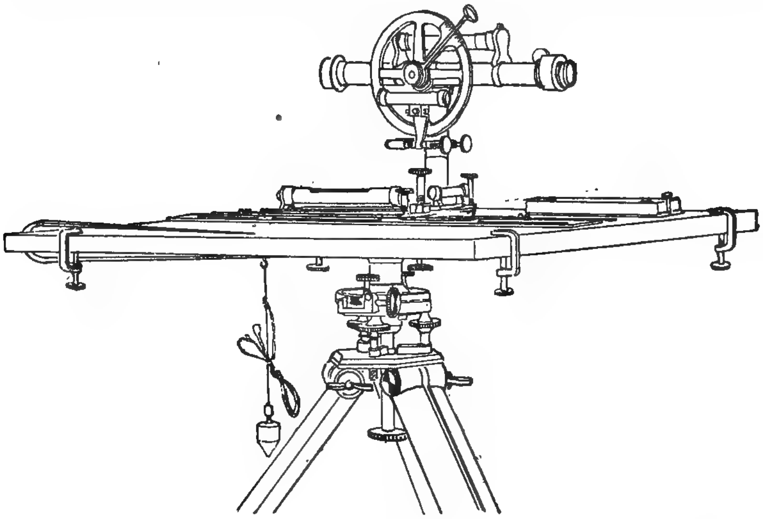
Fig. 10.

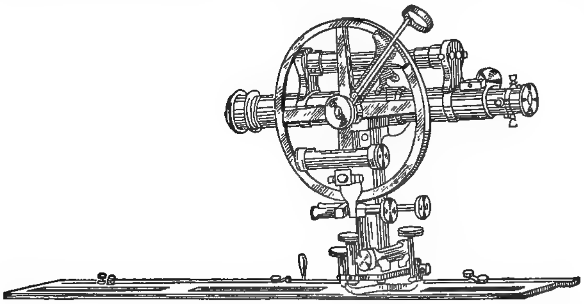
Fig. 11.

The Theodolite.—This, the most perfect portable instrument for measuring angles in azimuth and altitude, is made in three forms—the Y pattern, the Everest, and the transit. Certain parts are common to all the forms in use and to the level. The stand is generally made circular in section (Fig. 12), each of the three legs being shod at the lower extremity with steel. Their upper ends are hinged to a flat plate provided with a screwed collar of large diameter (Fig. 13). The hinge bolts should not be less in length than the width of one leg. The tripods are sometimes made like those of a camera; but though lighter for equal stiffness than those of circular section, they are inconvenient to carry, a matter of importance to the surveyor. To the legs is screwed a plate O O (Fig. 13), which supports the lower side of the plate P P. This receives the ends of the screws S S by which the instrument is levelled, its annular portion being larger than the collar in O O, so that, until clamped by the screwed plate above it, the whole of the instrument except the legs can be moved horizontally in any direction to the extent of about $\frac{1}{2}$ inch. This materially facilitates centring over a point. The upper plate P P is bored centrally to receive a parallel or conical pillar which supports the lower circle of the theodolite or the arm of the level which carries the telescope. In the theodolite the edge of the plate *r r* is bevelled and divided into 360 or 400 degrees, and to half degrees, or to 20 minutes or 10 minutes, according to the size of the instrument. A collar is provided, which when tightened on the vertical axis, otherwise free to move, holds it rigidly in position with respect to the plate P P. To this collar is attached a slow-motion screw, working against a reaction spring, by which the plate *r r* can be rotated through a small arc. The upper plate carrying two, three, or four verniers *v v* is attached to a vertical coned pillar passing through the centre of the large pillar and rotating in it; this plate can be clamped to the lower plate by means of the screw C, and can be rotated with respect to it by the slow-motion screw *d*. On the upper plate are placed two

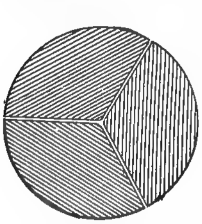
Fig 12.

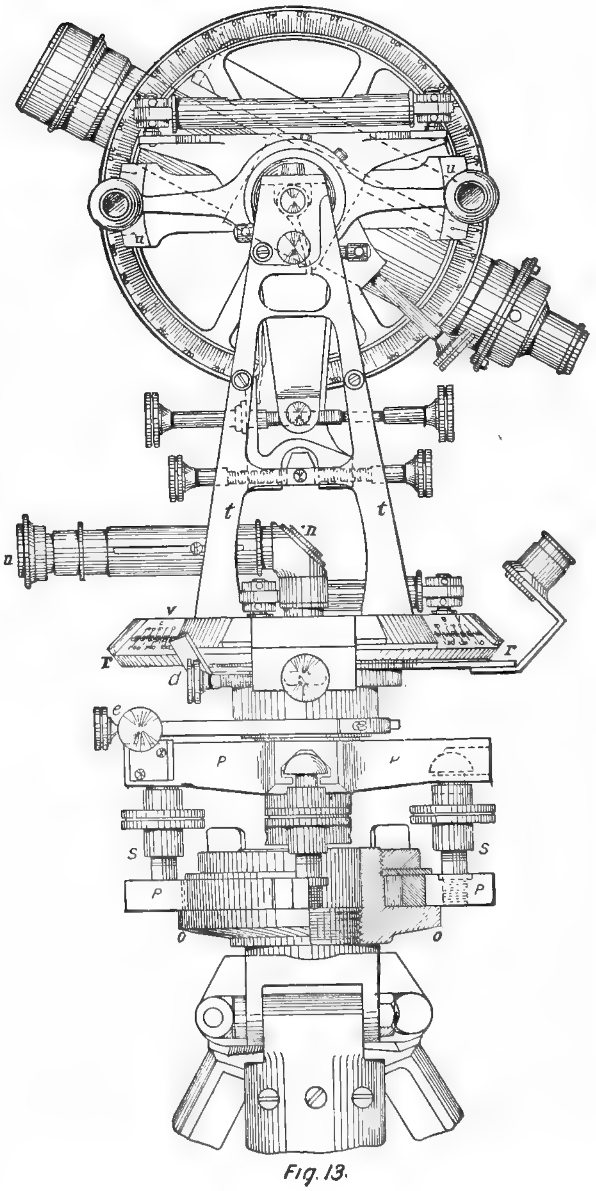

Fig. 13.

small levelling bubbles, and two standards *t t* are attached to the upper side of the plate for supporting the trunnions of the telescope T. The bearings for receiving these trunnions are V-shaped; the V on one side is fixed, while the other is cut through and can be narrowed or made wider, thus lifting or lowering the trunnion by means of two capstan-headed screws. To the telescope the vertical circle for reading angles in altitude is fixed, and rotates with it; both can be clamped to the standard, and motion can be given by a suitable double-ended motion screw. The verniers are attached to arms *u u* bearing on an enlargement of one trunnion of the telescope, one arm projecting downwards and embracing a projection on the standard *t*. To the same frame is attached a bubble, which should be parallel with the centre line of the verniers. The diagonal telescope *n n* is provided with cross hairs, and is used for the final centring of the instrument over an object. The use of aluminium in the construction of the instrument for all parts not liable to much wear is to be commended, since by the employment of that metal the weight which the surveyor has to carry is greatly reduced. A five-inch instrument made entirely of brass or gun-metal will weigh 28 ℔, while a similar instrument in the construction of which aluminium is used will weigh only 17 ℔. The Y theodolite differs from the transit in that the supports for the telescope are low, that the telescope rests in a cradle the trunnions of which rest on the supports, and that a segment of a circle attached to the cradle replaces the vertical circle. When it is desired to read a line in the reverse direction the telescope is lifted out of the cradle, turned end for end, and replaced in the Y bearings of the cradle again. In the Everest theodolite the supports are low and the telescope cannot be transited. The instrument is similar to that described above, except that the vertical circle is not continuous, but is formed of two arcs.

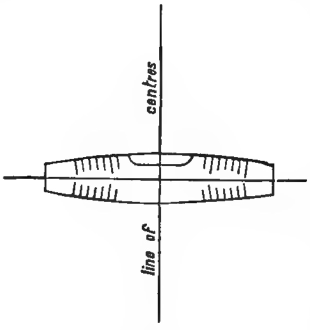

Fig 14

The Level.—To the upper side of the parallel plates the level is similar in construction to the theodolite. No provision is made for centring over a point. The upper plate is bored through the centre and carries a conical pillar, which rotates freely in it and supports a horizontal plate, to the extreme ends of which are attached, by means of capstan screws or otherwise, two vertical supports, on which the telescope, which is constructed to be perpendicular to the vertical axis of the instrument, rests and rotates with it. The level bubble (Fig. 14), by which the instrument is brought into a position at right angles to the axis of the earth, is generally placed on the top of the telescope. In the best telescopes, whether for theodolite or level, the diaphragm on which the image is formed is made of glass, and the cross hairs are engraved thereon. In the level the eye-piece and object-glass are interchangeable, to facilitate adjustment for collimation.

(R. E. M.)

II. Geographical Surveying.

Base measurements.

The introduction by mechanical means of superior graduation in instruments of the smaller class has lately placed it within the reach of surveyors to effect equally good results more rapidly in these days, and with less expenditure on equipment and on the staff necessary for transport in the field, than was formerly considered necessary. The 12-inch theodolite of the present day, with micrometer adjustments to assist in the reading of minute subdivisions of angular graduation, is found to be equal to the old 24-inch or even to the 36-inch instruments of thirty years ago. New methods have been adopted for the measurement of bases which promise largely to supersede the laborious process of measurement by the alignment of "compensation" bars, although they cannot at present be said to be entirely independent of them. The Jaderin apparatus, which consists of a wire 25 metres in length stretched along a series of cradles or supports, is undoubtedly the simplest means of measuring a base which has yet been devised; and experiments which have been carried out with it at the Pulkova observatory show it to be capable of producing most accurate results. But there is still a measurable defect in the apparatus, owing to the liability of the wires to change in length under variable conditions of temperature. It is therefore still considered necessary, where base measurements for geodetic purposes are to made with scientific exactness, that the Jaderin wires should be compared before and after use with a standard measurement—and this standard is best attained by the use of the Brunner, or Colby, bars. There is also a general consensus of opinion amongst experts that the direct process of measurement need not be extended to such lengths as formerly, but that from the ends of a shorter line, the length of which has been exactly determined, the base may be extended by a process of triangulation.

Object of geodetic triangulation.

The elaborate processes of first-class or "geodetic" triangulation have hitherto been held to be essential for two distinct purposes. One is the purely scientific object to be attained by an exact determination of the figure of the earth and of its dimensions. The other is the more practical issue which is gained by a rigidly accurate series, or backbone, of fixed points on which to base all subsequent survey operations; and it must be conceded in these practical days that it is the latter rather than the former aim which justifies the great cost and the time demanded by the process. In countries which are highly cultivated and parcelled out into more or less minute subdivisions for fiscal and political purposes—such countries as the great European states, Egypt, India, or Ceylon (where a single cocoa-nut tree may be the subject of endless litigation), where the necessity for cadastral (or field) surveys is paramount, and the political divisions between rival states must be demarcated with minute accuracy—it is obvious that the triangulation on which the whole system of surveys depends must be itself as perfect as it can be made, and the "value" of points fixed thereby must be beyond dispute or discussion. Here that class of triangulation which is termed "geodetic," extended from a base which has been measured with all the refinements which modern science can apply, is a paramount necessity. Expense and labour are fully justified in its attainment, because the expense (and possible danger) of disputes and litigation, arising from inaccurate boundary definition both of states and estates, will in the end be vastly greater than the initial outlay. Numerous instances in recent history could be cited in support of the statement did space permit.

"Geographical" triangulation.

It would, of course, be better that the whole habitable world should be surveyed on the system which inculcates the strictest accuracy in survey method; but this is impossible. There are vast spaces in it which at present exhibit no prospect of rapid development in civilization, but which are nevertheless of great importance in the future economy of nations, and of which it is most desirable that we should rapidly acquire such an accurate geographical knowledge as will enable us to lay down political boundaries, to project roads and railways, to formulate sound schemes of military strategy, and to attain such exact knowledge of special localities as will further military ends. Such surveys are called by various names —military surveys, first surveys, geographical surveys, &c.; but, inasmuch as they are all undertaken with the same end in view, *i.e.*, the acquisition of a sound topographical map on various scales, and as that end serves civil purposes quite as much as military, it seems appropriate to adhere to the latter term and to designate them geographical surveys only.

It is within this region of geographical surveying that the greatest advance has been made in recent years.

Principles which govern geographical surveys.

The governing principles of geographical surveys are rapidity and economy. Accuracy is of course a recognized necessity, but the term must admit of a certain elasticity in geographical work which is quite inadmissible in geodetic or cadastral functions. It is obviously foolish to expend as much money over the elaboration of topography in the vast silent sand wastes which border the Nile valley, for instance (albeit those deserts may be full of topographical detail), as in the valley itself—the great centre of Egyptian cultivation, the great military highway of northern Africa. On the other hand, the most careful accuracy attainable in the art of topographical delineation is requisite in illustrating the nature of a district which immediately surrounds what may prove hereafter to be an important military position. And this, again, implies a class of technical accuracy which is quite apart from the rigid attention to detail of a cadastral survey, and demands a much higher intelligence to compass.

Methods of survey.

The technical principles of procedure are, however, the same in geographical as in other surveys. A geographical survey must equally start from a base and be supported by triangulation, or at least by some process analogous to triangulation, which will furnish the necessary skeleton on which to adjust the topography so as to ensure a complete and homogeneous map.

The base.

This base may be found in a variety of ways. If geodetic triangulation exists in the country, that triangulation should of course include a wide extent of secondary determinations, the fixing of peaks and points in the landscape far away to either flank, which will either give the data for further extension of geographical triangulation, or which may even serve the purposes of the map-maker without any such extension at all. In this manner the Indus valley series of the great triangulation of India has furnished the basis for surveys across Afghanistan and Baluchistan to the Oxus and Persia.

Should, however, no such preliminary determinations of the value of one or two starting-points be available, and it becomes necessary to measure a base and to work *ab initio*, there can be little hesitation in adopting the Jaderin wire apparatus for the purpose. It is cheap (cost about £50), and far more accurate than the process of measuring either by any known "subtense" system (in which the distance is computed from the angle subtended by a bar of given length) or by measurement with a steel chain. This latter method may, however, be adopted with great success so long as the base can be levelled, repeated measurements obtained, and the chain be compared with a standard steel tape before and after use.

Initial data.

The initial data on which to start a comprehensive scheme of triangulation for a geographical survey are—(1) Latitude; (2) longitude; (3) azimuth; and (4) altitude, and this data should, if possible, be obtained *pari passu* with the measurement of the base.

A 6-inch transit theodolite, fitted with a micrometer eye-piece and extra vertical wires, is the instrument *par excellence* for work of this nature; and it possesses the advantages of portability and comparative cheapness.

Latitude and azimuth.

The method of using it for the purposes of determining values for (1) and (3), *i.e.*, for ascertaining the latitude of one end of the base and the azimuth of the other end from it, are fully explained in Major Talbot's paper on "Military Surveying in the Field" (J. Mackay and Co., Chatham, 1889), which is not a theoretical treatise, but a practical illustration of methods employed successfully in the geographical survey of a very large area of the Indian transfrontier districts. Recapitulation here would occupy too much space. But it should be noted that these observations are not merely of an initial character. They should be constantly repeated as the survey advances, and under certain circumstances (referred to subsequently) they require daily repetition.

Longitude.

The problems connected with the determination of (2) longitude have of late years occupied much of the attention of scientific surveyors. No system of absolute determination is accurate enough for combination with triangulation, as affording a check on the accuracy of the latter, and the spaces in the world across which geographical surveying has yet to be carried are rapidly becoming too restricted to admit of any liability to error so great as is invariably involved in such determinations. It is true that absolute values derived from the observation of lunar distances, or occultations, have often proved to be of the highest value; but there remains a degree of uncertainty (possibly due to the want of *exact* knowledge of the moon's position at any instant of time), even when observations have been taken with all the advantages of the most elaborate arrangements and the most scientific manipulation, which renders the roughest form of triangulation more trustworthy for ascertaining differential longitude than any comparison between the absolute determination of any two points. Consequently, if an absolute determination is necessary it should be made *once*, with all possible care, and the value obtained should be carried through the whole scheme of triangulation. It rests with the surveyor to decide at what point of the general survey this value can best be introduced, provided he can estimate the probable longitudinal value of his initial base within a few minutes of the truth. A final correction in longitude is constant, and can easily be applied. With reference to such absolute determinations of longitude, Major S. Grant's "Diagram for determining the parallaxes in declination and right ascension of a heavenly body and its application to the prediction of occultations" (*R.G.S. Journal* for June 1896) will afford the observer valuable assistance.

Telegraph determinations.

But the recognized method of obtaining a longitude value in recent geographical fields is by means of the telegraph—a method so simple and so accurate that it may be applied with advantage even to the checking of long lines of triangulation. No effort should be spared to introduce a telegraphic longitude value into any scheme of geographical survey. It involves a clear line and an instructed observer at each end, but, given these desiderata, the interchange of time signals sufficient for an accurate record only requires a night or two of clear weather. But inasmuch as rigorous accuracy in the observations for time is necessary, it would be well for the surveyor in the field to be provided with a sidereal chronometer. Under all other circumstances demanding time observations (and they are an essential supplement to every class of astronomical determination), an ordinary mean time watch is sufficient.

Altitude.

With reference to altitude determinations, there has lately been observable amongst surveyors a growing distrust of barometric results and a reaction in favour of direct levelling, or of differential results derived from direct observation with the theodolite (or clinometer) rather than from comparison of those determined by aneroid or hypermeter. It is indeed impossible to eliminate the uncertainties due to the variable atmospheric pressure introduced by "weather" changes from any barometric record. A mercurial barometer advantageously placed and carefully observed at fixed diurnal intervals throughout a comparatively long period may give fairly trustworthy results if a constant comparison can be maintained throughout that period with similar records at sea-level, or at any fixed altitude. Yet observations extending over several months have been found to yield results which compare most unfavourably with those attained during the process of triangulation by continued lines of vertical observations from point to point, even when the uncertainties of the correction for refraction are taken into account. Errors introduced into vertical observations by refraction are readily ascertainable and comparatively unimportant in their effect. Those due to variable atmospheric conditions on barometric records are still indefinite, and are likely to remain so. The result has been that the latter have been relegated to purely local conditions of survey, and that whenever practicable the former are combined with the general process of triangulation.

Conditions under which geographical surveys are carried out.

The conditions under which geographical surveys can be carried out are of infinite variety, but these conditions are rare which absolutely preclude the possibility of any such surveys at all. Perfect freedom of action, and the recognition of such work as a public benefit, are not often attainable. Far more frequently the opportunity offers itself to the surveyor with the progress of a political mission or the advance of an army in the field. It cannot be too strongly insisted on that geographical surveys are functions of both civil and military operations. Very much of such work is also possible where a country lies open to exploration, not actively hostile, but yet unsettled and adverse to strangers. The geographical surveyor has to fit himself to all such conditions, and it may happen that a continuous, comprehensive scheme of triangulation as a map basis is impossible. Under such circumstances other expedients must be adopted to ensure that accuracy of position which cannot be attained by the topographer unaided.

Route surveying.

During a long-continued march extending through a line of country generally favourable for survey purposes—a condition which frequently occurs—when forward movement is a necessity, and an average of 10 to 15 miles of daily progress is maintained, one officer and an assistant can measure a daily base, obtain the necessary astronomical determinations, triangulate from both ends so as to fix the azimuth and distance from the base of points passed yesterday and those to be passed to-morrow; project those points on to the topographer's plane-table to be ready for the next day's work, and check each day's record by latitude; whilst a second assistant runs the topography through the route, basing his work on points so fixed, on the scale of 2 or 4 miles to the inch, according to the amount of detail. Occasionally a hill can be reached in the course of the day's march, or during a day's halt, which will materially assist to consolidate and strengthen the series.

Triangulation or control.

It may, however, frequently be impossible to maintain a consistent series of triangulation for the "control" (to use an American expression) of the topography, even when the configuration of the land surface is favourable. In such circumstances the method of observing azimuths to points situated approximately near to the probable route in advance, and of determining the exact position of those points in latitude as one by one they are passed by the moving force, has been found to yield results which are quite sufficiently accurate to ensure the final adjustment of the entire route geography to any subsequent system of triangulation which may be extended through the country traversed, without serious discrepancies in compilation. It is, however, obvious that as accuracy depends greatly on the exact determination of absolute latitude values, this method is best adapted to a route running approximately parallel to a meridian, and is at complete disadvantage in one running east and west. Where the conditions are favourable to its application, it has been adopted with most satisfactory results; as, for instance, on the route between Sistan and Herat, where the initial data for the Russo-Afghan boundary delimitation was secured by this means, and more recently on the boundary surveys of western Abyssinia.

Military geography.

When an active enemy is in the field, and topographical operations are consequently restricted, it is usually possible to obtain the necessary "control" (*i.e.*, a few well-fixed points determined by triangulation) for topography in advance of a position securely held. With a very little assistance from the triangulator an experienced topographer will be able to sketch a field of action with far more certainty and rapidity than can be attained by the ordinary so-called "military surveyor," and he may, in favourable circumstances, combine his work with that of the military balloonist in such a way as to represent every feature of importance, even in a widely extended position held by the enemy. The application of the camera and of telephotography to the evolution of a map of the enemy's position is well understood in France (*vide* Colonel Laussedat's treatise on "The History of Topography"), as it is in Russia, and we must in future expect that all advantages of an expert and professional map of the whole theatre of a campaign will lie in the hands of the general who is best supplied with professional experts to compass them. Geographical surveying and military surveying are convertible terms, and it is important to note that both equally require the services of a highly trained staff of professional topographers. Twenty-five years ago, during the war between Russia and Turkey, upwards of a hundred professional geographical surveyors were pressed into military service, besides the regular survey staff which is attached to every army corps. Triangulation was carried across the Balkans by eight different series; every pass and every notable feature of the Balkans and Rhodope mountains was accurately surveyed, as well as the plains intervening between the Balkans and Constantinople. Surveys on a scale which averaged about 1 mile = 1 inch were carried up to the very gates of the city.

Photo-topography.

The use of the camera as an accessory to the plane-table (*i.e.*, the art of photo-topography) is a recent innovation in survey processes which has received much attention in Italy and in Canada, where it has been applied almost exclusively to geographical or exploratory surveys. The camera is specially prepared, resting on a graduated horizontal plate which is read with verniers, and with a small telescope and vertical arc attached. Cross wires are fixed in the focal plane of the camera, which is also fitted with a magnetic needle and a scale so placed that the magnetic declination, the scale, and the intersection of the cross wires are all photographed on the plate containing the view. A panoramic group of views (slightly overlapping each other) is taken at each station, and the angular distance between each is measured on the horizontal circle. The process of constructing the horizontal projection from these perspective views involves plotting the skeleton triangulation, as obtained from the primary triangulation, with the theodolite (which precedes the photo-topographical survey), or from the horizontal plate of the camera. With several stations so plotted, the view from each of them of a certain portion of the country may be projected on the plane of the map, and salient points seen in perspective may be fixed by intersection.

The field work of a photo-topographic party consists primarily in execution of a triangulation by the usual methods which would be adapted to any ordinary topographical survey. To this is added a secondary triangulation, which is executed *pari passu* with the photography for the purpose of fixing the position of the camera stations. From such stations alone the topographical details are finally secured with the aid of the photographs. Great care is necessary in the selection of stations that will be suitable both for the extension of triangulation and the purposes of closely overlooking topographical details. In order to obtain means for correctly orienting the photographic views when plotting the map from them, it is usual, whilst making the exposures, to observe two or three points in each view with the altazimuth attached to the camera, in order to ascertain the horizontal and vertical angles between them. It is also advisable to keep an outline sketch of the landscape for the purpose of recording names of roads, buildings, &c.

The process of projecting the map from the photographs involves the use of two drawing-boards, on one of which the graphical determination of the points is made, and on the other the details of the final topography are drawn. The principal trigonometrical points are plotted on both these boards by their co-ordinates, and the camera stations either by their co-ordinate values or by intersection. Intermediate points, selected as appearing on two or more negatives, are then projected by intersection. The horizontal projection of a panorama consisting of any given number of plates is a regular geometrical figure of as many sides as there are plates, enclosing an inscribed circle whose radius is the focal length of the camera. Having correctly plotted the position of one plate, or view, with reference to the projected camera station by means of the angle observed to some known point within it, it is possible to plot the position of the rest of the series, with reference to the camera station and the orienting triangulation point, by the angular differences which are dependent on the number of photographs forming the sides of the geometrical figure. Having secured the correct orientation of the horizontal plan, direction lines are drawn from the plotted camera station to points photographed, and the position of topographical features is fixed by intersection from two or more camera stations.

The difficulty of fitting in topographical detail from photographs taken from several points of view and in varying lights is very considerable; and leads to a generalizing of minor features which would be inadmissible in the ordinary plane-tabling. Thus the opinion of Canadian experts appears to be that "a map made from photographs and constructed in the office on a drawing-board, much on the same principle that a map is made on a plane-table board on the field, is less accurate and less satisfactory than the latter."[1] On the other hand, "considerable outlay is saved in photo-surveying by drafting the map in office, at the expense of only the individual draughtsman; moreover, under advantageous conditions of light, photo-surveying field operations can be conducted more rapidly than plane-table surveys." These conclusions accord with those arrived at by surveyors in India who have recently tested this method of geographical surveying. In their opinion the camera may be accepted as a useful auxiliary to the plane-table, especially in high altitudes where, owing to the varying atmospheric conditions, only limited opportunities are available of observing peaks, snow-fields, and glaciers; but that for all ordinary conditions of geographical topography it can never supersede a plane-table survey. As an adjunct to military topographical equipment there can be no doubt about its value.

Plane-table.

The plane-table is the instrument, *par excellence*, on which the geographical surveyor must depend for the final mapping of the physical features of the country under survey. It is employed almost exclusively by members of the topographical staff in India, Russia, America, and France, and it is unlikely that the art of photo-topography will finally supersede it in Canada. But the art of plane-tabling is not an easy art to acquire. To be effective it must be adopted as a profession, and it is unfortunate that England offers no opportunity for such professional training as is to be gained in the vast plains and mountains of Asia or America. The methods of adapting the plane-table to geographical requirements differ with those varying climatic conditions which affect its construction. In the comparatively dry climate of Asiatic Russia or of the United States, where errors arising from the unequal expansion of the plane-table board are insignificant, the plane-table is largely made use of as a triangulating instrument, and is fitted with slow-motion screws and with other appliances for increasing the certainty and the accuracy of observations. Such an adaptation of the plane-table is found to be impossible in India, where the great alternations of temperature, no less than of atmospheric humidity, tend to vitiate the accuracy of the projections on the surface of the board by the unequal effects of expansion in the material of which it is composed. The Indian plane-table is of the simplest possible construction, and it is never used in connexion with the stadia for ascertaining the distances of points and features of the ground (as is the case in America); and in place of the complicated American alidade, with its telescope and vertical arc, a simple sight rule is used, and a chirometer for the measurement of vertical angles. The Indian plane-table approximates very closely in general construction to the "Gannet" pattern of America, which is specially constructed for exploratory surveys.

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[1] *Vide* Wilson's *Topographic Surveying.* Wiley and Sons, New York.

Scale.

The scale on which geographical surveys are conducted is necessarily small. It may be reckoned at from 1 : 500000 to 1 : 125000, or from 1 inch=8 miles to 1 inch=2 miles. The 1 inch =1 mile scale is the normal scale for rigorous topography, and although it is impossible to fix a definite line beyond which geographical scales merge into topographical (for instance, the 1-inch scale is classed as geographical in America whenever the continuous line contour system of ground representation gives place to hachuring), it is convenient to assume generally that geographical scales of mapping are smaller than the 1-inch scale.

Out-turn.

On the smaller scales of 1 : 500000 or 1 : 250000 an experienced geographical surveyor will, in favourable country, complete an area of mapping from day to day which will practically cover nearly all that falls within his range of vision; and he will, in the course of five or six months of continuous travelling (especially if provided with the necessary "control" in the shape of triangulated points at suitable intervals) cover an area of geographical mapping illustrating all important topographical features representable on the small scale of his survey, which may be reckoned at tens of thousands of square miles. But inasmuch as everything depends upon his range of vision, and the constant occurrence of suitable features from which to extend it, there is obviously no guiding rule by which to reckon his probable out-turn.

Cost.

The same uncertainty which exists about "out-turn" manifestly exists about "cost." The normal cost of the 1-inch rigorous topographical survey in India, when carried over districts which present an average of hills, plains, and forests, may be estimated as between 25 and 30 rupees a square mile. This compares favourably with the rates which obtain in America over districts which probably present far more facilities for surveying than India does, but where cheap native labour is unknown. The geographical surveyor is simply a topographer employed on a smaller scale survey. His equipment and staff are somewhat less, but, on the other hand, his travelling expenses are greater. It is found that, on the whole, a fair average for the cost of geographical work may be struck by applying the square of the unit of scale as a factor to 1-inch survey rates; thus a quarter-inch scale survey (*i.e.*, 4 miles to the inch) should be one-sixteenth of the cost per mile of the 1-inch survey over similar ground. A geographical reconnaissance on the scale of 1 : 500000 (8 miles=1 inch) should be one-sixty-fourth of the square-mile cost of the 1-inch survey, &c. This is, indeed, a close approximation to the results obtained on the Indian transfrontier, and would probably be found to hold good for British colonial possessions.

Map reproduction.

In processes of map reproduction a recent invention by Mr Vandyke (patented in India) for the reproduction of drawings by a method of direct printing on zinc without the intervention of a negative promises to be of great value. A new section has already been formed in the Calcutta printing office, which has already turned out a considerable quantity of work in much less time and at a much lower cost than would be involved by any process of photo-zincography or lithography. A large number of cadastral maps have been reproduced at about one-ninth of the ordinary cadastral rate.

For the rapid reproduction of geographical maps in the field in order to meet the requirements of a general conducting a campaign, or of a political officer on a boundary mission, no better method has lately been evolved than that which is known as the ferrotype process, by which blue prints can be secured in a few hours from a drawing of the original on tracing-cloth. The sensitized paper and printing-frame are far more portable than any photolithographic apparatus. Sketches illustrative of a field of action may be placed in the hands of the general commanding on the day following the action, if the weather conditions are favourable for their development. The necessity for darkness whilst dealing with the sensitized material is a drawback, but it may usually be arranged with blankets and waterproof sheets when a tent is not available.

Nothing is more important to the geographical surveyor than a well-tried and well-considered equipment. For this he must be referred to the Mathematical Instrument Department, Calcutta, where "mobilization" equipment is retained, ready for issue for military purposes, and is carefully packed for mule or camel transport. It is equally well suited to the civil or military geographer.

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III. NAUTICAL SURVEYING.

The great majority of nautical surveys are carried out by H.M. surveying vessels under the orders of the Hydrographer of the Admiralty. Plans of harbours and anchorages are also received from H.M. ships in commission on foreign stations, but surveys of an extended nature can hardly be executed except by a ship specially fitted and carrying a trained staff of officers. The introduction of steam placed means at the disposal of nautical surveyors which largely modified the conditions under which they had to work in the earlier days of sailing vessels, and it has enabled the ship to be used in various ways previously impracticable. The heavy draught of ships in the present day, the growing increase of ocean and coasting traffic all over the world, coupled with the desire to save distance by rounding points of land and other dangers as closely as possible, demand surveys on larger scales and in greater detail than was formerly necessary; and to meet these modern requirements re-surveys of many parts of the world are continually being called for. Great Britain is, of all countries, most concerned in these matters, but the present expenditure for the purpose appears to be insufficient to keep pace with the demand, and it seems as if charts will get farther and farther behind the necessities of the case as years go on. Nautical surveys vary much in character according to the nature of the work, its importance to navigation, and the time available. The elaborate methods and rigid accuracy of a triangulation for geodetic purposes on shore are quite unnecessary, and are not attempted; astronomical observation spots at intervals in an extended survey prevent any serious accumulation of errors consequent upon a triangulation which is usually carried out with instruments, of which an 8-inch theodolite is the largest size used, whilst 5-inch theodolites generally suffice, and the sextant is largely employed for the minor triangulation. The scales upon which nautical surveys are plotted range from ½ inch to 2 or 3 inches to the sea-mile in coast surveys for the ordinary purposes of navigation, according to the requirements; for detailed surveys of harbours or anchorages a scale of from 6 to 12 inches is usually adopted, but in special cases scales as large as 60 inches to the mile are used. The general operations of a survey will be described in the following pages, but space precludes the possibility of entering into many of the details which are necessary in practice, and for these the standard works on the subject must be consulted. For the execution of marine surveys no abstruse mathematical training is required. Success depends chiefly upon the skill exercised by the officer in command in economizing the time at his disposal, or his judgment in evading the difficulties caused by contrary winds, bad weather, strong tides, an inhospitable population, and the natural features of the coast; and upon the concentrated attention given by himself and his assistants to a multitude of small details.

Instruments.

The following are the principal instruments required for use in the field: *Theodolite*, 5-inch, fitted with large telescope of high power, with coloured shades to the eye-piece for observing the sun for true bearings. *Sextant*, 8-inch observing, stand and artificial horizon. *Chronometers*, eight box, and two or three pocket, are usually supplied to surveying vessels. *Sounding Sextants*, differing from ordinary sextants in being lighter and handier. The arc is cut only to minutes, reading to large angles of as much as 140°, and fitted with a tube of bell shape so as to include a large field in the telescope which is of high power. *Measuring chain* 100 feet in length. *Ten-foot pole* for coast-lining, is a light pole carrying two oblong frames, 18 inches by 24 inches, covered with canvas painted white, with a broad vertical black stripe in the centre and fixed on the pole 10 feet apart. *Station-pointer*, an instrument in constant requisition either for sounding, coast-lining, or topographical plotting, which enables an observer's position to be fixed by taking two angles between three objects suitably situated. The movable legs being set to the observed angles, and placed on the plotting sheet, the chamfered edges of the three legs are brought to pass through the points observed. The centre of the instrument then indicates the observer's position. *Heliostats*, for reflecting the rays of the sun from distant stations to indicate their position, are invaluable. The most convenient form is Galton's sun signal; but an ordinary swing mirror, mounted to turn horizontally, will answer the purpose, the flash being directed from a hole in the centre of the mirror. *Pocket Aneroid Barometer*, required for topographical purposes. *Prismatic Compass*, *Patent Logs* (taffrail and harpoon), *Lucas Wire Sounding Machine* (large and small size), and *James's Submarine Sentry* are also required. For chart-room use are provided a graduated brass scale, steel straight-edges, and beam compasses of different lengths, rectangular vulcanite or ivory protractors of 6-inch and 12-inch length, and semi-circular brass protractors of 10-inch radius, a box of good mathematical drawing instruments, lead weights, drawing boards, and mounted paper.

Marks and beacons.

Every survey must have fixed objects which are first plotted on the sheet, and technically known as "points." A keen eye is required for natural marks of all kinds, but these must often be supplemented by whitewash marks, cairns, tripods, or bushes covered with white canvas or calico, and flags, white or black according to background. On low coasts, flagstaffs upwards of 80 feet high must sometimes be erected in order to get the necessary range of vision, and thereby avoid the evil of small triangles, in working through which errors accumulate so rapidly. A barling spar 35 feet in length, securely stayed and carrying as a topmast (with proper guys) a somewhat lighter spar, lengthened by a long bamboo, will give the required height. A *fixed beacon* can be erected in shallow water, 2 to 3 fathoms in depth, by constructing a tripod of spars about 45 feet long. The heads of two of them are lashed together, and the heels kept open at a fixed distance by a plank about 27 feet long, nailed on at about 5 feet above the heels of the spars. These are taken out by three boats, and the third tripod leg lashed in position on the boats, the heel in the opposite direction to the other two. The first two legs, weighted, are let go together; using the third leg as a prop, the tripod is hauled into position and secured by guys to anchors, and by additional weights slipped down the legs. A vertical pole with bamboo can now be added, its weighted heel being on the ground and lashed to the fork. On this a flag 14 feet square may be hoisted. *Floating beacons* can be made by filling up flush the heads of two 27-gallon casks, connected by nailing a piece of thick plank at top and bottom. A barling spar passing through holes cut in the planks between the casts, projecting at least 20 feet below and about 10 feet above them, is toggled securely by iron pins above the upper and below the lower plank. To the upper part of the spar is lashed a bamboo, 30 to 35 feet long, carrying a black flag 12 to 16 feet square, which will be visible from the ship 10 miles in clear weather. The ends of a span of $\frac{1}{2}$-inch chain are secured round the spar above and below the casks with a long link travelling upon it, to which the cable is attached by a slip, the end being carried up and lightly stopped to the bamboo below the flag. A wire strop, kept open by its own stiffness, is fitted to the casks for convenience in slipping and picking up. The beacon is moored with chain and rope half as long again as the depth of water. Beacons have been moored by sounding line in as great depth as 3000 fathoms with a weight of 100 ℔.

"Fixing."

There is nothing in a nautical survey which requires more attention than the "fix"; a knowledge of the principles involved is essential in order to select properly situated objects. The method of fixing by two angles between three fixed points is generally known as the "two-circle method," but there are really three circles involved. The "station-pointer" is the instrument used for plotting fixes. Its construction depends upon the fact that angles subtended by the chord of a segment of a circle measured from any point in its circumference are equal. The lines joining three fixed points form the chords of segments of three circles, each of which passes through the observer's position and two of the fixed points. The more rectangular the angle at which the circles intersect each other, and the more sensitive they are, the better will be the fix; one condition is useless without the other. A circle is "sensitive" when the angle between the two objects responds readily to any small movement of the observer towards or away from the centre of the circle passing through the observer's position and the objects. This is most markedly the case when one object is very close to the observer and the other very distant, but not so when *both* objects are distant. Speaking generally, the sensibility of angles depends upon the relative distance of the two objects from the observer, as well as the absolute distance of the nearer of the two.

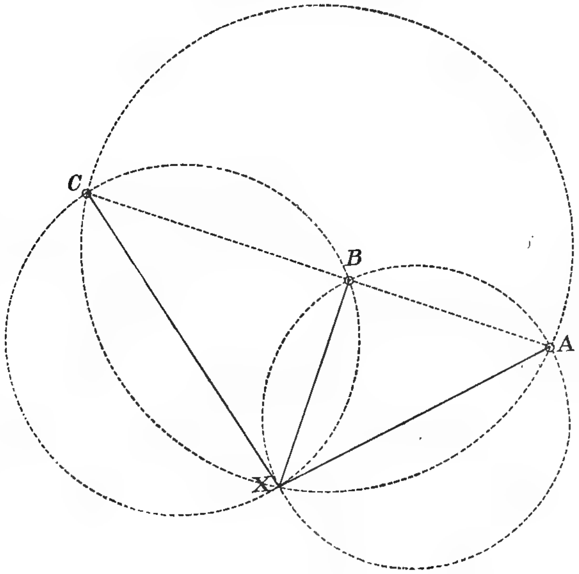

Fig. 1.

In the accompanying diagram A, B, C are the objects, and X the observer. Fig. 1 shows the circle passing through C, B, and X, cutting the circle ABX at a good angle, and therefore fixing X independently of the circle CAX, which is less sensitive than either of the other two. In Fig. 2 the two first circles are very sensitive, but being nearly tangential they give no cut with each other. The third circle cuts both at right angles; it is, however, far less sensitive, and for that reason if the right and left hand objects are both distant the fix must be bad. In such a case as this, because the angles CXB, BXA are both so sensitive, and the accuracy of the fix depends on the precision with which the angle CXA is measured, that angle should be observed direct, together with one of the other angles composing it. Fig. 3 represents a case where the points are badly disposed, approaching the condition known as "on the circle," passing through the three points. All three circles cut one another at such a fine angle as to give a very poor fix. The centre of the station-pointer could be moved considerably without materially affecting the coincidence of the legs with the three points. To avoid a bad fix the following rules are safe :—

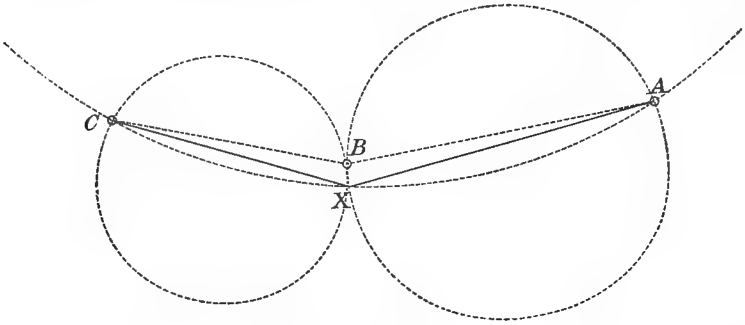

Fig. 2.

1. Never observe objects of which the central is the furthest unless it is *very* distant relatively to the other two, in which case the fix is admissible, but must be used with caution.

2. Choose objects disposed as follows: (*a*) One outside object distant and the other two near, the angle between the two near objects being not less than 30° or more than 140°. The amount of the angle between the middle and distant object is immaterial. (*b*) The three objects nearly in a straight line, the angle between any two being not less than 30°. (*c*) The observer's position being inside the triangle formed by the objects.

A fix on the line of two points in transit, with an angle to a third point, becomes more sensitive as the distance between the transit points increases relatively to the distance between the front transit point and the observer; the more nearly the angle to the third point approaches a right angle, and the nearer it is situated to the observer, the better the fix. If the third point is at a long distance, small errors either of observation or plotting affect the result largely. A good practical test for a fix is afforded by noticing whether a very slight movement of the centre of the station-pointer will throw one or more of the points away from the leg. If it can be moved without appreciably disturbing the coincidence of the leg and all three points, the fix is bad.

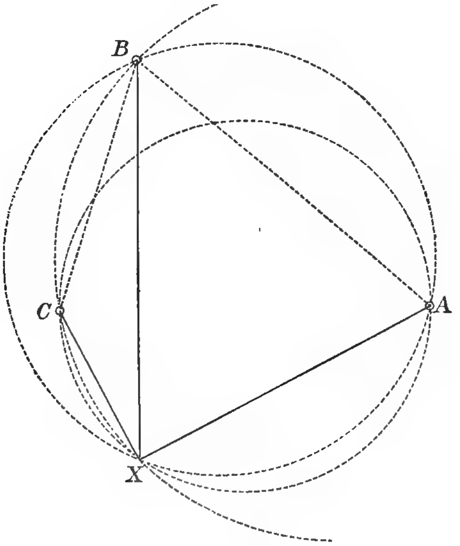

Fig. 3.

Tracing-paper answers exactly the same purpose as the station-pointer. The angles are laid off from a centre representing the position, and the lines brought to pass through the points as before. This entails more time, and the angles are not so accurately measured with a small protractor. Nevertheless this has often to be used, as when points are close together on a small scale the central part of the station-pointer will often hide them and prevent the use of the instrument. The use of tracing-paper permits any number of angles to different points to be laid down on it, which under certain conditions of fixing is sometimes a great advantage.

Bases.

Although marine surveys are in reality founded upon triangulation and measured bases of some description, yet when plotted irregularly the system of triangles is not always apparent. The triangulation ranges from the rough triangle of a running survey to the carefully formed triangles of detailed surveys. The measured base for an extended survey is provisional only, the scale resting ultimately mainly upon the astronomical positions observed at its extremes. In the case of a plan the base is absolute. The main triangulation, of which the first triangle contains the measured base as its known side, establishes a series of points known as main stations, from which and to which angles are taken to fix other stations. A sufficiency of secondary stations and marks enables the detail of the chart to be filled in between them. The points, embracing the area to be worked on, having been plotted, are transferred to field boards, upon which the detail of the work in the field is plotted; when complete the work is traced and retransferred to the plotting-sheet, which is then inked in as the finished chart, and if of large extent it is graduated on the gnomonic projection on the astronomical positions of two points situated near opposite corners of the chart.

The kind of base ordinarily used is one measured by chain on flat ground, of $\frac{1}{2}$ to $1\frac{1}{2}$ miles in length, between two points visible from one another, and so situated that a triangulation can be readily extended from them to embrace other points in the survey, forming well-conditioned triangles. The error of the chain is noted before leaving the ship, and again on returning, by comparing its length with the standard length of 100 feet marked on the ship's deck. The correction so found is applied to obtain the final result. If by reason of water intervening between the base stations it is impossible to measure the direct distance between them, it is permissible to deduce it by traversing.

A Masthead Angle Base is useful for small plans of harbours, &c., when circumstances do not permit of a base being measured on shore. The ship at anchor nearly midway between two base stations is the most favourable condition for employing this method. Theodolite reading of the masthead with its elevation by sextant observed simultaneously at each base station (the mean of several observations being employed) give the necessary data to calculate the distance between the base stations from the two distances resulting from the elevation of the masthead and the simultaneous theodolite-angles between the masthead and the base stations. The height of the masthead may be temporarily increased by securing a spar to extend 30 feet or so above it, and the exact height from truck to netting is found by tricing up the end of the measuring chain. The angle of elevation should not be diminished below about 1° from either station.

Base by Sound.—The interval in seconds between the flash and report of a gun, carefully noted by counting the beats of a watch or pocket chronometer, multiplied by the rate per second at which sound travels (corrected for temperature), supplies a means of obtaining a base which is sometimes of great use when other methods are not available. Three miles is a suitable distance for such a base, and guns or small brass Cohorn mortars are fired alternately from either end, and repeated several times. The arithmetical mean is not strictly correct, owing to the retardation of the sound against the wind exceeding the acceleration when travelling with it; the formula used is therefore $T=\frac{2tt'}{t+t'}$ where T is the mean interval required, t the interval observed one way, t' the interval the other way. The method is not a very accurate one, but is sufficiently so when the scale is finally determined by astronomical observations, or for sketch surveys. The measurement should be across the wind if possible, especially if guns can only be fired from one end of the base. Sound travels about 1090 feet per second at a temperature of 32° F., and increases at the rate of 1·15 foot for each degree above that temperature, decreasing in the same proportion for temperatures below 32°.

Base by Angle of Short Measured Length.—An angle measured by sextant between two well-defined marks at a carefully measured distance apart, placed at right angles to the required base, will give a base for a small plan.

Astronomical Base.—The difference of latitude between two stations visible from each other and nearly in the same meridian, combined with their true bearings, gives an excellent base for an extended triangulation; the only drawback to it is the effect of local attraction of masses of land in the vicinity on the pendulum, or in other words, on the mercury in the artificial horizon. The base stations should be as far apart as possible, in order to minimize the effect of any error in the astronomical observations. The observation spots would not necessarily be actually at the base stations, which would probably be situated on summits at some little distance in order to command distant views. In such cases each observation spot would be connected with its corresponding base station by a subsidiary triangulation, a short base being measured for the purpose. The ship at anchor off the observation spot frequently affords a convenient means of effecting the connexion by a masthead angle base and simultaneous angles. If possible, the observation spots should be east or west of the mountain stations from which the true bearings are observed.

If the base stations A and B are so situated that by reason of distance or of high land intervening they are invisible from one another, but both visible from some main station C between them, when the main triangulation is completed, the ratio of the sides AC, BC can be determined. From this ratio and the observed angle ACB, the angles ABC, BAC can be found. The true bearing of the lines AC or BC being known, the true bearing of the base stations A and B can be deduced.

Extension of Base.—A base of any description is seldom long enough to plot from directly, and in order to diminish errors of plotting, it is necessary to begin on the longest side possible so as to work *inwards*. A short base measured on flat ground will give a better result than a longer one measured over inequalities, provided that the triangulation is carefully extended by means of judiciously selected triangles, great care being taken to plumb the centre of each station. To facilitate the extension of the base in as few triangles as possible, the base should be placed so that there are two stations, one on each side of it, subtending angles at them of from 30° to 40°, and the distances between which, on being calculated in the triangles of the quadrilateral so formed, will constitute the first extension of the base. Similarly, two other stations placed one on each side of the last two, will form another quadrilateral, giving a yet longer side, and so on.

Main triangulation.

The angles to be used in the main triangulation scheme must be very carefully observed and the theodolite placed exactly over the centre of the station. Main angles are usually repeated several times by resetting the vernier at intervals equidistant along the arc, in order to eliminate instrumental errors as well as errors of observation. The selection of an object suitable for a zero is important. It should, if possible, be another main station at some distance, but not so far or so high as to be easily obscured, well defined, and likely to be permanent. Angles to secondary stations and other marks need not be repeated so many times as the more important angles, but it is well to check all angles once at least. Rough sketches from all stations are of great assistance in identifying objects from different points of view, the angles being entered against each in the sketch.

False Station.—When the theodolite cannot for any reason be placed over the centre of a station, if the distance be measured, and the theodolite reading of it be noted, the observed angles may be reduced to what they would be at the centre of the station. False stations have frequently to be made in practice; a simple rule to meet all cases is of great assistance to avoid the possibility of error in applying the correction with its proper sign. This may very easily be found as follows, without having to bestow a moment's thought beyond applying the rule, which is a matter of no small gain in time when a large number of angles have to be corrected.

Rule.—Put down the theodolite reading which it is required to correct (increased if necessary by 360°), and from it subtract the theodolite reading of the centre of the station. Call this remainder θ. With θ as a "course" and the number of feet from the theodolite to the station as a "distance," enter the traverse table and take out the greater increment if θ lies between 45° and 135°, or between 225° and 315°, and the lesser increment for other angles. The accompanying diagram (Fig. 4) will assist the memory. Refer this increment to the "table of subtended angles by various lengths at different distances" (using the distance of the object observed) and find the corresponding correction in arc, which mark + or − according as θ is under or over 180°. Apply this correction to the observed theodolite angle. A "table of subtended angles" is unnecessary if the formula

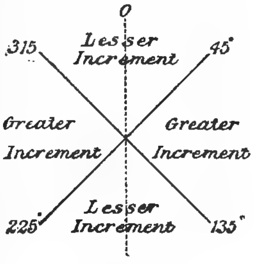

Fig. 4.

$$\text{Angle in seconds}=\frac{\text{number of feet subtended}\times 34}{\text{distance of object in sea-miles}}\text{ be used instead.}$$

Convergency of Meridians.—The difference of the reciprocal true bearings between two stations is called the "convergency." The formula for calculating it is: Conv. in minutes = dist. in sea-miles × sin. Merc. bearing × tan. mid. lat. Whenever true bearings are used in triangulation, the effect of convergency must be considered and applied. In north latitudes the southerly bearing is the greater of the two, and in south latitudes the northerly bearing. The Mercatorial bearing between two stations is the mean of their reciprocal true bearings.

Triangulated coast survey.

After a preliminary run over the ground to note suitable positions for main and secondary stations on prominent headlands, islands, and summits not too far back from the coast, and, if no former survey exists, to make at the same time a rough plot of them by compass and patent log, a scheme must be formed for the main triangulation with the object of enclosing the whole survey in as few triangles as possible, regard being paid to the limit of vision of each station due to its height, to the existing meteorological conditions, to the limitations imposed by higher land intervening, and to its accessibility. The tringles decided upon should be well-conditioned, taking care not to introduce an angle of less than 30° to 35°, which is only permissible when the two longer sides of such a triangle are of nearly equal length, and when in the calculation that will follow one of these sides shall be derived from the other and not from the short side. In open country the selection of stations is comparatively an easy matter, but in country densely wooded the time occupied by a triangulation is mainly governed by the judicious selection of stations quickly reached, sufficiently elevated to command distant views, and situated on summits capable of being readily cleared of trees in the required direction, an all-round view being, of course, desirable but not always attainable. The positions of secondary stations will also generally be decided upon during the preliminary reconnaissance. The object of these stations is to break up the large primary triangles into triangles of smaller size, dividing up the distances between the primary stations into suitable lengths; they are selected with a view to greater accessibility than the latter, and should therefore usually be near the coast and at no great elevation. Upon shots from these will depend the position of the greater number of the coast-line marks to be erected and fixed as the detailed survey of each section of the coast is taken in hand in regular order. The nature of the base to be used, and its position in order to fulfil the conditions specified under the head of "Bases," must be considered, the base when extended forming a side of one of the main triangles. It is immaterial at what part of the survey the base is situated, but if it is near one end, a very satisfactory check on the accuracy of the triangulation is obtained by comparing the length of a side at the other extreme of the survey, derived by calculation through the whole system of triangles, with its length deduced from a check base measured in its vicinity. It is generally a saving of time to measure the base at some anchorage or harbour that requires a large scale plan. The triangulation involved in extending the base to connect it with the main triangulation scheme can thus be utilized for both purposes, and whilst the triangulation is being calculated and plotted, the survey of the plan can be proceeded with. True bearings are observed at both ends of the survey, and the results subsequently compared. Astronomical observations for latitude are obtained at observation spots near the extremes of the survey and the meridian distance run between them, the observation spots being connected with the primary triangulation; they are usually disposed at intervals of from 100 to 150 miles, and thus errors due to a triangulation carried out with theodolites of moderate diameter do not accumulate to any serious extent. If the survey is a very extended one, intermediate observation spots afford a satisfactory check, by comparing the positions as calculated in the triangulation with those obtained by direct observation.

Calculating the Triangulation.—The triangles as observed being tabulated, the angles of each triangle are corrected to bring their sum to exactly 180°. We must expect to find errors in the triangles of as much as one minute, but under favourable conditions they may be much less. In distributing the errors we must consider the general skill of the observer, the size of his theodolite relatively to the others, and the conditions under which his angles were observed; failing any particular reason to assign a larger error to one angle than to another, the error must be divided equally, bearing in mind that an alteration in the small angle will make more difference in the resulting position than in either of the other two, and as it approaches 30° (the limit of a receiving angle) it is well to change it but very slightly in the absence of any strong reason to the contrary. The length of base being determined, the sides of all the triangles involved are calculated by the ordinary rules of trigonometry. Starting from the true bearing observed at one end of the survey, the bearing of the side of each triangle that forms the immediate line of junction from one to the other is found by applying the angles necessary for the purpose in the respective triangles, not forgetting to apply the convergency between each pair of stations when reversing the bearings. The bearing of the final side is then compared with the bearing obtained by direct observation at that end of the survey. The difference is principally due to accumulated errors in the triangulation; half of the difference is then applied to the bearing of each side. Convert these true bearings into Mercatorial bearings by applying half the convergency between each pair of stations. With the lengths of the connecting sides found from the measured base and their Mercatorial bearing, the Mercatorial bearing of one observation spot from the other is found by middle latitude sailing. Taking the observed astronomical positions of the observation spots and first reducing their true difference longitude to departure, as measured on a spheroid from the formula Dep. $= \text{T. D. long.}\ \frac{\text{no. ft. in 1 mile long.}}{\text{no. ft. in 1 mile of lat.}}$, then with the d. lat. and dep. the Mercatorial true bearing and distance between the observation spots is calculated by middle latitude sailing, and compared with that by triangulation and measured base. To adjust any discrepancy, it is necessary to consider the probable error of the observations for latitude and meridian distance; within those limits the astronomical positions may safely be altered in order to harmonize the results; it is more important to bring the bearings into close agreement than the distance. From the amended astronomical positions the Mercatorial true bearings and distance between them are re-calculated. The difference between this Mercatorial bearing and that found from the triangulation and measured base must be applied to the bearing of each side to get the final corrected bearings, and to the logarithm of each side of the triangulation as originally calculated must be added or subtracted the difference between the logarithms of the distance of the amended positions of the observation spots and the same distance by triangulation.

Calculating Intermediate Astronomical Positions.—The latitude and longitude of any intermediate main station may now be calculated from the finally corrected Mercatorial true bearings and lengths of sides. The difference longitude so found is what it would be if measured on a true sphere, whereas we require it as measured on a spheroid, which is slightly less. The correction $= \text{d. long.}\ \frac{\cos^2 \text{mid. lat.}}{150}$ must therefore be subtracted; or the true difference longitude may be found direct from the formula dep. $\frac{\text{no. ft. in 1 mile of lat.}}{\text{no. ft. in 1 mile of long.}}$. From the foregoing it is seen that in a triangulation for hydrographical purposes both the bearings of the sides and their lengths ultimately depend almost entirely upon the astronomical observations at the extremes of the survey; the observed true bearings and measured base are consequently more in the nature of checks than anything else. It is obvious, therefore, that the nearer together the observation spots, the greater effect will a given error in the astronomical positions have upon the length and direction of the sides of the triangulation, and in such cases the bearings as actually observed must not be altered to any large extent when a trifling change in the astronomical positions might perhaps effect the required harmony. For the reasons given under "Astronomical Bases," high land near observation spots may cause very false results, which may often account for discrepancies when situated on opposite sides of a mountainous country.

Plotting.

Great care is requisite in projecting on paper the points of a survey. The paper should be allowed to stretch and shrink as it pleases until it comes to a stand, being exposed to the air for four or five hours daily, and finally well flattened out by being placed on a table with drawing boards placed over it heavily weighted. If the triangulation has been calculated beforehand throughout, and the lengths of all the different sides have been found, it is more advantageous to begin plotting by distances rather than by chords. The main stations are thus got down in less time and with less trouble, but these are only a small proportion of the points to be plotted, and long lines must be ruled between the stations as zeros for plotting other points by chords. In ruling these lines care must be taken to draw them exactly through the centre of the pricks denoting the stations, but however carefully drawn, there is liability to slight error in any line projected to a point lying beyond the distance of the stations between which the zero line is drawn. In plotting by distances, therefore, all points that will subsequently have to be plotted by chords should lie well within the area covered by the main triangulation. Three distances must be measured to obtain an intersection of the arcs cutting each other at a sufficiently broad angle; the plotting of the main stations once begun must be completed before distortion of the paper can occur from change in the humidity of the atmosphere. Plotting, whether by distance or by chords, must be begun on as long a side as possible, so as to plot *inwards*, or with decreasing distances. In plotting by chords it is important to remember in the selection of lines of reference (or zero lines), that that should be preferred which makes the smallest angle with the line to be projected from it, and of the angular points those nearest to the object to be projected from them.

Irregular Methods of Plotting.—In surveys for the ordinary purposes of navigation, it frequently happens that a regular system of triangulation cannot be carried out, and recourse must be had to a variety of devices; the judicious use of the ship in such cases is often essential, and with proper care excellent results may be obtained. A few examples will best illustrate some of the methods used, but circumstances vary so much in every survey, that it is only possible to meet them properly by studying each case as it arises, and to improvise methods. Fixing a position by means of the "back-angle" is one of the most ordinary expedients. Angles having been observed at A, to the station B, and certain other fixed points of the survey, C and D for instance; if A is shot up from B, at which station angles to the same fixed points have been observed, then it is not necessary to visit those points to fix A. For instance, in the triangle ABC, two of the angles have been observed, and therefore the third angle at C is known (the three angles of a triangle being equal to 180°), and it is called the "calculated or back-angle from C." A necessary condition is that the receiving angle at A, between any two lines (direct or calculated), must be sufficiently broad to give a good cut; also the points from which the "back-angles" are calculated should not be situated at too great distances from A, relatively to the distance between A and B. A station may be plotted by laying down the line to it from some other station, and then placing on tracing-paper a number of the angles taken at it, including the angle to the station from which it has been shot up. If the points to which angles are taken are well situated, a good position is obtained, its accuracy being much strengthened by being able to plot on a line to it, which, moreover, forms a good zero line for laying off other angles from the station when plotted. Sometimes the main stations must be carried on with a point plotted by only two angles. An effort must be made to check this subsequently by getting an "angle back" from stations dependent upon it to some old well-fixed point; failing this, two stations being plotted with two angles, pricking one and laying down the line to the other will afford a check. A well-defined mountain peak, far inland and never visited, when once it is well fixed is often invaluable in carrying on an irregular triangulation, as it may remain visible when all other original points of the survey have disappeared, and "back-angles" from it may be continually obtained, or it may be used for plotting on true bearing lines of it. In plotting the true bearing of such a peak, the convergency must be found and applied to get the reversed bearing, which is then laid down from a meridian drawn through it; or the reversed bearing of any other line already drawn through the peak being known, it may simply be laid down with that as a zero. A rough position of the spot from which the true bearing was taken must be assumed in order to calculate the convergency. Fig. 5 will illustrate the foregoing remarks. A and B are astronomical observation spots at the extremes of a survey, from both of which the high, inaccessible peak C is visible. D, E, F are intermediate stations; A and D, D and E, E and F, F and B being respectively visible from each other. G is visible from A and D, and C is visible from all stations. The latitudes of A and B and meridian distance between them being determined, and the true bearing of C being observed from both observation spots, angles are observed at all the stations. Calculating the spheroidal correction (from the formula, correction=d. long. $\frac{\cos^2 \text{mid. lat.}}{150}$) and adding it to the true (or chronometric) difference longitude between A and B to obtain the spherical d. long.; with this spherical d. long. and the d. lat., the Mercatorial true bearing and distance is found by middle latitude sailing (which is an equally correct but shorter method than by spherical trigonometry, and may be safely used when dealing with the distances usual between observation spots in nautical surveys). The convergency is also calculated, and the true bearing of A from B and B from A are thus determined. In the plane triangle ABC, the angle A is the difference between the calculated bearing of B and the observed bearing of C from A; similarly angle B is the difference between calculated bearing of A and observed bearing of C from B. The distance AB having been also calculated, the side AC is found. Laying down AC on the paper on the required scale, D is plotted on its direct shot from A, and on the angle back from C, calculated in the triangle ACD. G is plotted on the direct shots from A and D, and on the angle back from C, calculated either in the triangle ACG or GCD. The perfect intersection of the three lines at G assures these four points being correct. E, F, and B are plotted in a similar manner. The points are now all plotted, but they depend on calculated angles, and except for the first four points we have no check whatever either on the accuracy of the angles observed in the field or on the plotting. Another well-defined object in such a position, for instance as Z, visible from three or more stations, would afford the necessary check, if lines laid off to it from as many stations as possible gave a good intersection. If no such point, however, exists, a certain degree of check on the angles observed is derived by applying the sum of all the calculated angles at C to the true bearing of A from C (found by reversing observed bearing of C from A with convergency applied), which will give the bearing of B from C. Reverse this bearing with convergency applied, and compare it with the observed bearing of C from B. If the discrepancy is but small, it will be a strong presumption in favour of the substantial accuracy of the work. If the calculated true bearing of B from A be now laid down, it is very unlikely that the line will pass through B, but this is due to the discrepancy which must always be expected between astronomical positions and triangulation. If some of the stations between A and B require to be placed somewhat closely to one another, it may be desirable to obtain fresh true bearings of C instead of carrying on the original bearing by means of the calculated angle.

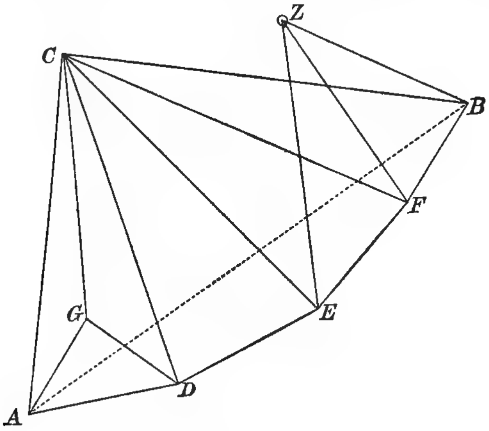

Fig. 5.

In all cases of irregular plotting the ship is very useful, especially if she is moored taut without the swivel, and angles are observed from the bow. Floating beacons may also assist an irregular triangulation.

Sketch surveys.

Surveys of various degrees of accuracy are included among sketch surveys. The roughest description is the ordinary running survey, when the work is done by the ship steaming along the coast, fixing points, and sketching in the coast-line by bearings and angles, relying for her position upon her courses and distances as registered by patent log, necessarily regardless of the effect of wind and current and errors of steerage. At the other extreme comes the modified running survey, which in point of practical accuracy falls little short of that attained by irregular triangulation. Some of these modifications will be briefly noticed. A running survey of a coast-line between two harbours, that have been surveyed independently and astronomically fixed, may often be carried out by fixing the ship on the points already laid down on the harbour surveys and shooting up prominent intermediate natural objects, assisted possibly by theodolite lines from the shore stations. Theodolite lines to the ship at any of her positions are particularly valuable, and floating beacons suitably placed materially increase the value of any such work. A sketch survey of a coast upon which it is impossible to land may be well carried out by dropping beacons at intervals of about ten miles, well out from the land and placed abreast prominent natural objects called the "breastmarks," which must be capable of recognition from the beacons anchored off the next "breastmark" on either side. The distance between the beacons is found by running a patent log both ways, noting the time occupied by each run; if the current has remained constant, a tolerably good result can be obtained. At the first beacon, angles are observed between the second beacon and the two "breastmarks," an "intermediate" mark, and any other natural object which will serve as "points." At the second beacon, angles are observed between the first beacon and the same objects as before. Plotting on the line of the two beacons as a base, all the points observed can be pricked in on two shots. At a position about midway between the beacons, simultaneous angles are observed to all the points, and laid off on tracing-paper, which will afford the necessary check, and the foundation is thus laid for filling in the detail of coast-line, topography, and soundings off this particular stretch of coast in any detail desired. Each section of coast is complete in itself on its own base; the weak point lies in the junction of the different sections, as the patent log bases can hardly be expected to agree precisely, and the scales of adjacent sections may thus be slightly different. This is obviated, as far as possible, by fixing on the points of one section and shooting up those of another, which will check any great irregularity of scale creeping in. The bearing is preserved by getting occasional true bearing lines at the beacons of the most distant point visible. Space does not here permit of dwelling upon the details of the various precautions that are necessary to secure the best results the method is capable of; it can only be stated generally that in all cases of using angles from the ship under weigh, several assistants are necessary, so that the principal angles may be taken simultaneously, the remainder being connected immediately afterwards with zeros involving the smallest possible error due to the ship not being absolutely stationary, these zeros being included amongst the primary angles. When close to a beacon, if its bearing is noted and the distance in feet obtained from its elevation, the angles are readily reduced to the beacon itself. Astronomical positions by twilight stars keep a check upon the work.

Sketch Surveys by Compass Bearings and Vertical Angles.—In the case of an island culminating in a high, well-defined summit visible from all directions, a useful and accurate method is to steam round it at a sufficient distance to obtain a true horizon, stopping to make as many stations as may be desirable, and fixing by compass bearing of the summit and its vertical angle. The height is roughly obtained by shooting in the summit, from two positions on a patent log base whilst approaching it. With this approximate height and Lecky's vertical danger angle tables, each station may be plotted on its bearing of the summit. From these stations the island is shot in by angles between its tangents and the summit, and angles to any other natural features, plotting the work as we go on any convenient scale which must be considered only as provisional. On completing the circuit of the island, the true scale is found by measuring the total distance in inches on the plotting-sheet from the first to the last station, and dividing it by the distance in miles between them as shown by patent log. The final height of the summit bears to the rough height used in plotting the direct proportion of the provisional scale to the true scale. This method may be utilized for the sketch survey of a coast where there are well-defined peaks of sufficient height at convenient intervals, and would be superior to an ordinary running survey. From positions of the ship fixed by bearings and elevations of one peak, another farther along the coast is shot in and its height determined; this second peak is then used in its turn to fix a third, and so on. The smaller the vertical angle the more liability there is to error, but a glance at Lecky's tables will show what effect an error of say 1′ in altitude will produce for any given height and distance, and the limits of distance must depend upon this consideration.

Surveys of Banks out of Sight of Land.—On striking shoal soundings unexpectedly, the ship may either be anchored at once, and the shoal sounded out by boats starring round her, using prismatic compass and masthead angle; or if the shoal is of large extent and may be prudently crossed in the ship, it is a good plan to get two beacons laid down on a bearing from one another and patent log distance of 4 or 5 miles. With another beacon (or mark-boat, carrying a large black flag on a bamboo 30 feet high) fixed on this base, forming an equilateral triangle, and the ship anchored as a fourth point, soundings may be carried out by the boats fixing by station-pointer. The ship's position is determined by observations of twilight stars.

Coast-lining.

In a detailed survey the coast is sketched in by walking along it, fixing by theodolite or sextant angles, and plotting by tracing-paper or station-pointer. A sufficient number of fixed marks along the shore afford a constant check on the minor coast-line stations, which should be plotted on, or checked by, lines from one to the other wherever possible to do so. When impracticable to fix in the ordinary way, the ten-foot pole may be used to traverse from one fixed point to another. With a coast fronted by broad drying coral reef or flats over which it is possible to walk, the distance between any two coast-line stations may be found by measuring at one of them the angle subtended by a known length placed at right angles to the line joining the stations. There is far less liability to error if the work is plotted at once on the spot on a field board with the fixed points pricked through and circled in upon it; but if circumstances render it necessary, the angles being registered and sketches made of the bits of coast between the fixes on a scale larger than that of the chart, they may be plotted afterwards; to do this satisfactorily, however, requires the surveyor to appreciate instinctively exactly what angles are necessary at the time. It is with the high-water line that the coast-liner is concerned, delineating its character according to the Admiralty symbols. The officer sounding off the coast is responsible for the position of the dry line at low-water, and on large scales this would be sketched in from a small boat at low-water springs. Heights of cliffs, rocks, islets, &c., must be inserted, either from measurement or from the formula,

$$\text{height in feet} = \frac{\text{angle of elevation in seconds} \times \text{distance in miles}}{34},$$

and details of topography close to the coast, including roads, houses, and enclosures, must be shown by the coast-liner. Rocks above water or breaking should be fixed on passing them. Coast-line may be sketched from a boat pulling along the shore, fixing and shooting up any natural objects on the beach from positions at anchor.

Sounding.

The most important feature of a chart is the completeness with which it is sounded. Small scale surveys on anything less than one inch to the mile are apt to be very misleading; such a survey may appear to have been closely sounded, but in reality the lines are so far apart that they often fail to disclose indications of shoal-water. The work of sounding may be proceeded with as soon as sufficient points for fixing are plotted; but off an intricate coast, it is better to get the coast-line done first. The lines of soundings are run by the boats parallel to one another and perpendicular to the coast at a distance apart which is governed by the scale; five lines to the inch is about as close as they can be run without overcrowding; if closer lines are required the scale must generally be increased. The distance apart will vary with the depth of water and the nature of the coast; a rocky coast with shallow water off it and projecting points will need much closer examination than a steep-to coast, for instance. The line of prolongation of a point under water will require special care to ensure the fathom lines being drawn correctly. If the soundings begin to decrease when pulling off-shore it is evidence of something suspicious, and intermediate lines of soundings or lines at right angles to those previously run should be obtained. Whenever possible lines of soundings should be run on transit lines; these may often be picked up by fixing when on the required line, noting the angle on the protractor between the line and some fixed mark on the field board, and then placing the angle on the sextant, reflecting the mark and noting what objects are in line at that angle. On large scale surveys whitewash marks or flags should mark the ends of the lines, and for the back transit marks natural objects may perhaps be picked up; if not, they must be placed in the required positions. The boat is fixed by two angles, with an occasional third angle as a check; the distance between the fixes is dependent upon the scale of the chart and the rapidity with which the depth alters; the 3, 5, and 10 fathom lines should always be fixed, allowing roughly for the tidal reduction. The nature of the bottom must be taken every few casts, and recorded. It is best to plot each fix on the sounding board at once, joining the fixes by straight lines and numbering them for identification. The tidal reduction being obtained, the reduced soundings are written in the field-book in red underneath each sounding as originally noted; they are then placed in their proper position on the board between the fixes. Suspicious ground should be closely examined; a small nun buoy anchored on the shoal is useful to guide the boat while trying for the least depth. Sweeping for a reported pinnacle rock may be resorted to when sounding fails to discover it. Local information from fishermen and others is often most valuable as to the existence of dangers. Up to depths of about 15 fathoms the hand lead line is used from the boats, but beyond that depth the small Lucas machine for wire effects a great saving of time and labour. The deeper soundings of a survey are usually obtained from the ship, but steamboats with wire rounding machines may assist very materially. By the aid of a steam winch, which by means of an endless rounding line hauls a 100-℔ lead forward to the end of the lower boom rigged out, from which it is dropped by a slipping apparatus which acts on striking the water, soundings of 40 fathoms may be picked up from the sounding platform aft, whilst going at a speed of 4½ knots. In deeper water it is quicker to stop the ship and sound from aft with the wire sounding machine. In running long lines of soundings on and off shore, it is very essential to be able to fix as far from the land as possible. Angles will be taken from aloft for this purpose, and a few floating beacons dropped in judiciously-chosen positions will often well repay the trouble. A single fixed point on the land used in conjunction with two beacons suitably placed will give an admirable fix. A line to the ship or her smoke from one or two theodolite stations on shore is often invaluable; if watches are compared, observations may be made at stated times and plotted afterwards. True bearings of a distant fixed object cutting the line of position derived from an altitude of the sun is another means of fixing a position, and after dark the true bearing of a light may be obtained by the time azimuth and angular distance of a star near the prime vertical, or by the angular distance of Polaris in the northern hemisphere.

Vigias.

A very large percentage of the bugbears to navigation denoted by vigias on the charts eventually turn out to have no existence, but before it is possible to expunge them a large area has to be examined. No bottom soundings are but little use, but the evidence of positive soundings should be conclusive. Submarine banks rising from great depths necessarily stand on bases many square miles in area. Of recent years our knowledge of the angle of slope that may be expected to occur at different depths has been much extended. From depths of upwards of 2000 fathoms the slope is so gradual that a bank could hardly approach the surface in less than 7 miles from such a sounding; therefore anywhere within an area of at least 150 square miles all round a bank rising from these depths, a sounding must show some decided indications of a rise in the bottom. Under such circumstances, soundings at intervals of 7 miles, and run in parallel lines 7 miles apart, enclosing areas of only 50 square miles between any four adjacent soundings, should effectually clear up the ground and lead to the discovery of any shoal; and in fact the soundings might even be more widely spaced. From depths of 1500 and 1000 fathoms, shoals can scarcely occur within 3½ miles and 2 miles respectively; but as the depth decreases the angle of slope rapidly increases, and a shoal might occur within three-quarters of a mile or even half a mile of such a sounding as 500 fathoms. A full appreciation of these facts will indicate the distance apart at which it is proper to place soundings in squares suitable to the general depth of water. Contour lines will soon show in which direction to prosecute the search if any irregularity of depth is manifested. When once a decided indication is found, it is not difficult to follow it up by paying attention to the contour lines as developed by successive soundings. Discoloured water, ripplings, fish jumping, or birds hovering about may assist in locating a shoal, but the submarine sentry towed at a depth of 40 fathoms is here invaluable, and may save hours of hunting. Reports being more liable to errors of longitude than of latitude, a greater margin is necessary in that direction. Long parallel lines east and west are preferable, but the necessity of turning the ship more or less head to wind at every sounding makes it desirable to run the lines with the wind abeam, which tends to disturb the dead reckoning least. A good idea of the current may be obtained from the general direction of the ship's head whilst sounding considered with reference to the strength and direction of the wind, and it should be allowed for in shaping the course to preserve the parallelism of the lines, but the less frequently the course is altered the better. A good position in the morning should be obtained by pairs of stars on opposite bearings, the lines of position of one pair cutting those of another pair nearly at right angles. The dead reckoning should be checked by lines of position from observations of the sun about every two hours throughout the day, preferably whilst a sounding is being obtained and the ship stationary. Evening twilight stars give another position.

Tides.—The datum for reduction of soundings is low-water ordinary springs, the level of which is referred to a permanent bench mark in order that future surveys may be reduced to the same datum level. Whilst sounding is going on the height of the water above this level is observed by a tide gauge. The time of high-water at full and change, called the "establishment," and the heights to which spring and neap tides respectively rise above the datum are also required. It is seldom that a sufficiently long series of observations can be obtained for their discussion by harmonic analysis, and therefore the graphical method is preferred; an abstract form provides for the projection of high and low waters, lunitidal intervals, moon's meridian passage, declination of sun and moon, apogee and perigee, and mean time of high-water following superior transit, and of the highest tide in the twenty-four hours. A good portable automatic tide gauge suitable for all requirements is much to be desired. A pneumatic gauge seems now to be perfected, but it has yet to be tried under practical conditions of service.

Deep-sea current meter.

Tidal Streams and Surface Currents are observed from the ship or boats at anchor in different positions, by means of a current log; or the course of a buoy drifted by the current may be followed by a boat fixing at regular intervals. Tidal streams often run for some hours after high and low water by the shore; it is important to find out whether the change of stream occurs at a regular time of the tide. *Undercurrents* are of importance from a scientific point of view. A deep-sea current meter, devised (1876) by Lieutenant Pillsbury, U.S.N., has, with several modifications, been used with success on many occasions, notably by the U.S. Coast and Geodetic Survey steamer *Blake* in the investigation of the Gulf Stream. The instrument is first lowered to the required depth, and when ready is put into action by means of a heavy weight, or messenger, travelling down the supporting line and striking on a metal plate, thus closing the jaws of the levers and enabling the instrument to begin working. The rudder is then free to revolve inside the framework and take up the direction of the current; the small cones can revolve on their axis and register the number of revolutions, while the compass needle is released and free to take up the north and south line. On the despatch of a second messenger, which strikes on top of the first and fixes the jaws of the levers open, every part of the machine is simultaneously locked. Having noted the exact time of starting each of the messengers, the time during which the instrument has been working at the required depth is known, and from this the velocity of the current can be calculated, the number of revolutions having been recorded, while the direction is shown by the angle between the compass needle and the direction of the rudder.

The instrument is shown in Fig. 6. A A are the jaws of the levers through which the first messenger passes and strikes on the metal plate B. The force of the blow is sufficient to press B down, thus bringing the jaws as close together as possible, and putting the meter into action. The second messenger falling on the first opens the levers again and prevents their closing, thus keeping all parts of the machine locked. C is the rudder which takes up the direction of the current when the levers are unlocked. D is a set of small levers on the rudder in connexion with A A. The outer end on the tail of the rudder fits into the notches on the outer ring of the frame when the machine is locked and thus keeps the rudder fixed, but when the first messenger has started the machine by pressing down B and opening the levers A A, this small lever is raised and the rudder can revolve freely. E E are four small cones which revolve on their axis in a vertical plane, similar to an anemometer; the axis is connected by a worm screw to geared wheels which register the number of revolutions up to 5000, corresponding to about 4 nautical miles. There is a small lever in connexion with A A which prevents the cones revolving when the machine is locked, but allows them to revolve freely when the machine is in action. Below the rudder-post is a compass-bowl F, which is hung in gimbals and capable of removal. The needle is so arranged that it can be lifted off the pivot by means of a lever in connexion with A A; when the meter is in action the needle swings freely on its pivot, but when the levers are locked it is raised off its pivot by the inverted cup-piece K placed inside the triple claws on the top of the compass and screwed to the lever, thus locking the needle without chance of moving. The compass-bowl should be filled with fresh water before lowering the instrument into the sea, and the top screwed home tightly. The needle should be removed and carefully dried after use, to prevent corrosion. The long arm G is to keep the machine steady in one direction; it works up and down a jackstay which passes between two sheaves at the extremity of the long arm. This also assists to keep the machine in as upright a position as possible, and prevents it from being drifted astern with the current. A weight of as much as 8 or 10 cwt. is required at the bottom of the jackstay in a very strong current. An elongated weight of from 60 to 80 ℔ must be suspended from the eye at the bottom of the meter to help to keep it as vertical as possible. On the outer part of the horizontal notched ring forming the frame, and placed on the side of the machine opposite to the projecting arm G, it has been found necessary to bolt a short arm supported by stays from above, from which is suspended a leaden counterpoise weight to assist in keeping the apparatus upright. This additional fitting is not shown in Fig. 6. A ¾-inch phosphor-bronze wire rope is used for lowering the machine; it is rove through a metal sheave H and indiarubber washer, and spliced round a heart which is attached to metal plate B. The messengers are fitted with a hinged joint to enable them to be placed round the wire rope, and secured with a screw bolt. To obtain the exact value of a revolution of the small cones it is necessary to make experiments when the actual speed of the current is known, by immersing the meter just below the surface and taking careful observations of the surface-current by means of a current log or weighted pole. From the number of revolutions registered by the meter in a certain number of minutes, and taking the mean of several observations, a very fair value for a revolution can be deduced. On every occasion of using the meter for under-current observations the value of a revolution should be re-determined, as it is apt to vary owing to small differences in the friction caused by want of oil or the presence of dust or grit; while the force of the current is probably another important factor in influencing the number of revolutions recorded.

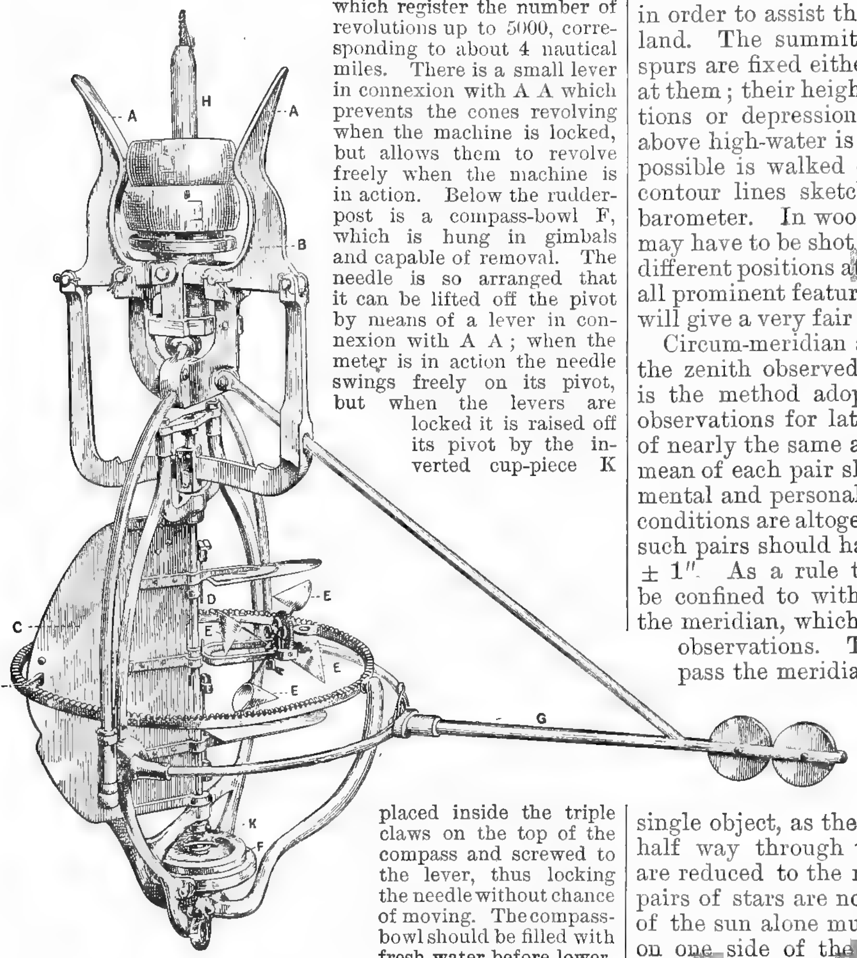

FIG. 6.—Deep-sea Current Meter.

Topography.

The features of the country should generally be delineated as far back as the skyline viewed from seaward, in order to assist the navigator to recognize the land. The summits of hills and conspicuous spurs are fixed either by lines to, or by angles at them; their heights are determined by theodolite elevations or depressions to or from stations whose height above high-water is known. As much of the ground as possible is walked over, and its shape is delineated by contour lines sketched by eye, assisted by an aneroid barometer. In wooded country much of the topography may have to be shot in from the ship; sketches made from different positions at anchor along the coast with angles to all prominent features, valleys, ravines, spurs of hills, &c., will give a very fair idea of the general lie of the country.

Latitudes.

Circum-meridian altitudes of stars on opposite sides of the zenith observed by sextant in the artificial horizon is the method adopted wherever possible for observations for latitudes. Arranged in pairs of nearly the same altitude north and south of zenith, the mean of each pair should give a result from which instrumental and personal errors and errors due to atmospheric conditions are altogether eliminated. The mean of several such pairs should have a probable error of not more than $\pm 1''$. As a rule the observations of each star should be confined to within 5 or 6 minutes on either side of the meridian, which will allow of from fifteen to twenty observations. Two stars selected to "pair" should pass the meridian within an hour of each other, and should not differ in altitude more than 2° or 3°. Artificial horizon roof error is eliminated by always keeping the same end of the roof towards the observer; when observing a single object, as the sun, the roof must be reversed when half way through the observations. The observations are reduced to the meridian by Raper's method. When pairs of stars are not observed, circum-meridian altitudes of the sun alone must be resorted to, but being observed on one side of the zenith only, none of the errors to which all observations are liable can be eliminated.

Chronometer errors.

Sets of equal altitudes of sun or stars by sextant and artificial horizon are usually employed to discover chronometer errors. Six sets of eleven observations, A.M. and P.M., observing both limbs of the sun, should give a result which, under favourable conditions of latitude and declination, might be expected to vary less than two-tenths of a second from the normal personal equation of the observer. Stars give equally good results. In high latitudes sextant observations diminish in value owing to the slower movement in altitude. In the case of the sun all the chronometers are compared with the "standard" at apparent noon; the comparisons with the chronometer used for the observations on each occasion of landing and returning to the ship are worked up to noon. In the case of stars, the chronometer comparisons on leaving and again on returning are worked up to an intermediate time. A convenient system, which retains the advantage of the equal altitude method, whilst avoiding the necessity of waiting some hours for the P.M. observation, is to observe two stars at equal altitudes on opposite sides of the meridian, and combining the observations, treat them as relating to an imaginary star having the mean R.A. and mean declination of the two stars selected, which should have nearly the same declination, and should differ from 4^h to 8^h in R.A.

Meridian distances.

The error of chronometer on mean time of place being obtained, the local time is transferred from one observation spot to another by the ship carrying usually eight box chronometers. The best results are found by using travelling rates, which are deduced from the difference of the errors found on leaving an observation spot and returning to it; from this difference is eliminated that portion which may have accumulated during an interval between two determinations of error at the other, or any intermediate, observation spot. A travelling rate may also be obtained from observations at two places, the meridian distance between which is known; this rate may then be used for the meridian distance between places observed at during the passage. Failing travelling rates, the mean of the harbour rates at either end must be used. The same observer, using the same instrument, must be employed throughout the observations of a meridian distance.

If the telegraph is available, it should of course be used. The error on local time at each end of the wire is obtained, and a number of telegraphic signals are exchanged between the observers, an equal number being transmitted and received at either end. The local time of sending a signal from one place being known and the local time of its reception being noted, the difference is the meridian distance. The retardation due to the time occupied by the current in travelling along the wire is eliminated by sending signals in both directions. The relative personal equations of the observers at either end, both in their observations for time, and also in receiving and transmitting signals, is eliminated by changing ends and repeating the operations. If this is impracticable, the personal equations should be determined and applied to the results. Chronometers keeping solar time at one end of the wire, and sidereal time at the other end, materially increase the accuracy with which signals can be exchanged, for the same reason that comparisons between sidereal clocks at an observatory are made through the medium of a solar clock. Time by means of the sextant can be so readily obtained, and within such small limits of error, by skilled observers, that in hydrographic surveys it is usually employed; but if transit instruments are available, and sufficient time can be devoted to erecting them properly, the value of the work is greatly enhanced in high latitudes.

True bearings.

True bearings are obtained on shore by observing with theodolite the horizontal angle between the object selected as the zero and the sun, taking the latter in each quadrant as defined by the cross-wires of the telescope. The altitude may be read on the vertical arc of the theodolite; except in high latitudes, where a second observer with sextant and artificial horizon are necessary, unless the precise errors of the chronometers are known, when the time can be obtained by carrying a pocket chronometer to the station. The sun should be near the prime vertical and at a low altitude; the theodolite must be very carefully levelled, especially in the position with the telescope pointing towards the sun. To eliminate instrumental errors the observations should be repeated with the vernier set at intervals equidistant along the arc, and A.M. and P.M. observations should be taken at about equal altitudes.

At sea, true bearings are obtained by measuring with a sextant the angle between the sun and some distant well-defined object making an angle of from 100° to 120°, and observing the altitude of the sun at the same time, together with that of the terrestrial object. The sun's altitude should be low to get the best results, and both limbs should be observed. The sun's true bearing is calculated from its altitude, the latitude, and its declination; the horizontal angle is applied to obtain the true bearing of the zero. On shore the theodolite gives the horizontal angle direct, but with sextant observations it must be deduced from the angular distance and the elevation.

For further information see WHARTON, *Hydrographical Surveying* (London, 1898); SHORTLAND, *Nautical Surveying* (London, 1890). (A. M. F*.)

Sus, an important province of southern Morocco (*q.v.*), once an independent kingdom, and still too unruly to be opened to Europeans, who have nevertheless for centuries past made repeated attempts, official and private, to secure admission or a foothold. Its principal towns are Tarudant, Iligh (the old capital), and Glîmîn on the Wad Nûn. Ports might be opened at Agadîr Ighîr (once the Santa Cruz of the Portuguese), Massa, Ifnî, Arksîs, and Assáka, at the mouth of the Nûn. As a coveted district, all descriptions of natural riches are attributed to Sûs, but in the present state of ignorance it may safely be assumed that they are much exaggerated. Europeans land at their peril, since the coast as far as Cape Bojador, 26° N., is recognized as Moorish territory, and as such it is by imperial order closed to trade, no custom-houses being provided. The inhabitants and language of Sus are principally Berber, but the Arabs and their tongue predominate in the extreme south.

Susquehanna, a river whose course for the most part is through Pennsylvania, U.S.A., rises in two branches, the North Branch, whose source is in southern New York, and the West Branch, whose source is in north-western Pennsylvania. The two branches, after tortuous courses among the ridges and valleys of the Appalachians, unite at Sunbury, Pennsylvania, and the river thence pursues a nearly straight course in a direction a little east of south to its mouth at the head of Chesapeake Bay. Its total length, following the North Branch, is 422 miles, and it drains an area of 27,655 square miles. The course of the river is shallow and rapid, and it is therefore of no value for purposes of navigation. Its valley and that of its main tributary, the Juniata, are, however, of the utmost importance in affording easy routes for railways.

Sussex, a southern and maritime county of England, is bounded W. by Hampshire, N. by Surrey, N.E. by Kent, and S. by the English Channel.

Area and Population.—The area of the ancient county is 933,269 acres or 1458 square miles, with a population in 1881 of 490,505, in 1891 of 550,446, of whom 253,438 were males and 297,008 females, and in 1901 of 605,052, the number of persons per square mile being 415, and of acres to a person 1·54. The area of the administrative county of East Sussex, including Brighton and Hastings, is 530,255 acres, with a population in 1901 of 450,697; and West Sussex an area of 402,478 acres, with a population of 151,541. Since 1891, however, various changes in the administrative area have been made: in 1895 the part of the parish of Broomhill in Kent was transferred to East Sussex, and the parts of the parishes of Horsemonden and Lamberhurst in East Sussex were transferred to Kent; in the same year the part of the parish of Bramshott in West Sussex was transferred to Southampton, and the parish of Crawley in East Sussex to West Sussex; and in 1897 the parts of the parishes of Fairlight, Hollington, Ore, and St Matthews were transferred from East Sussex to the county borough of Hastings. The area of the registration county is 938,630 acres, with a population in 1891 of 554,542, of which 324,363 were urban and 230,179 rural; and in 1901 of 605,763. Within the registration area the increase of population between 1881 and 1891 was 12·20 per cent., and between 1891 and 1901, 9·2 per cent. The excess of births over deaths between 1881 and 1891 was 63,018, and the actual increase of population was 60,304. The following table gives the numbers of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1898:—

Year.	Marriages.	Births.	Deaths.	Illegitimate Births.	
				Males.	Females.
1880	3326	14,942	8277	359	359
1890	3522	13,472	8541	405	343
1898	4173	13,756	8663	362	388

The number of marriages in 1899 was 4223, of births 13,861, and of deaths 9595.

The following table gives the marriage-, birth-, and death-rates per thousand of the population, with the percentage of illegitimate births, for a series of years :—

	1870–79.	1880.	1880–89.	1890.	1888–97.	1898.
Marriage-rate .	14·0	13·6	12·7	12·8	13·1	13·9
Birth-rate . .	30·2	30·5	28·4	24·8	24·7	22·9
Death-rate . .	17·5	16·9	15·9	15·5	15·1	14·4
Percentage of illegitimacy . .	5·2	4·8	5·3	5·6	5·4	5·5

Both the birth-rate and the death-rate are a good deal below the average. In 1891 the number of Scots in the county was 3493, of Irish 3963, and of foreigners 3551.

Constitution and Government.—The parliamentary and judicial arrangements are stated in the original article on the county. For administrative purposes Sussex is divided into two counties, East and West Sussex, and it also includes the county boroughs of Brighton and Hastings. East Sussex contains six municipal boroughs: Brighton (123,478), Eastbourne (43,337), Hastings (65,528), Hove (36,542), Lewes (11,249), and Rye (3900). The urban districts in this division are Battle (2996), Bexhill (12,210), Burgess Hill (4888), Cuckfield (1813), East Grinstead (6094), Haywards Heath (3717), Newhaven (6772), Portslade-by-Sea (5217), Seaford (3355), and Uckfield (2895). In West Sussex there are three municipal boroughs: Arundel (2738), Chichester (12,241), and Worthing (20,006). The urban districts are Bognor (6180), Horsham (9446), Littlehampton (7363), and New Shoreham (3837). The ancient county, which is almost entirely in the diocese of Chichester, contains 393 entire ecclesiastical parishes or districts, and parts of eight others.

Education.—At Brighton there is a residential training college (Chichester Diocesan) for schoolmistresses, and there is another at Chichester (Bishop Otter's Memorial). In Brighton there are a home blind school, a deaf and dumb institution, and an asylum for the blind. The total number of elementary schools in the county on 31st August 1899 was 439, of which 106 were board and 333 voluntary schools, the latter including 302 National Church of England schools, 1 Wesleyan, 23 Roman Catholic, and 8 "British and other." The average attendance at board schools was 42,307, and at voluntary schools 52,674. The total school board receipts for the year ended 29th September 1898 were over £150,214. The income under the Technical Instruction Act was over £1072, and that under the Agricultural Rates Act was over £2133. There is an important high-class school at Brighton, and many private educational establishments there and at other towns on the coast.

Agriculture.—About three-fourths of the total area of the county is under cultivation, and of this nearly three-fifths is in permanent pasture. There are also over 17,000 acres in hill pasture, over 3000 acres under orchards, and about 125,000 acres under woods. Within the last twenty years the acreage under corn crops has decreased by about a third, the decrease being chiefly in the acreage under wheat, which is now rather surpassed by that under oats, the two together occupying eleven-twelfths of the whole. Potatoes are not much grown, the acreage under green crops being devoted mainly to turnips and other food for cattle, and the supply of the usual varieties of vegetables for the London market. Many cattle are kept both for breeding and dairy purposes. The acreage under hops has within the last fifteen years decreased 50 per cent., and is now only about 5000 acres, or about 2000 acres less than Hereford, and only about a sixth of the hop acreage of Kent. Small fruit occupies over 1100 acres. The following table gives the larger main divisions of the cultivated area at intervals from 1885 :—

Year.	Total Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885	680,943	176,516	76,467	65,542	333,653	18,039
1890	684,785	169,505	67,350	64,857	358,250	17,236
1895	678,559	144,872	62,163	61,306	381,146	20,071
1900	666,292	135,950	58,740	61,148	392,340	12,044

The following table gives particulars regarding the principal live-stock for the same years :—

Year.	Total Horses.	Total. Cattle.	Cows or Heifers in Milk or in Calf.	Sheep.	Pigs.
1885	25,017	113,153	39,707	537,837	42,873
1890	25,217	110,717	42,570	503,829	46,822
1895	25,552	103,883	43,168	446,416	48,048
1900	24,421	115,877	49,551	434,236	38,781

Industries and Trade.—The total number of persons employed in factories and workshops in 1897 was 14,344, as compared with 12,900 in 1896. Non-textile industries employed 8533 persons, of whom 2694 were employed in the manufacture of machines, appliances, conveyances, and tools (many of them in the works of the London, Brighton, and South Coast Railway Company at Brighton), 1184 in drink industries, and 1437 in the manufacture of paper, &c. Of the 5764 persons employed in workshops, 3028 were employed in clothing industries. In 1899, 218,468 tons of chalk were raised, 54,994 tons of clay, 18,630 of gravel and sand, and 10,923 tons of chert and flint. The only valuable mineral is gypsum, of which in 1899, 18,454 tons were raised, valued at £6229. The development of what promised to be an extensive natural gas field was begun at Heathfield by a private company in 1901. The fisheries are of great importance, including cod, herrings, mackerel, sprats, plaice, soles, turbot, shrimps, crabs, lobsters, oysters, mussels, cockles, whelks, and periwinkles. In 1899, 70,745 cwt. of fish, valued at £57,567, was landed at the several fishing stations in the county. Shell-fish was further valued at £8907.

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Sutherlandshire, a northern maritime county of Scotland, is bounded E. by Caithness, S.E. by the Moray Firth, S. and S.W. by Ross and Cromarty, and N. and W. by the Atlantic and the North Sea.

Area and Population.—According to the latest official estimate, the area of the county (foreshore excluded) is 1,345,480 acres, or 2102 square miles. The population was, in 1881, 23,370; 1891, 21,896; in 1901, 21,550, of whom 10,550 were males and 11,000 females. Taking the land area only (1,197,848 acres of land or 2027·9 square miles), the number of persons to the square mile in 1901 was 10·6 and the number of acres to the person 55·5, the county being the most sparsely populated in Scotland. Between 1881 and 1891 the population decreased by 6·35 per cent. Between 1881 and 1891 the excess of births over deaths was 1455, and the decrease of the resident population 1474. The following table gives particulars of the births, deaths, and marriages, with the percentage of illegitimacy in 1880, 1890, and 1899 :—

Year.	Deaths.	Marriages.	Births.	Percentage of Illegitimates.
1880	260	85	518	5·5
1890	378	84	445	6·97
1899	370	91	465	4·5

The following table gives the birth-rate, death-rate, and marriage-rate per thousand of the population for a series of years :—

	1880.	1881–90.	1890.	1891–98.	1899.
Birth-rate . .	23·08	22·94	21·08	21·82	22·48
Death-rate . .	16·04	16·22	17·91	16·55	17·89
Marriage-rate .	3·79	3·19	3·98	3·24	4·40

In 1891 the number of Gaelic-speaking persons in the county was 14,786, of whom 1115 spoke Gaelic only, and there was one foreigner. Valuation in 1889–90, £94,320; 1899–1900, £93,594.

Administration.—The county returns a member to Parliament, and Dornoch (624), the county town, is one of the Wick group of parliamentary burghs, and the only royal burgh. There are 13 civil parishes, which form a poor-law combination; the number of paupers and dependents at September 1899 was 991. Sutherland is embraced in the same sheriffdom with Ross and Cromarty, and there is a resident sheriff-substitute in the county town.

Education.—Thirteen school boards manage 43 schools, which had an average attendance of 2803 in 1898–99, while one private school had 38. Eight schools give higher education, and the "residue" grant is expended in bursaries.

Agriculture.—In 1898 only 2·4 per cent. of the area was under cultivation, the county ranking lowest in Scotland in this regard. The great mass is grazing ground and forest. In 1895 there were 19,641 acres under wood, 302 of which had been planted since 1881. An attempt is being made to repeople Strathnaver, one of the glens depopulated in the famous Sutherland clearances of the second decade of the 19th century. Of the 2600 holdings in 1895, the date of the last return, the average size was 12 acres; 64·92 per cent., the highest proportion in Scotland, were under 5 acres; 31·23 were between 5 and 50 acres, and only 3·85 over 50. Forty-three were between 50 and 100 acres, 44 between 100 and 300, and only 12 over 300. The following table gives the principal acreages at intervals of five years from 1885:—

Year.	Area under Crops.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885	40,058	10,424	5190	7856	9260	7328
1890	31,078	9,767	4831	8089	8043	342
1895	31,816	9,622	4857	8207	9078	47
1899	32,884	9,386	4805	9062	9530	100

The following table gives particulars of the live-stock during the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or Calf.	Sheep.	Pigs.
1885	2641	12,569	5469	214,303	1248
1890	2495	10,814	5293	202,931	1028
1895	2678	12,002	5536	203,681	955
1899	2685	12,051	5814	208,540	815

In the period 1886–98 the Crofters' Commission disposed of 2562 applications in the county to fix fair rents, and reduced an aggregate rental of £7952 to £7253, wiping off £1647 out of arrears amounting to £6172. In the same period 822 applications for enlargement of holdings were dealt with, and 25,802 acres were added to existing holdings. At the census of 1891, 3170 men and 650 women were returned as being engaged in agriculture.

Industries and Trade.—At Helmsdale (1323), the only port of any consequence, a new harbour 3 acres in extent, with a breakwater 700 feet long, has been built in recent years, and several small harbour works have been undertaken by the county council with the help of Treasury grants. Nine Sutherland ports are included in the Lochbroom fishery district, the statistics of which will be found under Ross and Cromarty; and six of the eight ports in the Helmsdale district belong to Sutherland. The county ports of both districts had, in 1899, 279 boats of 2372 tons, 691 resident fishermen and boys, and the fish landed was valued at £16,069. The following table gives comparative statistics for the Helmsdale district alone:—

Year.	Boats.			Value of Gear.	Resident Fishermen and Boys.	Total Value of all Fish.
	No.	Tons.	Value.			
1890	191	1843	£7750	£8666	641	£16,204
1898	198	2221	£7335	£9803	414	£17,100
1899	197	2172	£7137	£9838	413	£14,301

Of the total value of fish caught in 1899, £8861 was the value of herrings only. The number of persons employed in the district at the various branches of the sea fisheries was 1143. A light railway 7½ miles long is being built from Mound to Dornoch.

AUTHORITIES.—R. MACKAY. *House and Clan of Mackay.* 1829.—Sir W. FRASER. *The Sutherland Book.* Edinburgh, 1892.—D. MACLEOD. *The Gloomy Memories of Sutherland.*—MACKENZIE. *Highland Clearances.* Inverness, 1883.—HARVIE-BROWN. *Fauna of Sutherland.*—D. W. KEMP. *Pococke's Tour in Sutherland.* Edinburgh, 1888.—A. MACKAY. *Sketches of Sutherland Characters.* Edinburgh, 1889.—W. B. NICHOLSON. *Golspie.* London, 1897.—J. MACKAY. *The Reay Fencibles.* Glasgow, 1892.—H. MORRISON. *Guide to Sutherland and Caithness.* Wick, 1883.—A. GUNN and J. MACKAY. *Sutherland and the Reay Country.* Glasgow, 1897.—D. SAGE. *Memorabilia Domestica.* Wick, 1889.

(W. WA.)

Sutton, a town in the Epsom parliamentary division of Surrey, England, 11 miles by rail from London (Victoria). Among the buildings are the parish church of St Barnabas, a technical institute, and a Masonic hall. A cemetery was opened in 1890. Population of the urban district and parish (1891), 13,977; (1901), 17,224.

Sutton-in-Ashfield, a parish, town, and railway station in the Mansfield parliamentary division of Nottinghamshire, England, 3 miles west-south-west of Mansfield. Recent erections are a town hall, a public hall, and a free library. Area of township (an urban district), 4879 acres. Population (1881), 8523; (1891), 10,562; (1901), 14,862.

Suwałki, a government in the extreme north-east of Russian Poland, bordering on Prussia. It has an area of 4846 square miles, and a domiciled population which numbered 606,573 in 1883, and 738,632 in 1899, when there were 371,609 women, and the urban population numbered 69,834. The majority (389,424) of the inhabitants are Lithuanians, mostly found in the north; there are 159,427 Poles (and Mazurs), chiefly occupying the towns; 118,712 Jews; 39,107 Germans; and 31,026 Russians. The chief towns of the seven districts into which the government is divided are Suwałki (22,646 inhabitants), Augustowo (12,746), Kalwarya (8420), Mariampol (6298), Seiny (3771), Wilkowiszki or Volkovyshki (9101), and Władisławow (3988). The standard of education is about the average in Poland; in 1898 there were 189 primary schools attended by 7603 boys and 2544 girls. A good feature of these schools was that no less than 150 village schools had gardens for teaching gardening, and bees were kept in 13 schools. No less than 856,410 acres were under crops in 1900. The average yield in 1895–99 was: rye, 2,580,000 cwt.; wheat, 534,000 cwt.; oats, 1,220,000 cwt.; barley, 659,000 cwt.—all cereals, 5,270,000 cwt.; also potatoes, which are largely grown for distilleries, 5,179,000 cwt. There were in the province in 1897 114,030 horses, 181,700 horned cattle, 341,640 sheep, and 165,450 pigs. Bee culture is widely spread, and about 40,000 ℔ of honey are obtained every year. The weaving of linen and plain woollen cloth and fishing-nets is extensively carried on in the villages as a domestic industry, and in 1899 there were, too, 631 factories, but most of them were small, and their aggregate returns did not total more than 3,000,000 roubles. Thus a great number of the inhabitants are still compelled to seek work in winter in the other provinces. The felling of timber, which is floated down the Nyeman, gives occupation to large numbers. The Nyeman is navigated by steamers between Grovno and Kovno.

Suwałki, the capital of the above government, is situated 75 miles north-west of Grodno. It is well built, and one of the best kept towns in Poland. Its trade is chiefly in timber, grain, woollen cloth, and other manufactured goods. Its population in 1899 was 27,165.

Definition.

Suzerainty.—"Suzerain," a term of feudal law, is now used to describe persons or states in positions of superiority to others. Its etymology, according to Professor Skeat (*Etymological Dictionary*), is as follows: "A coined word; made from French *sus*, Latin *susum* or *sursum*, above, in the same way as sovereign is made from Latin *super;* it corresponds to a low Latin type *suseranus.*" Another form of the word is souseran (Godefroy, *De l'Ancienne Langue Française*). Suzeran has been defined as "Qui possede un fief dont d'autres fiefs relèvent (*Littré* and *Dictionnaire de l'Académie Française*). Loyseau, in his *Traité des Seigneuries* (1610, 3rd ed., p. 14), explains that there are two kinds of public seigneuries, that is, sovereign seigneurs, possessing *summum imperium*, and suzerains, "Les suzeraines sont celles qui ont puissance supérieure mais non suprème." Elsewhere he says that suzerainty is a form of public seigneuries which has been "usurpée par les particuliers pour laquelle exprimer il nous a fallu forger un mot exprés, et l'appeller suzeraineté, mot qui est aussi étrange comme celle espece de seigneuries est absurde" (p. 11). Loyseau adds, "Seigneurie suzeraine est dignité d'un fief ayant justice" (p. 38). Bousquet (*Nouveau Dictionnaire de Droit*) defines suzerain as "supérieur, celui dont un fief relevait"; Rogulau (*Glossaire du Droit François*), "superieur en quelque charge ou dignité autre que le roy." The name does not occur in the *Consuetudines Feudorum*, or in Hotoman's *De Verbis Feudalibus Commentarius.* It was rare in feudal times in England. But it was used in France to describe a feudal lord, the supreme suzerain being the king. Merlin, under "suzeraineté," shows that the word was not used by all feudal writers in the same sense. (See also Butler's note to *Coke on Litt.*, 191 *a.*)

Modern usage.

In modern times the term has come to be used as descriptive of relations, ill-defined and vague, which exist between powerful and dependent states; its very indefiniteness being its recommendation. According to feudal law the vassal owed certain duties to the lord; he promised fidelity and service; and the lord was bound to perform reciprocal duties, not very clearly defined, to the vassal—*Dominus vassallo conjux et amicus dicitur.* The relation between a lord and his vassals, implied in the oath of fealty, has been extended to states of unequal power; it has been found convenient to designate certain states as vassal states, and their superiors as suzerains. Originally and properly applicable to a status recognized by feudalism, the term vassal state has been used to describe the subordinate position of certain states once parts of the Ottoman Empire, and still loosely connected therewith. Such are Egypt and Bulgaria. Rumania, Servia, and Montenegro, once vassal states, may now be regarded as independent. The relations of these states to the Ottoman Porte are very varied. Egypt has been variously described as a vassal state or as a protectorate. But all of these pay tribute to the Sultan, or in some way acknowledge his supremacy (Ullmann, *Völkerrecht*, s. 16); M. de Martens (*Traité de Droit International*, 1883, i. 333, n.) thus defines the term: "La suzeraineté est la souveraineté limitée exercée par le pouvoir suprême d'un état sur un gouvernment mi-souverain," a definition applicable to protectorates, with which it is often confounded. Thus Mommsen (*History of Rome*) indiscriminately describes the supremacy of Rome over Armenia as "suzerainty" or "protectorate." To illustrate the vague use of the word in modern diplomacy may be quoted the description of suzerainty given by Lord Kimberley, which Mr Chamberlain in the correspondence as to South Africa mentioned with approval: "Superiority over a state possessing independent rights of government subject to reservations with reference to certain specified matters" (1899 [C., 9057], p. 28).

Protectorates and suzerainty.

M. Gairal (*Le Protectorat International*) distinguishes suzerainty from protectorate in these respects: (*a*) suzerainty proceeds from a concession on the part of the suzerain (p. 112); (*b*) the vassal state is bound to perform specific services; and (*c*) the vassal state has larger powers of action than those belonging to a protected state; (*d*) there is reciprocity of obligation. According to M. Despagnet, the term suzerain is applicable to a case in which a state concedes a fief, in virtue of its sovereignty (*Essai sur le Protectorat International*, p. 46), reserving to itself certain rights as the author of this concession.

Another writer draws these distinctions: (*a*) a state connected by protectorship with another previously enjoyed autonomy; the vassal state did not; (*b*) the protected state retains its nationality and its internal administration; the vassal state acquires a distinct nationality; (*c*) the establishment of a protectorate modifies few of the institutions of the protectorate state except as to foreign relations; the establishment of a suzerainty changes the institutions of the vassal state; (*d*) the protected state exercises its internal sovereignty *a peu prés pleinement;* the vassal state remains subordinate in several respects; (*e*) while the protected state has the right to be assisted in case of war by the protecting state, but is not bound to defend the latter, the vassal state is bound to aid its suzerain (Tchomacoff, *De la Souveraineté*, p. 53). See also Hachenburger, *De la Nature Juridique du Protectorat.*

Hall thus defines vassal states: "States under the suzerainty of others are portions of the latter which during a process of gradual disruption or by the grace of the sovereign have acquired certain of the powers of an independent community, such as that of making commercial conventions or of conferring their exequatur on foreign consuls. Their position differs from that of the foregoing varieties of states (protectorates, &c.), in that a presumption exists against the possession by them of any given international capacity (*International Law,* 4th ed., p. 31).

Another suggested distinction is this: Suzerainty is title without corresponding power; protectorate is power without corresponding title (Professor Freund, *Political Science Quarterly*, p. 28, 1899).

On the whole, usage seems to favour this distinction: while a protectorate flows from, or is a reduction of, the sovereignty of the protected state, suzerainty is conceived as derived from, and a reduction of, the sovereignty of the dominant state.

As to the power of making treaties, a vassal state cannot, as a rule, conclude them; such power does not exist unless it is specially given. On the other hand, a protected state, unless the contrary is stipulated, retains the power of concluding treaties (Bry, p. 294).

There is one practical difference between the two relations: while the protecting and protected states tend to draw nearer, the reverse is true of the suzerain and vassal states; a protectorate is generally the preliminary to incorporation, suzerainty to separation. Sometimes it is said that the territory of the vassal state forms part of the territory of the suzerain; a proposition which is true for some purposes, but not for all.

Instances of suzerainty.

All definitions of suzerainty are of little use. Each instrument in which the word is used must be studied in order to ascertain its significance. Even in feudal times suzerainty might be merely nominal, an instance in point being the suzerainty or over-lordship of the Papacy over Naples. In some cases it may be said that suzerainty brings no practical advantages and implies no serious obligations. Among the instances in which the term is actually used in treaties are these: the General Treaty, Peace of Paris, 1856 (Article 21 and 22), recognized the suzerainty of Turkey over the Danubian Principalities, Moldavia and Wallachia, modifying the "sovereignty" of Turkey recognized by the Treaty of Adrianople. "Les Principautés de Valachie et de Moldavia continueront à jouir, sous la suzeraineté de la Porte et sous la garantie des Puissances contractantes, des privilèges et des immunités dont elles sont en possession." The convention of 19th August 1858 (Hertslet, x. 1052) organized the then Principalities "under the suzerainty of the Sultan" (Article 1). The internal government was to be exercised by a Hospodar, who received his investiture from the Sultan, the sign of vassalship, it has been said (Tchomacoff, p. 45). The autonomy of these vassal states has been fully recognized by the Treaty of Berlin of 1878 (Article 1). In the Interpretation Act, 1889, s. 18 (5), "suzerainty" is used to describe the authority of the sovereign over native princes.

The word suzerain is used in the Pretoria Convention of 3rd August 1881 between the British Government and the late South African Republic. The convention (by its preamble) granted to the inhabitants complete self-government, "subject to the suzerainty of her Majesty," and this suzerainty was reaffirmed in the articles. Even when the convention was being negotiated doubts arose as to its meaning, and legal authorities were divided as to its effect (see speech of Lord Cairns, *Hansard*, 269, p. 261; Lord Selborne, 260, p. 309; answer of Attorney-General, 260, 1534). It was doubtful whether territory could be ceded by the Crown of its own authority; and if the power existed the cession could, it was said, be made only by virtue of clear words. From the articles substituted in the London Convention of 27th February 1884 for those of 1881, the word "suzerainty" was omitted. Fresh doubts arose as to the effect of this omission; and a correspondence on the subject took place between the British Government and the Government of the Republic before the outbreak of hostilities in South Africa, the former maintaining that the preamble of 1881, by which alone any self-government was granted, was still in force, and therefore that the suzerainty—whatever it involved—remained; the Transvaal Government, on the other hand, contending that the suzerainty had been abolished by the substitution of the 1884 convention for that of 1881. Writers on international law differ greatly as to the exact position of the South African Republic under the later convention. Some considered it an independent sovereign state. Mr Taylor (*A Treatise of International Public Law*, p. 174) treats the Transvaal after the convention of 1884 as a "neutralized state only part sovereign." Other writers describe the relation as that of a protectorate (see Professor Westlake, *Revue de Droit International*, 1896, p. 268 *et seq.*). Professor de Louter defines it as "une servitude du droit des gens (servitus juris gentium), et qui diffère de la servitude du droit privé en ce qu'elle ne constitue pas un droit reel (jus in re aliena) mais un droit entre deux personnes de droit International (subjecta juris gentium) (*Revue de Droit International*, 1899, p. 330). Dr Von Liszt (*Das Völkerrecht*, p. 331) treats the South African Republic as an example of a half sovereign state. M. Gairal describes it as a vassal state. Probably the soundest opinion is that the British Crown reserved no other rights than those expressly stated in the convention of 1884.

See STUBBS. "Suzerainty, or the Rights and Duties of Suzerain and Vassal States," 1882, *Revue de Droit International*, 1896, pp. 39, 278.—WESTLAKE. "L'Angleterre et le Republique Sud-Africaine," *Revue de Droit International*, 1896, p. 268.—BORNHAK. *Einseitige Abhängigskeitsverhältnisse unter den modern Staaten*, 1896.—DR ULLMANN. *Völkerrecht*, s. 16 (1898).—TCHOMACOFF. *De la Souveraineté*, 1901.—JELLINEK. *Die Lehre von den Staatenverbindungen*, 1882.—*Correspondence Relating to South African Republic*, 1899 [C., 9507].—*Law Magazine*, p. 413, 1900; *Law Quarterly Review*, p. 122, 1896; *Journal of Comparative Legislation*, I., N.S., 432. (J. MT.)

Svea, or SVEALAND, the middle of the three great territorial divisions of Sweden, embraces the counties of Stockholm, Upsala, Södermanland, Vermland, Örebro, Vestmanland, Kopparberg, and the county of the city of Stockholm, with a combined area of 32,589 square miles, and population (1880), 1,343,305; (1890), 1,445,744; and (1900), 1,579,954. This is the region of lakes and islands, forests and mines, embracing Lakes Mälar and Hjelmar, Siljan, the upper portion of Wener, and a multitude of smaller sheets of water.

Svendborg, a seaport town of Denmark, capital of Svendborg county, on the south shore of the island of Fünen, 29 miles by rail south from Odense, a picturesque old place, possessed of importance in the 13th century. The harbour is accessible to vessels drawing 20 feet. Svendborg manufactures tobacco and earthenware, and has boatbuilding yards and distilleries. The harbour is entered and cleared by some 5500 vessels of 250,000 tons annually, butter being the principal export, and petroleum, coal, and iron the chief imports. Population (1870), 7184; (1890), 8755; (1900), 11,543.

Svendsen, Johann Severin (1840- ——), Norwegian composer. Born in Christiania, 30th September 1840, Svendsen learnt the elements of music and violin-playing from his father, and after serving for some time in the army, and later touring as violinist with a wandering troup of instrumentalists, he entered the Conservatorium at Leipzig through the aid of the king of Sweden. There David, Dreyschock, Hauptmann, and Richter were his masters. After another tour, which extended to the British Isles, Svendsen spent a year in Paris, and in 1871–72 was leader of the once famous Euterpe Concerts in Leipzig. In 1871 he married an American, and from 1872 to 1877 he conducted the Christiania Musical Society, while in 1877–78–79 he lived in Rome, London, and Paris. Since 1883 Svensden has been Court Capellmeister at Copenhagen. Probably we have to go back to Schubert to find a composer whose Opus 1 has attained the wide popularity of Svensden's A minor string quartet, while his Opus 3, the beautiful octet, carried his name almost at once the wide world over. Though Svendsen was at one time intimate with Wagner, the latter does not seem to have influenced his music, which includes two symphonies, an excellent violin concerto, and a hackneyed romance for violin, as well as a number of orchestral rhapsodies.

Swan, Joseph Wilson (1828- ——), English physicist and electrician, was born at Sunderland on 31st October 1828. After serving his apprenticeship with a chemist in his native town, he became first assistant and later partner in a firm of manufacturing chemists in Newcastle. Among its operations this firm included the manufacture of photographic plates, and thus Swan was led to one of the advances in photography with which his name is associated—the production of extremely rapid dry plates, which were the outcome of an original observation made by him on the effect of heat in increasing the sensitiveness of a gelatino-bromide of silver emulsion. In 1862 he patented the first commercially practicable process for carbon printing in photography. This depended on the fact that when gelatine is exposed to light in the presence of bichromate salts, it is rendered insoluble and non-absorbent of water. Swan took a surface of gelatine, dusted over with lampblack and sensitized with bichromate of ammonium, and exposed it to light below a photographic negative; the result was to make the gelatine from the surface downwards insoluble to a depth depending on the intensity, and therefore penetration, of the light which had reached it through the negative. In this operation the surface of the gelatine was also rendered insoluble, and it therefore became necessary to get at its back in order to be able to wash away the portions that still remained soluble; this was effected by cementing the insoluble surface to a fresh sheet of paper by means of indiarubber solution, and then detaching the original support. It thus became possible to reach the soluble portions with water and to obtain a representation of the picture, though reversed as to right and left, in relief on the pigmented gelatine. This process has been simplified and improved by subsequent workers, but in its essential features it forms the basis of some of the methods of photographic reproduction most widely used at the present day. But Swan's name deserves remembrance even more in connexion with the invention of the incandescent electric lamp than with improvements in photographic technique. He was one of the first to undertake the production of an electric lamp in which, as in the glow lamp of to-day, the light should be produced by the passage of an electric current through a carbon filament, and he was almost certainly far ahead, in point of time, of any other worker in the same field in realizing the conditions to be met and the difficulties to be overcome. So far back as 1860 he constructed an electric lamp with a carbon filament, which was formed by packing pieces of paper or card with charcoal powder in a crucible and subjecting the whole to a high temperature. The carbonized paper thus obtained he mounted in the form of a fine strip in a vacuous glass vessel and connected it with a battery of Grove's cells, which though not strong enough to raise it to complete incandescence, were sufficient to make it red-hot. This was substantially the method adopted by Edison nearly twenty years later, after various fruitless efforts to make a practical lamp with a filament of platinum or a platinum alloy had convinced him of the unsuitability of that metal for the purpose—a conclusion which Swan had reasoned out for himself many years before. By the time Edison had hit upon the idea of carbonizing paper or bamboo by heat to form the filament, Swan had devised the further improvement of using cotton thread "parchmentized" by the action of sulphuric acid, and it was by the aid of such carbon filaments that on 20th October 1880 he gave at Newcastle the first public exhibition on a large scale of electric lighting by means of glow lamps practically identical with those now in universal use. In another method devised by him for the manufacture of filaments, collodion was squirted into a coagulating solution and the tough threads thus obtained carbonized by heat. Dr Swan has also devoted attention to apparatus for measuring electric currents, to the improvement of accumulators, and to the conditions governing the electro-deposition of metals. He was elected a fellow of the Royal Society in 1894, and served as president of the Institution of Electrical Engineers in 1898–99 and of the Society of Chemical Industry in 1901. In the last-named year he received the honorary degree of D.Sc. from Durham University.

Swanage, an urban district and watering-place, Dorsetshire, England, in the Eastern parliamentary division of the county, 10 miles south-east of Wareham by rail. The pier, built in 1896, cost £10,000. The neighbourhood is a beautiful one. Corfe Castle lies 10 miles north-west of the town. Purbeck stone is largely exported. Population (altered area), (1891), 2631; (1901), 3384.

Swansea, a seaport and municipal (extended 1889), county (1888), and parliamentary borough, Glamorganshire, Wales, at the mouth of the Tawe, on Swansea Bay, 202 miles by rail west of London. The seat of a suffragan bishop since 1890, Swansea is divided into 10 wards under a mayor, 10 aldermen, and 30 councillors. In 1885 the parliamentary representation was increased to 2 members. There are 25 churches, 2 Catholic churches, and over 60 Dissenting chapels; also a female training college, intermediate and technical instruction schools, museums, art galleries, public libraries, and many board and National schools. The market has been rebuilt at a cost of £26,000. Victoria Park (16 acres) was opened in 1887, and there are several other parks and pleasure-grounds. In 1891, 3442 persons were engaged in the manufacture of tin and tin goods, about three-quarters of the whole British output of tin-plate being manufactured within a dozen miles of the port; 1192 in the manufacture of copper and copper goods, 1731 in iron and steel manufactures, 341 in the manufacture of zinc and zinc goods, and 831 in mining. There are 3 daily newspapers. In connexion with the docks, covering over 60 acres, there are 30 hydraulic lifts (shipping up to 10 tons of coal a minute) and 62 hydraulic cranes. In 1888 the tonnage of the vessels registered was 59,565 tons; in 1898, 46,985 tons; in 1900, 56,090 tons. In 1890, 4778 vessels of 1,499,529 tons entered and 4593 of 1,464,587 tons cleared; in 1900, 5042 vessels of 2,048,002 tons entered and 5004 of 2,053,116 tons cleared. The total value of the imports of foreign and colonial merchandise in 1900 was £4,682,400, against £2,724,572 in 1888. The total value of the exports in 1900 was £5,951,000, against £3,445,367 in 1888. Area of municipal and county borough, 5963 acres; population (1881), 76,430; (1891), 90,349; (1901), 94,514. The parliamentary representation is divided between Swansea town and Swansea district, which latter includes part of Swansea borough, with the boroughs of Aberavon, Kenfig, Loughnor, and Neath. Area of Swansea town, 4863 acres; population (1881), 50,043; (1891), 57,492. Area of Swansea district, 10,719 acres; population (1881), 50,547; (1891), 59,875.

Swanwick, Anna (1813–1899), English writer and philanthropist, was the youngest daughter of John Swanwick of Liverpool, and was born on the 22nd June 1813. She was educated partly at home and partly at one of the fashionable boarding-schools of the day, where she received the usual education of accomplishments. Dissatisfied with her own intellectual attainments she went in 1839 to Berlin, where she took lessons in German, Greek, and Hebrew. On her return to London she continued these pursuits, along with the study of mathematics. In 1843 appeared her first volume of translations, *Selections from the Dramas of Goethe and Schiller*. In 1847 she published a translation of Schiller's *Jungfrau von Orleans;* this was followed in 1850 by *Faust*, *Tasso*, *Iphigenie*, and *Egmont*. In 1878 she published a complete translation of both parts of *Faust*, which appeared with Retsch's illustrations. It passed through several editions, was included in Bohn's series of translations, and ranks as a standard work. It was at the suggestion of Baron Bunsen that she first tried her hand at translation from the Greek. In 1865 she published a blank verse translation of Æschylus's *Trilogy*, and in 1873 a complete edition of Æschylus, which appeared with Flaxman's illustrations. Miss Swanwick is chiefly known by her translations, but she also published some original work. In 1886 appeared *Books, our Best Friends and Deadliest Foes;* in 1888, *An Utopian Dream and How it may be Realized;* in 1892, *Poets, the Interpreters of their Age;* and in 1894, *Evolution and the Religion of the Future.* Miss Swanwick was interested in many of the social and philanthropic movements of her day. In 1861 she signed John Stuart Mill's petition to Parliament for the political enfranchisement of women. She helped in the higher education movement, took part in the foundation of Queen's and Bedford Colleges, and continued to take a sympathetic interest in the movement which led to the opening of the universities to women. Her work was acknowledged by the University of Aberdeen, which bestowed on her the degree of LL.D. She died in November 1899. (A. Z.)

Swat is the territory on the north-west frontier of India which is comprised in the Swat valley, and does not include that which is drained by its great affluent the Panjkora. The Swat river rises on the southern slopes of the Hindu Koh or Davél mountains, not far from the sources of the Gilgit river, and it joins the Kabul between Michni and Naoshera. Only that portion of the valley which lies beyond the Peshawar frontier hills, and which is reached by the Malakand, the Shahkot, and other passes from the south, is Swat. To the east are the independent hill provinces of Tangir, Kohistan, and Buner, all bordering the Indus, and to the west are Dir and Bajaor, which absorb the Panjkora.

Swat was better known to the ancients, and to the warriors of Baba's time, than it was to us until the frontier risings of 1895–1896 gave our surveyors the opportunity of visiting the country. The ancient name of the river was Suâstos, and that of the Panjkora, Ghoura, under which names they figure in the history of Alexander's campaign. The site of the city Massaga, the capital of the Assakeni, is supposed to be near the modern Manglaor. But since the adoption of the Khaibar as the main high road from Kabul to India the Swat routes had passed into oblivion. Only the lower portion of the Swat valley, where the river intervenes between Malakand and the passes leading to Dir from the Panjkora, is of military significance. The upper valley is closely gripped between mountain spurs stretching southwards from the Hindu Koh, rising to 15,000 feet on one side and 19,000 on the other, leaving but a narrow space between their rugged summits and the banks of the river. The valley, narrow though it is, and traversed by the worst conceivable type of hill tracks, contains many villages or hamlets, and is pretty thickly populated.

The dominating race in Swat is the Yusufzai, an Afghan people who migrated hither from the Kandahar country within historic periods. They are a fine, manly race, living under tribal laws which encourage activity and independence. There are many Yusufzais in the pay of the Indian Government, and they are reckoned amongst the best of Government servants. Hidden amongst the valleys of the higher mountain slopes there are still to be found a remnant of the old Buddhist population, a people allied to the Tibetans, about whom very little is at present known. Beyond the post of Malakand, the chief point of importance to us is Chakdana, where a fort has been built to protect the bridge across the Swat river. Chakdana maintained a gallant defence against the tribespeople in 1897 when Malakand was attacked.

The relative distances to Chitral by the Gilgit route and by Swat may be estimated as follows:—Rail-head at Rawal Pindi to Gilgit about 400 miles; Gilgit to Chitral, 200 miles; total, 600. From the railway at Dargai (to which point the line will ultimately reach), at the southern foot of the Malakand Pass, to Chitral, about 150 miles, or one-fourth of the Gilgit route distance.

The Government of India's political and survey reports for 1896–1897, and Bellew's report on the Yusufzais, are the best recent authorities on the subject of Swat. (T. H. H*.)

Swatow, a treaty port in the province of Kwangtung, China. The trade has shown a reasonable development, the total value in 1899 having been H. taels 44,030,750 (£6,834,000) as compared with H. taels 21,176,000 (£5,838,000) in 1880, the silver valuation (taels), however, more nearly representing the volume; that is to say, while the tael valuation shows an increase of 107 per cent., the pound sterling valuation shows an increase of not more than 17 per cent. Of the imports (£4,794,000 in 1900), consisting principally of cotton goods and opium (each to the extent of over half a million sterling), with kerosene oil, tin, flour, fish, and rice, some 59 per cent. ranks as native Chinese trade and 41 per cent. as international trade. Sugar (£843,750 in 1900) is the principal export; other articles being paper, cloth, tobacco, fruit, beans, and bean cake and bean oil. The shipping which entered in 1900 amounted to 2127 vessels of 2,185,550 tons The former turbulent and anti-foreign character of the people has much toned down of late years. There are now numerous missionary stations within the district.

Swazieland, a mountainous country of British South Africa, about 3000 square miles in area. Lying on the eastern border of the Transvaal, between the Drakensberg and Lobombo ranges, it is separated from the Indian Ocean by a strip of territory known as Tongaland, recently incorporated with Zululand (Natal). The Swazies are a branch of the Bantu family, and are a comparatively industrious and intelligent mountain tribe. They are closely allied to the Zulus, whom they resemble in appearance, and they possess equally fine physique. Swazieland was first constituted a petty native state in 1843, when the Barabuza people under their chief, Swaze, rose against their Zulu oppressors, and according to custom took their name from the founder of their chieftaincy. In 1855 the Swazies, in order to get a strip of territory between themselves and the Zulus, ceded to the Transvaal a narrow piece of land on the Pongola. Ten years later, in response to the demands of the Zulus, this boundary was again altered.

In the Pretoria Convention, which came into existence between Great Britain and the Transvaal after the retrocession of the Transvaal in 1881, the following clause was inserted especially dealing with the Swazies: "The independence of the Swazies within the boundary line of Swazieland, as indicated in the first article of the Convention, will be fully recognized." A similar provision was also made in the London Convention of 1884, when a new set of articles was substituted for those of the Convention of 1881. Neither of these charters of freedom proved of much value to the Swazies. In 1886 the governor of Natal received a paper from Umbandine, the chief of the Swazies, stating that Piet Joubert had called on him and requested him to sign a paper saying that "he and all the Swazies agreed to go over and recognize the authority of the Boer Government, and have nothing more to do with the English." On his refusal the Boers replied to him, "Why do you refuse to sign the paper? You know we defeated the English at Majuba." The Boers further added that if the Swazies were relying on the British, they were leaning on a broken reed, and would find themselves left in the lurch. Subsequently to this incident Umbandine applied to the Colonial Office for British protection, but without result. Later on, in 1887, both Boers and gold prospectors of all nationalities were overrunning his country, and Umbandine asked for a British resident. This request was also refused. The Boers now determined to adopt towards Swazieland the policy which had proved so successful in Zululand. A colony of Boers settled within the Swazie territories and proclaimed "The Little Free State." Umbandine was then at length induced to ask the Transvaal for annexation. The Transvaal applied in 1889 to Great Britain for permission to accede to this request, but the British Government replied that the only intervention to which they could consent must be a dual one. Consequently a joint commission was appointed to visit Swazieland and report on the condition of things there. Sir Francis de Winton, the English commissioner, who was accompanied by Generals Joubert and Smit on behalf of the Transvaal, reported that Umbandine had already granted concessions, such as "postal, telegraphic, banking, customs," &c., to the Transvaal, and concessions of mining and grazing rights to various adventurers. He therefore considered a British Protectorate inadvisable and impracticable, and recommended that the South African Republic should be allowed access through the country to the sea, provided (1st) that England should have the first right to such port if the Transvaal ever gave it up, and (2nd) that the Transvaal should join the Customs Union. This offer, although ratified by a Convention in 1890, when the dual control on the part of Great Britain and the Transvaal over Swazieland was arranged, was not finally accepted by the

Transvaal, as they objected to the clause about the Customs Union. In 1893 a further conference on the Swazie question took place between Sir Henry Loch and President Kruger, the result of which was that the administration of Swazieland, with certain reservations as to the rights of the natives, was practically made over to the South African Republic. The Swazies at this time were governed by a queen regent, who bitterly resented the arrangement come to between Sir H. Loch and President Kruger, and refused to sign the agreement. In the following year six Swazie envoys visited England for the purpose of asking the Queen to take Swazieland under her protection. In view, however, of the arrangement come to, this petition had to be refused. In 1894 a Convention was formally signed between England and the Transvaal, and the Boers, in spite of the Swazie opposition, assumed administration of the country. Ubanu was installed by them as paramount chief.

The Boers' object in intriguing to acquire Swazieland was not merely that of extending their territories. They cherished above all things the idea of getting a road through the country to a seaport of their own—Kosi Bay, from which a railway has now been projected to Standerton on the Durban–Pretoria line. But inasmuch as their acquisition of Swazieland was profoundly distasteful to the Swazies themselves, and was at variance with the whole spirit of both conventions, England was justified in deciding that this policy of expansion could not be tolerated indefinitely, and after strong representations from Sir Henry Loch she declared a protectorate over Tongaland, thus blocking the Boers' farther progress towards the sea. In 1898 the Boer administration of Swazieland again called for a protest from the British Government, who pointed out that the Boers were not fulfilling the terms of the Convention of 1894, which reserved certain privileges and rights of self-government to the natives. The war of 1899 diverted attention from the Swazies, but after the flight of the sanguinary King Ubanu in 1898, a provisional government was carried on at the chief kraal by the queen regent; and in the absence of any white control a good many excesses were committed. Under the Boer régime "concessions" of various public interests were acquired by the Transvaal Government, and various other concessions were granted to private individuals, including "banking."

In 1899 the European inhabitants of Swazieland were estimated by Mr Allister M. Miller, for several years a resident in the country, at about 1600. The natives are estimated at between 70,000 and 80,000. The imports are valued at £90,000; exports, £26,000. This discrepancy is due to the fact that the larger mining and land companies with auriferous and other mineral areas have hitherto spent a good deal more on their mines than they have been able to recover. Under more favourable auspices the auriferous belt, stated to be about 250 square miles in extent, might prove to contain payable mines. In addition to gold, tin, copper, and coal are said to be among the mineral resources of the country. Swazieland offers decided inducements to the stock farmer and agriculturist. Water is plentiful, and the general character of the country is much like that of Natal. It is believed that out of the five million acres which the country contains, at least two millions are adapted to the requirements of the small agriculturist. The soil is in many parts rich, and the climate is genial and healthy, except in some of the deeper valleys.

THEAL. *History of South Africa.*—MILLER. "*Swazieland,*" *Journal Royal Colonial Institute.*—PRATT. *Leading Points in South African History.*

(A. P. H.; A. H. K.)

Sweating System.—The "sweating system" is a term loosely used in connexion with oppressive industrial conditions in certain trades. This "system" originated early in the 19th century, when it was known as "the contract system." Contractors supplying the Government with clothing for the army and navy got the work done by giving it out to sub-contractors, who in some cases made the garments or boots themselves with the assistance of other workmen, and in others sublet their sub-contracts to men who carried them out with similar help. Afterwards this plan was adopted in the manufacture of ready-made clothing for civilian use, and of "bespoke" garments (made to the order of the customer). Previously the practice had been for coats, &c., to be made up by workmen employed on the premises of the master tailor or working together in common workshops, but in either case directly employed by the master tailor. The new plan brought a large number of workpeople possessing little skill and belonging to a very needy class into competition with the regular craftsmen; and in consequence a fall in wages took place, which affected, to a greater or less extent, the whole body of workmen in the tailoring trade. The work was done in overcrowded and insanitary rooms, and the earnings of the workers were extremely low. In 1850 a vigorous agitation against "the sweating system" was commenced, based mainly upon a series of articles in the *Morning Chronicle*, which were followed by a pamphlet, *Cheap Clothes and Nasty*, written by Charles Kingsley under the name of "Parson Lot," and by his novel *Alton Locke*. Kingsley and his friends, the Christian Socialists, proposed to combat the evils of the sweating system by promoting the formation of co-operative workshops; and several experiments of this nature were made, which, however, met with little success. Except that in 1876–77 the outcry against the sweating system was renewed (principally on the ground of the risk of infection from garments made up in insanitary surroundings), the matter attracted little public notice until 1887, when the system again came into prominence in connexion with the immigration of poor foreigners into East London, where large numbers of these people were employed in various trades, especially in the tailoring, boot-making, and cabinet-making industries, under conditions generally similar to those complained of in the earlier agitations. In 1888 a Select Committee of the House of Lords was appointed to inquire into the subject; and after a lengthy investigation — in the course of which evidence was given by 291 witnesses in relation to tailoring, boot-making, furriery, shirt-making, mantle-making, cabinet-making and upholstery, cutlery and hardware manufacture, chain and nail making, military accoutrements, saddlery and harness-making, and dock labour—this committee presented its final report in April 1890. The committee found themselves unable to assign an exact meaning to the term "sweating," but enumerated the following conditions as those to which that name was applied:—"(1) A rate of wages inadequate to the necessities of the workers or disproportionate to the work done; (2) excessive hours of labour; (3) the insanitary state of the houses in which the work is carried on." They stated that, "as a rule, the observations made with respect to sweating apply, in the main, to unskilled or only partially skilled workers, as the thoroughly skilled workers can almost always obtain adequate wages." With regard to the sweating system, the committee declared that this cannot be regarded as responsible for the industrial conditions described; for "the middleman is the consequence, not the cause of the evil; the instrument, not the hand which gives motion to the instrument, which does the mischief. Moreover, the middleman is found to be absent in many cases in which the evils complained of abound." While, on the one hand, we find, as pointed out by this committee, that "sweating" exists without the presence of the "middleman" (the fact being that many grossly underpaid workpeople are in the direct employment of large firms), it is, on the other hand, no less true that the "middleman" (*i.e.*, subordinate employer) is common in numerous trades in which there is no trace of any such oppression of the workpeople employed by the sub-contractors as is denoted by the term "sweating." Thus, for example, in shipbuilding in many cases men work in squads, the leading workmen employing their own helpers; in the cotton trade the mule-minders engage and pay their own piecers, and the weavers their own tenters; in the manufactured iron trade, in mining, &c., a good deal of work is done under sub-employers employing their own assistants, none of these sub-contractors being alleged to "sweat" their helpers. There is, in short, no system of employment which can properly be called "the sweating system." At the same time, wherever workers possessing a small degree of skill and deficient in organization are employed under a number of small masters, there "sweating" is likely to obtain.

The common idea, that the "sweater" is an unscrupulous tyrant, who fulfils no useful function, and who makes enormous profits, has no counterpart in fact. Whatever may have been the case in earlier days, before the internecine competition of the "middlemen" had time to produce its inevitable effects upon the position of these sub-employers, it may now be considered to be beyond dispute that the small master ("sub-contractor," "garret-master," "fogger," &c.) usually works at least as hard as his employés, and that his gains are, as a rule, no more than a fair return for the work which he performs—work which in many instances consists in doing some difficult part of the job, and in all cases in organizing the labour engaged. So far as concerns the "manufacturer," by whom the "sweater" is employed, and who is clearly the *causa causans* of "the sweating system," for him the practice of getting his work done in outside workshops is undoubtedly convenient, especially in localities where rent is high, because he is saved the expense of providing accommodation for those who do his work. He is also free from restrictions as to the subdivision of labour and the employment of a certain class of workpeople which the sentiment of the regular factory workers would impose upon him. The regular tailor, for example, thinks that no one who has not, by a lengthy period of tuition, acquired the capacity to make a coat "right out" ought to be allowed to enter the tailoring trade. But in the workshop of the sub-contractor the work is split up into fractions, each of which is soon learned, so that it becomes possible to introduce into the trade persons possessing no previous training, and generally willing to work for wages far lower than those to which the regular tailors consider themselves entitled, and which, so long as they are not exposed to the competition of these outsiders, they are usually able to secure. On the other hand, while it may suit the manufacturer, anxious to keep down the cost of production, to give his work out to middlemen, it is beyond question that any form of the "small master" system is necessarily liable to abuse in many directions. Among these small masters the eagerness to secure employment is usually so keen, that the work is often taken at a price too low for it to be possible for these sub-employers to pay to their workpeople wages adequate to provide the reasonable requirements of working-class life. The workshops of the middlemen are scattered over large districts, and these little masters frequently remove their business from one house to another. Both of these are circumstances which tend strongly to make efficient regulation by the factory and the sanitary inspectors very difficult. Not seldom, especially when trade is brisk, these work-places are overcrowded in a manner injurious to health, and in not a few cases their sanitary condition is defective. It will readily be understood that combination among the people employed in these numerous small isolated work-places is much less easy than among the compact bodies of workers employed in large factories, so that any attempt to resist oppressive conditions of employment by trade union organization meets with serious obstacles. But perhaps the worst of all the features which this method of manufacture presents is the absence of motor power and machinery. The fact that a manufacturer has laid out a large sum in plant, thus entailing a heavy expenditure in "standing charges," necessarily induces him to do his best to make employment regular. In the little outside workshop, on the other hand, lengthy spells of enforced idleness are followed by short periods of most severe toil, during which the hours of daily labour are prolonged to an inhuman extent. At the same time, the workpeople employed in the ill-equipped workshop of the little master are competing with the much more efficient production of the factory provided with labour-saving machinery driven by steam or other mechanical power; and in many cases their only chance of retaining the work under these circumstances is to take it at starvation prices. But the progress of invention moves fast, and antiquated methods of production are gradually being abandoned. Already, in many of the trades in which the sweating system has hitherto largely prevailed, especially in the tailoring, the boot-making, the cabinet-making, and the nail-making industries, the factory system is coming so far to the front in the race for cheapness of production that, although in certain industrial centres, in which the rents of factories are high and a specially abundant supply of needy and unskilled workpeople is available, a good deal of work is still given out to small outside masters, the proportion of the total output manufactured in this manner is day by day diminishing. (D. SCH.)

SWEDEN.

I. GEOGRAPHY AND STATISTICS.

SWEDEN forms the eastern and larger portion of the Scandinavian peninsula, extending from 69° 3′ 21″ to 55° 20′ 18″ N. It is separated from Norway on the W. by the Kölen mountains, and from Finland, on the N.E., by the Torneå Elf, together with its tributary the Muonio Elf. On the E. and S. its shores are washed by the Baltic Sea, and on the S.W. by the Sound and the Cattegat, which separate it from Denmark.

Area and Population.—For administrative purposes the kingdom is divided into 24 governments (län) besides the capital; their respective areas and populations at the end of 1901 are given in the table on the following page.

An older division of the country that still maintains itself, being based on the physical features, is that into provinces. Of these Skåne embraces governments Nos. 11–12 in the following table, Småland (and Öland), Nos. 6–8, &c. The largest of the provinces is Lapland, which consists of the inland districts of governments 24 and 25, and has an area of about 45,000 square miles, with a population of 61,234. Only 6,000 of these, however, are Lapps.

Län.	Square miles.	Population.	Population per sq. mile.
1. Stockholm (city)	13	303,356	23,351·1
2. Stockholm (rural)	3,015	176,281	58·5
3. Upsala	2,051	125,043	61·0
4. Södermanland	2,631	167,888	63·8
5. Östergötland	4,264	281,657	66·1
6. Jönköping	4,447	203,746	45·8
7. Kronoberg	3,825	159,266	41·6
8. Kalmar	4,456	228,177	51·2
9. Gotland	1,219	52,828	43·3
10. Blekinge	1,164	146,787	126·1
11. Kristianstad	2,488	219,459	88·2
12. Malmöhus	1,864	413,421	221·8
13. Halland	1,900	141,344	74·4
14. Göteborg and Bohus	1,948	340,402	174·7
15. Elfsborg	4,912	280,101	57·0
16. Skaraborg	3,273	240,907	73·6
17. Vermland	7,459	254,975	34·2
18. Örebro	3,511	196,462	56·0
19. Vestmanland	2,612	149,332	57·2
20. Kopparberg	11,522	220,116	19·1
21. Gefleborg	7,613	241,420	31·7
22. Vesternorrland	9,856	234,968	23·8
23. Jemtland	19,675	112,761	5·7
24. Vesterbotten	22,771	145,961	6·4
25. Norrbotten	40,870	138,630	3·4
The four great lakes	3,516	...	...
Total	172,875	5,175,228	29·9

In 1870 the number of inhabitants was 4,168,525; in 1900 (the last census), 5,136,441. In 1901 the 5,175,228 inhabitants comprised 2,526,179 males and 2,649,049 females. The greatest increase of the population during the last twenty years of the 19th century took place in Norrland. As regards the rest of the kingdom, the rural population during that period in general remained stationary or decreased, whereas the urban population increased very greatly. In 1870 the town population formed 12·9 per cent. of the whole; in 1890, 18·8 per cent.; and in 1901, 21·7 per cent. The populations of the principal towns at the end of 1901 were:—Stockholm, 303,356; Göteborg (Gothenburg), 132,111; Malmö, 62,954; Norrköping, 41,549; Gefle, 30,146; Helsingborg, 25,164; Karlskrona, 24,607; Upsala, 23,802; Jönköping, 23,519; Örebro, 22,807; Lund, 16,493; Borås, 16,004; Halmstad, 15,567; Sundsvall, 15,087.

Movement of Population.—The average number per annum of marriages, living births, and deaths per 1000 inhabitants in the years stated were:—

Years.	Marriages.	Living Births.	Deaths.
1871–80	6·81	30·5	18·3
1891–95	5·76	27·4	16·6
1896–98	6·01	26·8	15·9
1899	6·24	26·2	17·6

The figures for the years 1891–95 were lower than those for any other European country, with the exception of the birth-rate for France. The rate of mortality more especially decreased in towns, falling from 24·1 per 1000 inhabitants in 1871–80 to 18·0 in 1891–95. During the same period the rate among children in the first year of life decreased from 129·9 to 104·0 per 1000 children born living. About 10 per cent. of the births are illegitimate. The censuses of 1870–90 showed that the several classes of occupation engaged the following percentages of the population:—

Class of Occupation.	1870.	1880.	1890.
Agriculture	71·87	67·42	60·92
Mining and manufactures	14·71	17·75	22·72
Commerce and transport	5·06	7·14	8·92
Public services, &c.	8·36	7·69	7·44

Consequently the number of persons employed in agricultural pursuits formed even in 1890 more than three-fifths of the total population; but as the development of the country since that date has proceeded continuously, the ratio has steadily decreased, the number of those engaged in manufactures having greatly risen.

Religion.—The census of 1890 registered only 49,763 adherents of creeds other than the Lutheran. These were for the most part Baptists and Methodists; there were 1390 Roman Catholics and 3402 Jews.

Education.—During recent years the Swedish system of instruction in sloyd has particularly attracted attention. The education in primary or national schools has been gratuitous and compulsory for sixty years, and hence it is now rare to come across any adult who is unable to read and write. The cost of maintaining the primary schools is little more than a million sterling, of which the State contributes about one-fourth and the local districts the remainder. There were 11,981 primary schools in 1901, with 833,601 pupils and 5367 male and 10,257 female teachers. There are, furthermore, the specifically Scandinavian institutions called peasant high schools, for the further education of the rural population, 29 in number, with 1510 pupils. Secondary instruction is provided for boys at 75 public schools entirely maintained by the State, with 18,085 pupils. Education of a similar standard is provided for girls at some 120 private schools (about 13,000 pupils), supported in part by grants from the State and the local districts. The State universities at Upsala and Lund now have 1546 and 693 students respectively. The medical college at Stockholm has about 300 students. Private subscriptions have enabled two independent universities to be founded, one at Stockholm and the other at Gothenburg. In addition to a large number of technical, forestry, and agricultural schools of a lower grade, there are, for more advanced teaching, the technical high school at Stockholm (428 students), Chalmer's College at Gothenburg, the college of forestry at Stockholm, the agricultural colleges at Ultuna and Alnarp, and the dairy college at Alnarp. At Stockholm, too, is the gymnastic central institute, where the teachers of the Swedish system of gymnastics receive their training. Among the scientific and literary societies are noted the Swedish Academy, consisting of 18 members, which was instituted in 1786 by Gustavus III., after the pattern of the Académie Française, for the cultivation of the Swedish language and literature, and the Academy of Science, founded in 1739 by Linnæus and others for the promotion of the natural sciences. Among other things, the former distributes one and the latter two of the prizes of the Nobel Institution. A fourth prize is distributed by the Medical College at Stockholm.

Finance.—The revenue and expenditure were estimated in the national budget for 1903 at £9,497,000. The sources of income were principally: Customs, £2,671,000; excise on Swedish brandy, £1,074,000; on Swedish sugar, £578,000; income from State railways (net), £385,000; from domains, £501,000; income and property tax (to be paid in 1903), £889,000; surplus from 1901, £876,000. This surplus has been constant during recent times. On the expenditure side the following items appeared: Army, £2,832,000; navy, £988,000; education, £992,000; interest and amortization of debt, £659,000; railway rolling stock and railway construction, £339,000. To these items must be added an additional sum of £312,000 for railway construction to be covered by loans. The national debt, the existence of which is almost exclusively due to railway construction, amounted on 31st December 1900 to £18,607,214. To balance it were the following: Funds, £14,295,154; railways, £21,254,544; real estate, £13,964,648 (whereof domains, £7,657,400); to these may be added the funds of the Riksbank. The communal revenues amounted in 1899 to £4,772,045; their expenditure to £5,636,948. On the revenue side may be mentioned the following items: Income and property tax, £2,251,305; proceeds of the sale of spirits (the Gothenburg system is generally introduced), £425,483; contribution from the Treasury, £333,721. On the expenditure side: Primary schools, £1,064,141; administration of the poor laws, £760,141; Church purposes, £625,007. The liabilities of the communes in 1875 were £3,252,512, and in 1899 £12,478,470; their assets, £20,699,511 in 1899.

Army and Navy.—General military service was introduced in 1885. The standing army is divided into two classes: there are the *Värfvade*, almost all garrisoned on a two to three years' service system, and there are the so-called *Indelta*, to which body belong the majority of the infantry and about half the cavalry. These latter are drawn from the peasantry. They serve a considerable number of years, and live, as a rule, scattered over the country districts, some of them in small cottages placed at their disposal. After their recruit period is over, they are drilled twenty-two or twenty-three days annually. Besides the standing army there is the *Värnpligtige*, or the conscripts, to which every Swedish man belongs from the age of 21 to 40. For the first twelve years he is one of the *Beväring*, who are apportioned among the regiments and corps of the army and the different branches of the navy; for the last eight years the *Värnpligtige* are numbered in the *Landstorm*, intended solely for local defence on shore. The conscripts were formerly trained for ninety days, but according to the law of 1901 the conscript is bound to serve in time of peace—in the infantry, position artillery, fortress artillery, fortress engineers, and the army service corps a total of 240 days; and in the cavalry, field artillery, field engineers, and field telegraph corps a total of 365 days. The *Indelta*, on the other hand, are gradually to be abandoned, and the *Värfvade*, now 39,000 men, to be brought down to about 21,500 men (2293 officers, 557 officer-aspirants, 1805 non-commissioned officers, 6857 corporals, 836 civilian officers, &c.). During the years 1902–07 all conscripts are to be trained for only 172 days. The *Beväring* of the first year consists of about 29,000 men, of the twelve years of about 255,000; the *Landstorm* (of the eight years) of about 205,000 men. The organization of the army in time of peace is as follows: 82 battalions of infantry (28 regiments), 50 squadrons of cavalry, 71 field artillery and 7 position artillery batteries, 10 fortress artillery, 16 engineer, and 18 army service corps companies. The men in the navy consist partly of enlisted and partly of *Värnpligtige* sailors; of the former there are 4100, of the latter about 17,000. The conscripts are to be trained 300 days (in 1902–07 only 172 days). The fleet includes 11 ironclads of 3100 to 3650 tons and 4 of 1500 to 1600 tons, 5 torpedo-cruisers, 1 destroyer, 15 torpedo-boats of 67 to 90 tons, and 11 of 40 to 58 tons, &c. To the navy department belong furthermore the two coast artillery regiments, which complete will consist of 1568 men without the conscripts. The naval stations are Karlskrona (the head station) and Stockholm. Fortresses: Karlsborg, at the Lake Wettern; Boden (in course of construction), at the railway Luleå–Gellivara, Karlskrona, Vaxholm, and Oskar-Fredriksborg, at the entrance of Stockholm, and some forts at Gothenburg (in construction) and on the island of Gotland.

Mining.—The copper and silver mines at Falun and Sala, that were formerly of such great importance, are now of but little note. The iron mines, on the other hand, continue to be of great importance. The best iron ore is found mainly within a belt which extends from the southern parts of the Bothnian Gulf to the districts north of Lake Venern. In the extreme north of the country also there are considerable iron ore deposits, some of which are among the largest and richest in the world; such are those at Gellivara, Kirunnavara, Luossavara, and Ruotivara. Until lately these deposits have been unworked, partly on account of bad communications, partly owing to the high percentage of phosphorus and titanium in them. During the last decade, however, a railway has been opened from Gellivara to Luleå, on the Gulf of Bothnia; but the harbour there is inaccessible for half the year on account of ice. A railway has been constructed by the State from Gellivara, past Kirunnavara and Luossavara, to the Norwegian boundary, with a projected continuation from there to the Ofoten Fjord, where there is always open water. The amount of iron ore obtained in 1891 was 976,544 tons, and with a constantly increasing production this became in 1901, 2,795,160 tons, 1,076,564 tons being from Gellivara. (See *Commerce.*) In 1901, 48,630 tons of zinc ore and 23,660 tons of copper ore were mined. In the same year 271,509 tons of coal were obtained from the isolated field in Malmöhus Län. The number of miners employed in 1901 was 14,583. In consequence of the great supply of iron ores containing but little phosphorus, and of the immense forests and numerous waterfalls, the iron trade attained great prosperity during the 17th and 18th centuries, and down to about the year 1790 the production of pig-iron was greater in Sweden than in Great Britain; but subsequent to the successful introduction of the use of coal in the iron trade, this state of things was soon changed. Now the production of pig-iron in Sweden, though doubled during the last thirty years, and 528,375 tons in 1901, is, however, not 1½ per cent. of the production of the world. Owing to its excellent quality, Swedish iron is often preferred to other varieties for special purposes. The amount of wrought iron and steel produced in 1901 was 434,046 tons, and this also shows a very appreciable increase. There were 16,008 workmen employed in iron-works in 1901.

Agriculture.—The number of petty landowners has always been great. In 1900, 288,000 farmers owned the land they cultivated, and only 50,400 were tenants. 93,023 acres (2·47 acres = one *har* or *hectare*) were occupied by orchards and market-gardens in 1900; 8,693,906 acres were arable land, and 3,607,445 acres natural meadows. The acreage devoted to orchards and gardens had increased since 1870 by 28,000 acres; 2,400,000 acres had been added to the arable land, while meadow land had decreased by 1,300,000 acres. The increase in arable land goes on steadily, and is partly due to the decrease in meadow land, partly to the transformation of fens and marshes into fertile soil. The extent of these fens and marshes capable of cultivation is so great that the total acreage of arable land at the present time would be more than doubled if they were brought into a cultivable condition. 2·2 per cent. of the arable land produced wheat, 11·7 per cent. rye, 6·2 per cent. barley, 23·4 per cent. oats, 3·7 per cent. mixed crops, 1·3 per cent. other corn crops, 4·4 per cent. potatoes, 1·4 per cent. sugar-beet and other root crops, 29·2 per cent. clover and grass, 0·1 per cent. flax, tobacco, &c.; 4·6 per cent. is devoted to pasturage, and 11·8 per cent. lies fallow. The section lying fallow is decreased year by year (in 1870, 15·2 per cent.). The average value of the harvests yielded by arable and meadow land is £28,750,000, £16,400,600 of it being for corn, £2,630,000 for roots, and £9,720,000 for hay. During the last few decades an increasing proportion of field land has been set aside for the cultivation of those cereals used as fodder, owing to the great advance made in cattle-rearing and in dairy farming. The cultivation of sugar-beet has advanced since 1890 with such strides that the produce is sufficient to supply the whole demand of the country. The consumption of wheat per inhabitant is double what it was in 1880, and is now half that of rye. The wheat produced in the country supplies not half the demand; the rye, six-sevenths. The export of oats, in former times very considerable, has greatly diminished, owing to their more extensive use at home. The export of butter has become so large that it counterbalances the diminution in the export of grain, and the country still produces a sufficient supply of food for the needs of its inhabitants. The live stock included, at the end of 1900, 533,050 horses, 2,582,555 horned cattle, 1,261,493 sheep, 79,826 goats, 805,805 pigs, and 231,960 reindeer. Since 1870 the number of horses has increased by 100,000, of horned cattle by over 600,000, of pigs by 450,000; the number of sheep has diminished by 330,000, of goats by 45,000.

Forests.—These cover 51,150,000 acres, and provide fuel both for household purposes and for the numerous iron-works, besides affording an article of export in such large quantities that the quantity of timber exported from Sweden is greater than from any other country. The public forests form about a third of the whole. At the saw-mills, situated for the most part on the Gulf of Bothnia, 43,312 workmen are employed.

Fisheries.—By reason of unsuccessful fishing, the export trade in herrings sank to 30,000 tons annually in 1897–1900.

Manufactures.—In spite of the fact that Sweden has but inconsiderable deposits of coal, and wholly lacks colonial possessions, it possesses important mechanical industries, which have made great strides, especially during the last few years. In 1900 machine shops employed 20,681 hands; factories for iron and steel manufactured goods, 19,146; mills for weaving woollen and other materials, 14,730; stone-cutting works, 11,697; brickyards, 10,337; spinning-mills, 10,255; furniture factories, 10,103; charcoal works, sugar factories, wood-pulp factories, paper mills, breweries, match factories, glass factories, printing houses, and shipyards, each class between 5000 and 7700. The number of workmen engaged in practical trades is 87,322. The productions of the Swedish factories are disposed of for the most part in the country itself, though a not inconsiderable amount is sent abroad. The industries connected with wood-pulp, sugar, machinery, shoes, and electricity have made the greatest advances in recent years.

Commerce.—The aggregate value of the foreign trade of Sweden in 1870 was estimated at £16,199,780 (imports £7,802,093, exports £8,397,687), and in 1900 at £51,006,007 (imports £29,456,780, exports £21,549,227). The principal articles of import in 1900 were: Coal and coke, £4,682,052; grain, £2,462,263; coffee, £1,490,588; machines and implements, £1,270,179; yarn and thread, £854,824; cotton, £790,198; hides and skins, £779,619; woollen woven goods, £726,976; fish, £725,800; petroleum, £602,000; wool, £542,898. The coal and coke imported forms more than 90 per cent. of the total supply, and amounted in 1900 to 3,130,000 tons. The principal articles of export were: Wood (not worked, sawn, or cut), £8,466,409; iron and steel, £2,747,942; butter, £2,026,021; wood-pulp, £1,471,794; iron ore, £718,965; paper, £683,467; machines and implements, £637,655; carpentry work, £598,446; stone, £571,993; iron and steel goods, £545,624; matches, £465,896. The exportation of iron ore has increased remarkably; in 1891 only 172,232 tons, in 1901 it was 1,761,000 tons: Germany takes most of the supply. The value of the (direct) imports from and exports to non-European countries was in 1900 but £662,930 and £476,487 respectively. Trade was principally with the following countries:—

	United Kingdom.	Germany.	Denmark.
Imports	£9,719,383	£10,346,806	£3,443,007
Exports	9,319,824	3,592,786	2,625,661

Shipping and Navigation.—In 1900 there were 2076 sailing vessels of 288,687 tons, and 911 steamers of 325,105 tons; total, 2987 vessels of 613,792 tons. Of these only 10 sailing vessels and 90 steamers were of 1000 tons or more, and the largest was of only 3377 tons. In 1870 the aggregate tonnage was 350,200 tons (sailing vessels 319,300, steamers 30,900).

Railways, Posts, Telegraphs, and Telephones.—Sweden has more miles of railway in proportion to population than any other European country. The first line was open for traffic in 1856. In 1870 the total length was 1060 miles (State railroads 366, private 694), which had increased to 4979 miles in 1890 and to 7217 at the close of 1901, when 2392 miles belonged to the State and 4825 to private companies, while about 800 miles was in course of construction. The line from Gellivara to the Norwegian frontier is the most important recently under construction; it is the most northerly railway in the world. The State railways yielded a profit of 3·73 per cent. in 1899 and 3·06 per cent. in 1900; the private lines, on an average, one of 5·62 per cent. in 1898 and 5·24 per cent. in 1899. The total number of letters, parcels, &c., transmitted through the post in 1900 amounted to 123,261,253, without counting newspapers and journals; the number of telegrams despatched was 2,749,483. In 1870 the corresponding numbers were 13,360,440 and 738,000. The telephone system has been more speedily developed than perhaps in any other country. It is now largely in the hands of the State. The total number of telephones at the close of 1901 was about 95,000, of which about 33,000 were in Stockholm alone.

Banks.—The Riksbank or National Bank of Sweden is the principal and oldest bank in the kingdom, and the first in the world from which notes were issued. Founded as a private concern, it was taken over in 1668 by the State, to which it belongs entirely. It is managed by directors who, with the exception of the president, are elected for three years by the Diet; the president is appointed by the king. Other banks are of two categories: private banks with solidary responsibility, which alone, along with the Riksbank, possess the right of issuing notes; and joint-stock banks, with limited responsibility and not possessing the right to issue notes. At the close of 1901 the value of all notes in circulation was £8,625,616, those of the Riksbank amounting to £5,560,724, and of the private banks to £3,064,892. At the close of 1903 private banks will forfeit the right of issuing notes, that right from thenceforward belonging to the Riksbank alone. The capital and the reserve funds, besides funds to further disposition (after distribution of the year's profits) at the end of 1901, were as follows: the Riksbank, £3,887,589; private banks, £7,006,760; joint-stock banks, £6,482,600. In 1900 there were 388 savings banks in existence. At the close of the year the deposits in these amounted to £24,085,416 (in 1870, £3,155,386), and in the Post Office Savings Bank in 1901 to £2,986,959.

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II. RECENT HISTORY.

The economic condition of Sweden, owing to the progress in material prosperity which had taken place in the country as the result of the Franco-German war, was at the accession of Oscar II. to the throne on the 18th September 1872 fairly satisfactory. Politically, however, the outlook was not so favourable. In their results, the reforms inaugurated during the preceding reign did not answer expectations. Within three years of the introduction of the new electoral laws, De Geer's ministry had forfeited much of its former popularity, and had been forced to resign. In the vital matter of national defence no common understanding had been arrived at, and during the conflicts which had raged round this question, the two Chambers had come into frequent collision and paralysed the action of the Government. The peasant proprietors, who, under the name of the "Landtmanna party,"[1] formed a compact majority in the Second Chamber, pursued a consistent policy of class interests in the matter of the taxes and burdens that had, as they urged, so long oppressed the Swedish peasantry; and consequently, when a Bill was introduced for superseding the old system of army organization by general compulsory service, they demanded as a condition of its acceptance that the military burdens should be more evenly distributed in the country, and that the land taxes, which they regarded as a burden under which they had wrongfully groaned for centuries, should be abolished. In these circumstances, the "Landtmanna" party in the Riksdag, who desired the lightening of the military burden, joined those who desired the abolition of landlordism, and formed a compact and predominant majority in the Second Chamber, while the burgher and Liberal parties were reduced to an impotent "intelligence" minority. This majority in the Lower Chamber was at once attacked by another compact majority in the Upper, who on their side maintained that the hated land taxes were only a kind of rent-charge on land, were incidental to it and in no way weighed upon the owners, and, moreover, that its abolition would be quite unwarrantable, as it was one of the surest sources of revenue to the State. On the other hand, the First Chamber refused to listen to any abolition of the old military system, so long as the defence of the country had not been placed upon a secure basis by the adoption of general compulsory military service. The Government stood midway between these conflicting majorities in the Chambers, unable to find support in either.

Accession of Oscar II.

Such was the state of affairs when Oscar II., surrounded by his late brother's advisers, began his reign. One of his first cares was to increase the strength of his navy, but in consequence of the continued antagonism of the political parties, he was unable to effect much. In the first Riksdag, however, the so-called "compromise," which afterwards played such an important part in Swedish political life, came into existence. It originated in the small "Scania" party in the Upper House, and was devised to establish a *modus vivendi* between the conflicting parties, *i.e.*, the champions of national defence, and those who demanded a lightening of the burdens of taxation. The king himself perceived in the compromise a means of solving the conflicting questions, and warmly approved it. He persuaded his ministers to constitute a special inquiry into the proposed abolition of land taxes, and in the address with which he opened the Riksdag of 1875 laid particular stress upon the necessity of giving attention to the settlement of these two burning questions, and in 1880 again came forward with a new proposal for increasing the number of years of service with the militia. This motion having been rejected, De Geer resigned, and was succeeded by Count Arvid Posse. The new prime minister endeavoured to solve the question of defence in accordance with the views of the "Landtmanna" party. Three parliamentary committees had prepared schemes for a remission of the land taxes, for a new system of taxation, for a reorganization of the army based on a *stammtrupp* (regular army), by the enlistment of hired soldiers, and for naval reforms. In this last connexion the most suitable types of vessels for coast defence as for offence were determined upon. But Count Posse, deserted by his own party over the Army Bill, resigned, and was succeeded on 16th May 1884 by Oscar Themptander, who had been minister of finance in the previous Cabinet. The new premier succeeded in persuading the Riksdag to pass a Bill, increasing the period of service with the colours in the army to six years and that in the militia to forty-two days, and as a set-off a remission of 30 per cent. on the land taxes.

The party compromise of 1874.

Influenced by the economic reaction which took place in 1879 in consequence of the state of affairs in Germany, where Prince Bismarck had introduced the protectionist system, a protectionist party had been formed, which tried to gain adherents in the

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[1] The Swedish "Landtmanna" party was formed in 1867. It consisted mostly of the larger and smaller peasant proprietors, who at the time of the old "Standers Riksdag" were always opposed to the nobility and the clergy. The object of the party was to bring about a fusion between the representatives of the large landed proprietors and the regular peasant proprietors, to support the interests of landed proprietors in general against those of the town representatives, and to resist Crown interference in the administration of local affairs.

Riksdag. It is true that in the Riksdag of 1882 the commercial treaty with France was renewed, but since 1885 the protectionist party was prepared to begin the combat, and a duty on corn, which had been proposed in the Riksdag of the same year, was rejected by only a slight majority. During the period of the unusually low price of corn of 1886, which greatly affected the Swedish farmers, protection gained ground to such an extent that its final triumph was considered as certain within a short time. During the Riksdag of the same year, however, the premier, Themptauder, emphatically declared himself against the protectionist party, and while the parties in the Second Chamber were equal in number, the proposed tax on corn was rejected in the First Chamber. In the Riksdag of 1887 there was a majority for protection in the Second Chamber, and in the first the majority against the tax was so small that the tax on corn would have triumphed in a combined meeting of the two Chambers. The Government, availing itself of its formal right not to dissolve the Chamber in which it had the support of a majority, therefore dissolved only the Second Chamber (March 1887).

Protectionist movement.

The new Riksdag assembled in May with a free trade majority in the Second Chamber, but nothing in connexion with the great question of customs was settled. In the meantime, the powerful majority in the Second Chamber split into two groups—the new "Landtmanna" party, which approved protection in the interests of agricultural classes; and a somewhat smaller group, the old "Landtmanna" party, which favoured free trade.

The victory of the free traders was not, however, destined to be of long duration, as the protectionists obtained a majority in both Chambers in the next Riksdag (1888). To the First Chamber protectionists were almost exclusively elected, and in the Second all the twenty-two members for Stockholm were disqualified, owing to one of their number not having paid his taxes a few years previously, which prevented his being eligible. Instead, then, of twenty-two free traders representing the majority of the Stockholm electors, twenty-two protectionists, representing the minority, were elected, and Stockholm was thus represented in the Riksdag by the choice of a minority in the capital. This singular way of electing members for the principal city in the kingdom could not fail further to irritate the parties. One result of the Stockholm election came at a convenient time for the Themptauder ministry. The financial affairs of the country were found to be in a most unsatisfactory state. In spite of reduced expenses, a highly estimated revenue, and the contemplated raising of taxes, there was a deficit, for the payment or discharge of which the Government would be obliged to demand supplementary supplies. The Themptauder ministry resigned. The king retained, however, for a time several members of the ministry, but it was difficult to find a premier who would be able, during the transition from one system to another, to command sufficient authority to control the parties. At last Baron Gillis Bildt, who, while Swedish ambassador in Berlin, had witnessed the introduction by Prince Bismarck of the agrarian protectionist system in Germany, accepted the premiership, and it was under his auspices that the two Chambers imposed a series of duties or necessaries of life. The new taxes, together with an increase of the excise duty on spirits, soon brought a surplus into the State coffers. At a Council of State (12th October 1888) the king declared his wishes as to the way in which this surplus should be used. He desired that it should be applied to a fund for insurance and old-age pensions for workmen and old people, to the lightening of the municipal taxes by State contributions to the schools and workhouses, to the abolition of the land taxes and of the obligation of keeping a horse and man for military service, and, lastly, to the improvement of the shipping trade; but the Riksdag decided to devote it to other objects, such as the payment of the deficit in the Budget, the building of railways and augmentation of their material, as well as to improvements in the defences of the country.

Baron Bildt resigned as soon as the new system seemed settled, making room for Baron Gustav Akerhjelm. The latter, however, also soon resigned, and was succeeded on 10th July 1891 by Erik Gustav Bostrom, a landed proprietor. The protectionist system gained in favour on the expiry of the commercial treaty with France in 1892, as it could now be extended to articles of industry. The elections of 1890, when the metropolis returned free traders and Liberals to the Second Chamber, certainly effected a change in the latter, as the representatives of the towns and the old "Landtmanna" party joined issue and established a free-trade majority in the Chamber, but in the combined meetings of the two Chambers the compact protectionist majority in the First Chamber turned the scale. The customs duties were, however, altered several times in accordance with market prices and ruling circumstances. Thus in 1892, when the import duty on unground corn was reduced from 2s. 10d. to 1s. 5d., and that on ground corn from 4s. 9d. to 2s. 10d. for 100 kilogrammes, the same duties were also retained for the following year. They were also retained for 1894 at the request of the Government, which desired to keep faith with their promise that while the new organization of the army was going on no increase of duties on the necessaries of life should take place. This measure caused much dissatisfaction, and gave rise to a strong agrarian movement, in consequence of which the Government, in the beginning of 1895, before the assembling of the Riksdag, made use of its right of raising the two duties on corn just referred to, to 3s. 7d. and 7s. 2d., which were afterwards somewhat reduced as far as seed corn for sowing purposes was concerned.

The question of customs duties now settled, that of national defence was taken up afresh, and in the following year the Government produced a complete scheme for the abolition of the land tax in the course of ten years, in exchange for a compensation of ninety days' drill for those liable to military service, proposed to retain the old military system of the country and to strengthen the defences of Norrland, and the Government Bill for a reorganization of the army was accepted by the Riksdag in an extraordinary session. But it was soon perceived that the new plan was unsatisfactory and required recasting, upon which the minister of war, Baron Rappe, resigned, and was succeeded by Colonel von Crustebjorn, who immediately set to work to prepare a complete reorganization of the army, with an increase of the time of active service on the lines of general compulsory service. The Riksdag of 1900, in addition to grants for the fortifications at Boden, in the province of Norrbotten, on the Russian border, and other military objects, voted a considerable grant for an experimental mobilization, which fully exposed the defects and faults of the old system. In the Riksdag of 1901 E. G. Bostrom resigned, and was succeeded by Admiral F. W. von Otter, who introduced a new Bill for the army reorganization, the most important item of which was the increase of the period of training to 365 days. The cost in connexion with the new scheme was expected to amount to 22 millions of kronor. The Riksdag, however, did not accept the new plan in its full extent. The time of drilling was reduced to 240 days for the infantry, to 300 days for the navy, while for the cavalry and artillery the time fixed was 365 days. The plan, thus modified, was then accepted by the Government.

National defence.

After the elections in 1890, the alliance already mentioned between the old "Landtmanna" party and the representatives of the towns had the result that the Liberals in the Second Chamber, to whom the representatives of the towns mostly belonged, were now in a position to decide the policy which the two united parties should follow. In order to prevent this, it was proposed to readjust the number of the members of the Riksdag. The question was only settled in 1894, when a Bill was passed fixing the number of the members of the Riksdag in the First Chamber at 150, and in the Second at 230, of which 150 should represent the country districts and 80 the towns. The question of protection being now considered settled, there was no longer any reason for the continued separation of the two "Landtmanna" parties, who at the beginning of the Riksdag of 1895 joined issue and became once more a compact majority in the Second Chamber, as they had been up to the Riksdag of May 1887. The influence of the country representatives was thus re-established in the Second Chamber, but now the demands for the extension of the franchise came more and more to the front, and the premier, Bostrom, at last felt bound to do something to meet these demands. He accordingly introduced in the Riksdag of 1896 a very moderate Bill for the extension of the franchise, which was, nevertheless, rejected by both Chambers, all similar proposals by private members meeting the same fate. When at last the Bill for the reorganization of the army, together with a considerably increased taxation, was accepted by the Riksdag of 1901, it was generally acknowledged that, in return for the increased taxation, it would only be just to extend the right of taking part in the political life and the legislative work of the country to those of the population who hitherto had been excluded from it. The Government eventually laid a proposal for the extension of the franchise before the Riksdag of 1902, the chief feature of which was that the elector should be twenty-five years of age, and that married men over forty years should be entitled to two votes. The Riksdag, however, finally agreed to a proposal by Bishop Billing, a member of the First Chamber, that an address should be presented to the king asking for a full inquiry into the question of extending the franchise for the election of members to the Second Chamber.

Franchise reform.

Labour movement.

In 1897 the Riksdag had received among its members the first socialistic representative in the person of R. H. Brauting, the leader of the Swedish Social Democrats. The Socialists, who had formerly confined their activity to questions affecting the working classes and their wages, took, however, in 1902 an active part in the agitation for the extension of the franchise. Processions of many thousands of workmen were organized, in Stockholm and in other towns of the kingdom, just before the Riksdag began the discussion on the above-mentioned Bill of the Government, and when the Bill was introduced in the Chambers a general and well-organized strike took place, and continued during the three days the debate on the Bill lasted. As this strike was of an exclusively political kind, and was intended to put pressure on the Chambers, it was generally disapproved, and failed in its object. The prime minister, Admiral von Otter, resigned shortly after the end of the session, and was succeeded by Bostrom, the ex-premier, who at the request of the king again assumed office.

Relations with Norway.

The relations with Norway during King Oscar's reign had great influence on political life in Sweden, and at times it even seemed as if the union between the two countries was on the point of being wrecked. The dissensions chiefly had their origin in the demand by Norway for separate consuls and foreign ministers, to which reference is made under Norway. At last, after vain negotiations and discussions, the Swedish Government in 1895 gave notice to Norway that the commercial treaty which, till then, had existed between the two countries, and would lapse in July 1897, would, according to a decision in the Riksdag, cease, and as Norway at the time had raised the customs duties, a considerable diminution in the exports of Sweden to Norway took place. The Swedish minister of foreign affairs, Count Lewenhaupt, who was considered as too friendly disposed towards the Norwegians, resigned, and was replaced by Count Ludvig Douglas, who represented the opinion of the majority in the First Chamber. When, however, the Norwegian Storthing, for the third time, passed a Bill for a national or "puré" flag, which King Oscar eventually sanctioned. Count Douglas resigned in his turn, and was succeeded by the Swedish minister at Berlin, Lagerheim, who managed to pilot the questions of the Union into more quiet waters. He succeeded all the better as the new elections to the Riksdag of 1900 showed clearly that the Swedish people was not inclined to follow the ultra-conservative or so-called "patriotic" party, which resulted in the resignation of the two leaders of that party, Professer Oscar Alin and Court Marschal Patrick Reutersvard as members of the First Chamber. On the other hand, ex-Professor E. Carlson, of the High School of Gothenburg, succeeded in forming a party of Liberals and Radicals to the number of about 90 members, who, besides being in favour of the extension of the franchise, advocated the full equality of Norway with Sweden in the management of foreign affairs.

During King Oscar's reign many important social reforms have been carried out by the legislature. The statistics show in a very striking manner how the country has developed in all directions. In the Riksdag of 1884 a new patent law was adopted, the age at which women should be held to attain their majority was fixed at twenty-one years, and the barbarous prison punishment of "bread and water" abolished. In order to meet the cost of the new army organization, the Riksdag of 1902 increased the revenue by progressive taxation, but only for one year. Bills for the improvement of the social conditions of the people and in the interests of the working classes have also been passed. During the five years 1884–89 a committee was occupied with the question of workmen's insurance, and thrice the Government made proposals for its settlement, on the last occasion adopting the principle of invalidity as a common basis for insurance against accidents, illness, or old age. The Riksdag, however, delayed coming to a decision, and contented itself by earmarking money for an insurance fund. At last the Riksdag of 1901 accepted a Bill for insurance against accidents which also extended to agricultural labourers, in connexion with the establishment of a State institution for insurance. The Bill for protection against accidents, as well as for the limitation of working hours for women and children, was passed, together with one for the appointment of special factory inspectors.

The so-called "Nobel Gift" has given Sweden an important rôle in the history of culture, which is quite unique. Alfred Nobel, a civil engineer, in 1896 left the whole of his immense property, amounting to over one and three-quarter million pounds, to a fund, the yearly income of which was to be divided between those who, in the course of the current year, had rendered the greatest service to mankind in various branches of science, in literature, and in the cause of peace. The prizes for 1901 were distributed as follows: Professor Röntgen (natural philosophy), Professor Van't Hoff (chemistry), Professor Behriz (medicine), and Sully Prudhomme (literature). These prizes were adjudged by the Swedish Academy; while the prize for services rendered in the cause of peace is, in accordance with the testator's will, left in the hands of the Norwegian Storthing to distribute. The prize for 1901 was divided between Henri Drenant, the founder of the Red Cross, and Frederic Passy, the secretary of the Peace Congresses. Each prize amounts to about £8300, and will be distributed yearly.

When in 1897 King Oscar celebrated his jubilee of twenty-five years as king, the exhibition which had been organized in Stockholm offered a convincing proof of the progress the country had made in every direction, while the thousands of provincial visitors who flocked to the metropolis took the opportunity to attest their respect and loyalty to the king and the royal family. The amount collected all over the country on the occasion of the jubilee as a gift to the king, amounting to £140,000, was, according to His Majesty's wishes, applied to the building of sanatoria for sufferers from consumption. (x.)

III. Literature since 1885.

The serenity of Swedish literature was rudely shaken about 1884 by an incursion of realism and by a stream of novel and violent imaginative impulse. The controversy between the old and the new schools raged so fiercely, and the victory has remained so obviously in the hands of the latter, that it is difficult, especially for a foreigner, to hold the balance perfectly even. It will therefore be best in this brief sketch to say that the leader of the elder school was Viktor Rydberg (1828–1895) (*q.v.*), and that he was ably supported by Carl Snoilsky (b. 1841) (*q.v.*), who in 1902 was the principal living poet of the bygone generation in Sweden. Snoilsky is prominent for the richness of his lyrical style, his cosmopolitan interests, and his great width of culture. Carl David af Wirsén (b. 1842) has distinguished himself, and made himself very unhappy, by his dogged resistance to every species of renaissance in Swedish thought, or art, or literature. A man of great talent, he was a violent reactionary, and suffered from the consequences of an attitude so unpopular. Of less importance were Karl Herman Sätherberg (1812–1897), a romantic poet who was also a practising physician of distinction; the elegiac poet Johan Nybom (1815–1889); and the poet, novelist, and dramatist Frans Hedberg (b. 1828), who in his old age made many concessions to the modern taste. Two exceedingly popular novelists of the preceding age, Emilie Flygare-Carlén (1807–1892) and K. A. Wetterbergh ("Onkel Adam") (1804–1889), survived into the period we are now considering. The posthumous poems of the Bishop of Strängnäs, Adam Teodor Strömberg (1820–1889) were collected by Wirsén, and created some sensation. A typical academician was the poet, antiquary, and connoisseur Nils Fredrik Sander (1828–1900). The improvisator of *Gluntarne,* Gunner Wennerberg (1817–1901) (*q.v.*), was a romantic figure of the past, surviving through nearly the whole of this period. Still older was the poetess Wilhelmina Nordström (1815–1902), long a schoolmistress in Finland. The æsthetic critic and poet, Carl Rupert Nyblom (b. 1832), continued the studies, translations, and original pieces which had created him a reputation as one of the most accomplished general writers of Sweden. King Oscar II. (b. 1829) (*q.v.*) did not add any work of importance to his poetical repertory after 1885. Professor Gustaf Ljunggren (b. 1825) continued his valuable researches into the early history of Swedish literature. A. T. Gellerstedt (b. 1836), an architect of position, has written poems of small range but of very fine quality. The dramatist, Thure August Säfström (b. 1813), had in 1902 been silent for nearly forty years. Among writers of a still earlier generation who survived into our period were Achatius Johan Kahl (1794–1888), the biographer of Tegnér, and Per Erik Bergfalk (1798–1890), the critic and supporter of Geijer. The distinguished historian and academician, Karl Johan Schlyter (1795–1889), was another silent nonogenarian. Other historical writers were Frederik Ferdinand Carlson (1811–1887), Vilhelm Erik Svedelius (1816–1889), and Martin Weibull (1835–1902). It is perhaps not necessary to mention any more of the veteran reputations of this period, for our interest certainly centres in their successors.

Four influences may be mentioned as having acted upon young Sweden, and as having combined to release its literature from the old hard-bound conventions. These are English philosophy in the writings of Mr Herbert Spencer, French realism in the practice and the preaching of M. Zola, Norwegian drama mainly through Ibsen, and Danish criticism in the essays and monographs of Georg Brandes. Unquestionably the greatest name in Swedish literature during twenty years after 1882 was that of Johan August Strindberg (b. 1849). His drama of *Master Olof* in 1878 began the revolutionary movement. It was the sensation caused in 1884 by the lawsuit brought against Strindberg's *Married* (a collection of short stories dealing realistically with some of the seamy sides of marriage) which brought to a head the rebellion against the elegant and superficial conventions which were strangling Swedish literature. It was not the first occasion on which Strindberg's works had caused a scandal. His early dramas had been looked at askance, and his sketches of low life in the capital, entitled *The Red Room* (1879), had introduced naturalism into Sweden, and made the author notorious if not famous. In 1882 he found the restraint of life in Stockholm intolerable, and he exiled himself to Paris. When he came back to defend *Married*, he received from his followers an ovation which turned into a frenzy of joy when he won his case. Strindberg's career is a very curious one. He affronts every canon of taste, more by a radical absence, it would seem, of the sense of proportion than by any desire to shock. His diatribes against woman suggest a touch of madness, and he was in fact at one time seized with an attack of insanity. He writes like a man whose view is distorted by physical or mental pain. His phraseology and his turns of invention are too empirically pseudo-scientific for the simplicity of nature. With all these faults, and in spite of a terrible vulgarity of mind, an absence of humour, and a boundless confidence in the philosophy of Nietzsche, Strindberg is a writer of very remarkable power and unquestionable originality. His mind has undergone singular transformations. After devoting himself wholly to realism of the coarsest kind, he began in 1889 his series of mystico-pathological novels about life in the archipelago of Stockholm. This led him to a *culte du moi*, of which the strangest result was an autobiography of crude invective, *A Fool's Confession* (1893), the printing of which in Swedish was forbidden. He rapidly passed on, through books like *Inferno* (1897), the diary of a semilunatic, up into the sheer mysticism of *In Damascus* (1898), where he reconciles himself at last to Christianity. His best work is classic in its breadth of style, exquisite in local colour and fidelity to the national characteristics of Sweden. Strindberg's latest productions have been a series of historical dramas, four of which, *Gustavus Wasa, Erik XIV., Gustavus Adolphus*, and *Carol XII.*, appeared between 1899 and 1902. He was then engaged in pouring forth these dramas of national history in quick succession. The future of Strindberg stimulates and baffles curiosity.

A curious antidote to the harsh pessimism of Strindberg was offered by the delicate and fantastic temperament of Ola Hansson (b. 1860), whose poems came prominently before the public in 1884, and who, in *Sensitiva Amorosa* (1887), preached a gospel of austere self-restraint. Hansson has been as ardent in the idolatry of woman as Strindberg has been in his hostility to the sex. He has since exiled himself to Germany. Of those who have worked side by side with Strindberg, the most prominent and active has been Gustaf af Geijerstam (b. 1858), in his curious and severely realistic studies of country life. A melancholy interest surrounds the name of Victoria Benedictsson ("Ernst Ahlgren") (1850–1889), who committed suicide in Copenhagen in the midst of a highly successful career as a novelist. Her biography, a most affecting narrative, was published by Ellen Key, and her autobiography by Axel Lundegård (b. 1861), who, after some miscellaneous writing, produced in 1889 a curious novel of analysis called *The Red Prince*, and who, becoming a devout clerical, has since published a number of popular stories in a neo-romantic manner. A historical novelist of unequal powers, but great occasional merit, is Matilda Malling (b. 1864), whose romance about Napoleon (1894) enjoyed a huge success. Tor Hedberg (b. 1861) also began as a decided realist, and has turned to a more psychological and idealist treatment of life. His most striking work was *Judas* (1886); he has written some excellent dramas. The latest successes in the novel have been those of Hilma Angered-Strandberg (*On the Prairie*, 1898) and Gustaf Janson (*Paradise*, 1900). The most remarkable of the novelists of the latest group is Selma Lagerlöf (b. 1858), who, when a schoolmistress in Landskrona, published *Gösta Berling's Saga* in 1891–92, and achieved an immense success. A later romance, *The Miracles of Antichrist* (1898), still further established the fame of this lady, who is certainly in the front rank of living Swedish writers. In 1901 she published *Jerusalem*, a novel describing a religious revival in the country. She employs the Swedish language with an extraordinary richness and variety. After 1897, entirely devoted to literature, Miss Lagerlöf resided in Fahlun. But perhaps the greatest recent novelist of Sweden is Per Hallström (b. 1866), who spent much of his youth in America, and appeared as an imaginative writer first in 1891. He has published volumes of ballads, short stories and sketches, fantastic and humoristic, all admirable in style.

Among the recent lyrical poets of Sweden, the first to adopt the naturalistic manner was Albert Ulrik Bååth (b. 1853), whose earliest poems appeared in 1879. In his rebellion against the sweetness of Swedish convention he proved himself somewhat indifferent to beauty of form, returned to "early national" types of versification, and concentrated his attention on dismal and distressing conditions of life. He is a resolute, but harsh and rocky writer. From 1882 onwards Bååth was steadily productive. Karl Alfred Melin (b. 1849) has described in verse the life in the islands of the Stockholm archipelago. Among lyrists who have attracted attention in their various fields are Oskar Levertin (b. 1862) and Emil Kléen (1868–1898). Of these Levertin is the more highly coloured and perfumed, with an almost Oriental richness; Kléen has not been surpassed in the velvety softness of his language. But by far the most original and enjoyable lyrical genius of the period is that of Gustaf Fröding (b. 1860), whose collection of poems, called *Guitar and Accordion*, humorous, amatory, and pathetic, produced a great sensation in 1891. Three other volumes followed in 1894, 1895, and 1897, each displaying to further advantage the versatility and sensuous splendour of Fröding's talent, as well as its somewhat scandalous recklessness. In 1897 he was struck down with insanity, and after three months' confinement in the asylum at Upsala, although he recovered his senses, all his joyousness and wildness had left him. He became gloomily religious, and in a new volume of poems he denounced all that he valued and enjoyed before his conversion. The youngest poet who has appeared in Sweden is K. G. Ossian-Nilssen (b. 1875), the author of two volumes of vigorous dramatic and satiric verse.

The writer who was exercising most influence in Sweden at the opening of the 20th century was Verner von Heidenstam (b. 1859). He only started authorship in 1888, after which time he led a reaction against realism and pessimism, and has turned back to a rich romantic idealism in his novels of *Endymion* (1889) and *Hans Alienus* (1892), and in his stories (1897) of the time of Charles XII. His latest work is *The Pilgrimage of St Bridget* (1901). Heidenstam has also published interesting volumes of literary criticism. Miss Ellen Key (b. 1849), a secularist lecturer of great fervour, has lately become an author in biographical and critical studies of remarkable originality. She is distinguished from Selma Lagerlöf, who is simply an artist, by her exercise of pure intellect; she is a moral leader; she has been called "the Pallas of Sweden." She published in 1897 a biography of the Swedish author, Almqvist; in 1899 she collected her finest essays in the volume called *Thought Pictures;* in 1900 appeared, under the title *Human Beings,* studies of the Brownings and of Goethe; but the finest of Ellen Key's books is *The Century of Childhood* (1901), a philosophical survey of the progress of elementary education in the last hundred years. She exercises a very remarkable power over the minds of the latest generation in Sweden. A polemical essayist of elaborate delicacy of style is Hjalmar Söderberg (b. 1869), who has been influenced by Strindberg and by Anatole France. His ironic romance, *Martin Birck's Youth,* created a sensation in 1901. Karl Johan Warburg (b. 1852), has done good work both as an essayist and as a historian of literature. But in this latter field by far the most eminent recent name in Swedish literature is that of Professor Johan Henrik Schück (b. 1855), who has made great discoveries in the 16th and 17th centuries, and who has published, besides a good book about Shakespeare, studies in which a profound learning is relieved by elegance of delivery. Warburg and Schück have written an excellent history of Swedish literature down to 1888. The poet Levertin, who is also a distinguished critic, has written a good book about the Swedish theatre. Drama has rarely flourished in Sweden, but several of the poets mentioned above have written important plays, and, somewhat earlier, the socialistic problem-pieces of A. C. Edgren-Leffler, duchess of Cajanello (1849–1893), possessed considerable dramatic talent, working under a direct impulse from Ibsen; but her greatest gift was as a novelist. The plays of Harald Johann Molander (b. 1858) have been popular in the theatres of Sweden and Finland since his first success with *Rococo* in 1880. These brief remarks do little justice to the remarkable revival of belles-lettres in Sweden which has taken place, after a long period of inertness and conventionality, during the last fifteen years. It is regrettable, for its own sake, that the Swedish Academy, which in earlier generations had identified itself with the manifestations of original literary genius, has closed its doors to the new writers with an almost vindictive pertinacity. Not one individual identified with the revival of taste has been admitted to the Swedish Academy, whose latest members (June 1902) were the diplomatist, Baron Bildt, and Professor M. G. Retzius (b. 1842), the histologist and craniologist. But the new movement, the manifestations of which are still imperfect, but which is connected with a return to the study of national history, will probably attract much attention from the future historian of literature. (E. G.)

Swellendam, a town of Cape Colony, on the left bank of the Breede river, and one of the oldest Dutch settlements in the colony, dating from about the middle of the 18th century. It is a thriving agricultural and trading centre, with a population which increased from about 3000 in 1887 to 3300 in 1890. Swellendam is memorable in the colonial records as the place where the burghers first raised the standard of revolt against the Dutch authorities and established a national party shortly before the arrival of the English.

Swimming.—During the last fifteen years of the 19th century much attention was paid to swimming in Great Britain. Its great development is largely due to the Amateur Swimming Association, which from small beginnings has grown into a strong and powerful body, and has been the means of founding kindred associations in Scotland, Ireland, and Wales. It is also due to the vast increase in the bathing accommodation provided by municipalities throughout the kingdom. With baths brought almost to their very doors, swimmers have been able to practice more frequently than their predecessors, to study more carefully the relative value of the various strokes, to eradicate that which was bad and to develop that which was good. Speed rates have been revolutionized, and times which were once considered good enough to win championships are now not even fast enough for standard certificates. Much of this improvement dates from 1886, when Joseph Nuttall, the greatest swimmer of his age, won the hundred yards championship of England. His wonderful leg kick and extraordinary speed powers astonished every one, and swimmers were not slow in taking advantage of the object-lesson afforded them, and soon learnt to adopt his style. A peculiar screw movement of the leg is the distinctive feature of it. Suppose the swimmer to be lying on his right side at rest, the legs one above the other. The under leg is bent double and the left leg pushed slightly forward, and bent a little at the knee. Then the left leg is straightened with force, and the right simultaneously swirled rapidly to it, the foot of the right leg swinging as on a hinge. The lower arm is pulled down towards the hips, then the hand is turned quickly thumb upwards, so that together with the lower part of the arm it cuts the water, the arm at this stage being bent almost double. As the arm is shot forward the hand is gradually turned palm downward, and is hollowed for the next sweep downwards. The upper arm used to be fully extended beyond the head, but now it is customary to bring it only a foot in front of the face, then pull it through the water towards the waist and recover close to the body, the arm straightening as it leaves the water. When the under arm is in position for its stroke, the upper arm should have completed its sweep and the legs be extended ready for the kick. Breathing should be regular and timed with the stroke. It is carried on principally through the nose, and after a time a swimmer learns to inhale naturally during the recovery of the upper arm.

Another method of swimming which has helped to increase speed rates, especially over short distances, is that known as the "Trudgen," or double over-arm stroke. It is a modification of a style peculiar to Indians and those who get their living on surf-beaten shores, and was first brought into special prominence in England by an amateur named Trudgen in 1873. It was, however, not until water polo made headway that the study of the stroke became general. Since then it has become highly popular and been greatly improved. Each arm is in turn thrown out of the water beyond the head, and swept round through the water to the side. The leg kick is the same as in the ordinary over-arm stroke. When the kick is taken the body is on its side, and as the legs are widened out, one arm is being brought into position out of the water while the other is finishing its stroke, and the body then turns on the breast. By this action a water polo player is able to get a good view of the field of play, and as it is a very fast stroke, it is extremely useful when racing for, or dribbling, the ball.

Water polo.

Water polo has also been one of the factors in the advance of swimming. It appears to have been played first in the 'seventies, but it was not until the institution of the English Championship in 1888 that swimmers began to take much interest in the game. Its growth was, however, rapid, for in 1889 a big London League was formed; on 26th July 1890 the first county match was played, and two days later England and Scotland met at Kensington. There is now a regular County Championship, and a series of annual international matches between England, Scotland, Ireland, and Wales. The teams consist of seven a side, and the game is played in a bath or open water not more than 30 yards or less than 19 yards in length, while the width must not be more than 20 yards and the depth not less than 3 feet. The goal posts are 10 feet apart, with cross bar 3 feet above the surface when the water is 5 feet and over in depth, or 8 feet from the bottom when the water is less than 5 feet in depth. An ordinary Football Association match ball is used, and when playing it the men are not allowed to touch it with both hands, or take it under water. Neither must they stand on the bottom when playing it, duck an opponent (unless he is in possession of the ball), retain possession of the ball when ducked, interfere with or impede an opponent unless he is holding the ball, or jump from the bottom, or push off from the side, in order to play the ball or duck an opponent. There are also numerous rules as to penalties for fouls, &c. From the mere scramble which the game was in 1888, water polo has now become a scientific exposition of skill in the water. Its great use to swimmers has been the development of staying power.

Floating.

Since 1891 scientific swimming and diving have made great advances. A knowledge of floating is of vital necessity before one can become an expert in the higher branches of swimming, and the ability to float properly in fresh water can only be acquired by long practice. The relative buoyancy of each individual varies, and as a consequence a position which would suit one man would send another to the bottom. The best way to learn is to stand on the bottom of the bath and gradually let the head back until all of it except the face is immersed, the arms meanwhile being carried slowly back until they are in a line with the rest of the body (as you would hold your arms above your head if on dry land). Keep the legs together, and then, after taking a good inspiration, push gently away from the bottom. If the balance has been correctly gauged the legs will rise slowly to the surface. Probably the water will wash over the face, but this must not make the learner give up, as that inconvenience will in all likelihood be only temporary. Above all things, the beginner must not try to see whether he is floating, *i.e.*, lift up his head to see if the legs are on the surface. This is a common fault, and as it upsets the balance at once, the learner often gives up the attempt to float in despair. Once floating has been mastered, the smart feats of the experts may be gradually acquired by careful study. A system of back swimming which is of excellent service in saving life has been perfected by the officers of the Life Saving Society. When carrying a person, if the ordinary back stroke kick were made, the rescuer, as well as the person being rescued, would at intervals sink below the surface, and it is therefore essential that the legs should be inclined towards the bottom at a greater angle, and that progression should be made by semicircular sweeps of the legs from the knees downwards. Another service to English swimming rendered by the Life Saving Society was its invitation to the expert amateur divers of Sweden to give a demonstration of their skill at the Diamond Jubilee Gala in the West India Docks, at which the Prince and Princess of Wales were present. Nothing like their display had ever before been seen in this country, but since then their styles have been copied, and great improvement has taken place in the form of English divers. The Swedes are wonderfully skilful and graceful in dives from great heights. Forward and backward headers, backward springs, somersaults, and swallow-like dives are mere child's-play to them, and 60 feet is a common drop. The "swallow" is one of the most thrilling dives. The Swede will stand on a platform 60 feet above the surface, make a run, and then spring out into the air. His head is then at once thrown backwards, the back hollowed, the arms flung out horizontally and at right angles to the body, and the legs straightened and closed. He falls in this position until some 8 feet from the water, when suddenly the arms close, the head falls between them, and the body comes into the correct and usual position for entering the water.

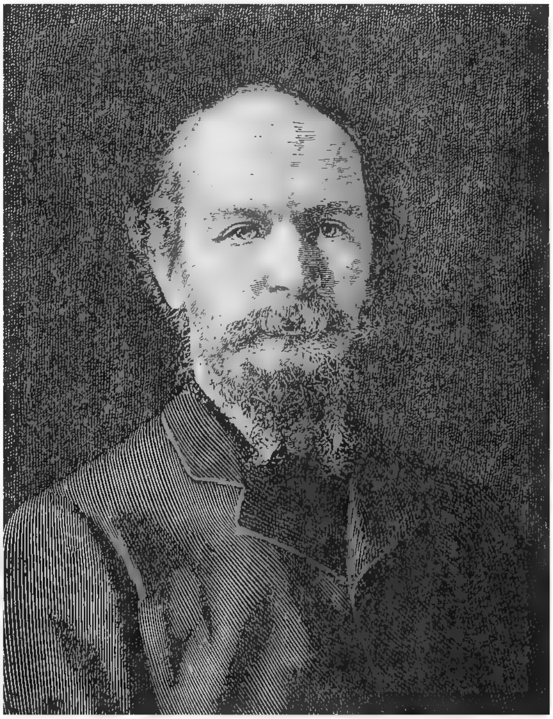
Diving.

Swimming Records, 1902.—100 yards, 1 minute ⅕ second, by J. H. Derbyshire, Manchester Osborne, at Manchester, 23rd November 1898; 150 yards, 1 minute 38⅘ seconds, by J. H. Derbyshire, Manchester Osborne, at Burslem, 8th June 1899; 220 yards 2 minutes 34⅘ seconds, by J. H. Derbyshire, Manchester Osborne, at Burslem, 8th June 1899; 220 yards, 2 minutes 34⅘ seconds, by J. H. Derbyshire, Manchester Osborne, and F. C. V. Lane, New South Wales (dead heated), at Birmingham, 17th September 1900; 300 yards, 3 minutes 47⅘ seconds, by F. C. V. Lane, New South Wales, at Blackpool, 11th September 1899; 440 yards, 5 minutes 52⅗ seconds, by J. A. Jarvis of Leicester, at Bacup, 27th October 1900; 500 yards, 6 minutes 42⅗ seconds, by J. A. Jarvis of Leicester, at Sunderland, 4th October 1899; 880 yards, 12 minutes 29 seconds, by J. A. Jarvis of Leicester, at Leicester, 8th August 1899; 1000 yards, 14 minutes 10 seconds, by J. A. Jarvis of Leicester, at Walsall, 15th July 1899; 1 mile, 25 minutes 13⅖ seconds, by J. A. Jarvis of Leicester, at Leicester, 8th August 1899.

Plunging Records.—With time-limit of 60 seconds, 78 feet 9 inches, by W. Taylor of Bootle, at Bootle, 14th September 1899. Without time-limit, 82 feet, by W. Taylor of Bootle, at Bootle, 6th September 1899.

M. A. Holbein swam from Blackwall to Gravesend Town Pier, a distance of about 20 miles, on 29th June 1900, in 4 hours 43 minutes 6 seconds. Captain Webb swam the same distance in July 1875, in 4 hours 52 minutes 44 seconds. M. A. Holbein swam from Blackwall to 2 miles beyond Gravesend Town Pier and back to within a mile of his starting-point on 25th July 1899, in 12 hours 27 minutes 42¾ seconds, the distance covered being about 43 miles. M. A. Holbein swam for 12 hours in Spithead and the Solent, on 14th August 1899, and in that time it was computed that he covered between 46 and 47 miles. He was quite fresh, and his body warm when he left the water, and, but for darkness coming on, would have gone farther. On 27th August 1902, Holbein almost succeeded in swimming the Channel from Cape Grisnez to Dover, being taken out of the water a mile from land owing to the adverse tide. F. Holmes, of Birmingham, swam 14 miles in 4 hours and 45 minutes, on 24th July 1900, in an attempt to swim the English Channel from Dover to Calais. Madame Isacescu, an Austrian lady, swam nearly 20 miles in 10 hours, on 5th September 1900, in an attempt to swim the English Channel from Calais to Dover. (S. H*.)

Swinburne, Algernon Charles (1837-——), English poet and critic, was born in Chapel Street, Belgravia, 5th April 1837. He was the son of Admiral Charles Henry Swinburne (of an old Northumbrian family) and of Lady Jane Henrietta, a daughter of George, third earl of Ashburnham. It may almost be said to have been by accident that Mr Swinburne owed London for his birthplace, since he was removed from it immediately, and always felt a cordial dislike for the surroundings and influences of life in the heart of a great city. His own childhood was spent in a very different environment. His grandfather, Sir John Edward Swinburne, Bart., owned an estate in Northumberland, and his father, the Admiral, bought a beautiful spot between Ventnor and Niton in the Isle of Wight, called East Dene, together with a strip of undercliff known as the Landslip. The two homes were in a sense amalgamated. Sir Edward used to spend half the year in the Isle of Wight, and the Admiral's family shared his northern home for the other half; so that the poet's earliest recollections took the form of strangely contrasted emotions, inspired on the one hand by the bleak north, and on the other by the luxuriant and tepid south. Of the two, the influences of the island are, perhaps naturally, the stronger in his poetry; and many of his most beautiful pieces were actually written at the Orchard, an exquisite spot by Niton Bay, which belonged to relatives of the poet, and at which he was a constant visitor. After some years of private tuition, Mr Swinburne was sent to Eton, where he remained for five years, proceeding to Balliol College, Oxford, in 1857. He was three years at the University, but left without taking a degree. Clearly he must have cultivated while there his passionate and altogether unacademic love for the literature of Greece; but his undergraduate career was unattended by university successes, beyond the Taylorian Prize for French and Italian, which he gained in 1858. He contributed to the "Undergraduate Papers," published during his first year, under the editorship of John Nichol, and he wrote a good deal of poetry from time to time, but his name was probably regarded without much favour by the college authorities. He took a second class in classical moderations in 1858, but his name does not occur in any of the "Final" honour schools. He left Oxford in 1860, and in the same year published those remarkable dramas, *The Queen Mother* and *Rosamond*, which, despite a certain rigidity of style, must be considered a wonderful performance for so young a poet, being fuller of dramatic energy than most of his later plays, and rich in really magnificent blank verse. The volume was scarcely noticed at the time, but it attracted the attention of one or two literary judges, and was by them regarded as a first appearance of uncommon promise.



ALGERNON CHARLES SWINBURNE.
(From a photograph by Elliott and Fry, London.)

It is a mistake to say, as most biographers do, that Mr Swinburne, after leaving Oxford, spent some time in Italy with Walter Savage Landor. The facts are quite otherwise. The Swinburne family went for a few weeks to Italy, where the poet's mother, Lady Jane, had been educated, and among other places they visited Fiesole, where Landor was then living in the house that had been arranged for him by the kindness of the Brownings. Swinburne was a great admirer of Landor, and, knowing that he was likely to be in the same town with him, had provided himself with an introduction from his friend, Richard Monckton Milnes. Landor and Swinburne met and conversed, with great interest and mutual esteem; but the meetings were not for more than an hour at a time, nor did they exceed four or five in number. Mr Swinburne never lived in Italy for any length of time. In 1865 appeared the lyrical tragedy of *Atalanta in Calydon*, followed in the next year by the famous *Poems and Ballads*, and with them the poet took the public gaze, and began to enjoy at once a vogue that may almost be likened to the vogue of Byron. His sudden and imperative attraction did not, it is true, extend, like Byron's, to the unliterary; but among lovers of poetry it was sweeping, permeating, and sincere. The *Poems and Ballads* were vehemently attacked, but *Dolores* and *Faustine* were on every one's lips: as a poet of the time has said, "We all went about chanting to one another these new, astonishing melodies." *Chastelard*, which appeared between *Atalanta* and *Poems and Ballads*, enjoyed perhaps less unstinted attention; but it is not too much to say that by the close of his thirtieth year, in spite of hostility and detraction, Mr Swinburne had not only placed himself in the highest rank of contemporary poets, but had even established himself as leader of a choir of singers to whom he was at once master and prophet.

Meanwhile, his private life was disturbed by troublous influences. A favourite sister died at East Dene, and was buried in the little shady churchyard of Bonchurch. Her loss overwhelmed the poet's father with grief, and he could no longer tolerate the house that was so full of tender memories. So the family moved to Holmwood, in the Thames valley, near Reading, and the poet, being now within sound of the London literary world, grew anxious to mix in the company of the small body of men who shared his sympathies and tastes. Rooms were found for him in North Crescent, off Oxford Street, and he was drawn into the vortex of London life. The Pre-Raphaelite movement was in full swing, and for the next few years he was involved in a rush of fresh emotions and rapidly-changing loyalties. It is indeed necessary to any appreciation of Mr Swinburne's genius that one should understand that his inspiration has been almost invariably derivative. His first book is deliberately Shakespearian in design and expression; the *Atalanta*, of course, is equally deliberate in its pursuit of the Hellenic spirit. Then, with a wider swing of the pendulum, he recedes, in *Poems and Ballads*, to the example of Baudelaire and of the Pre-Raphaelites themselves; with the *Song of Italy* (1867) he is drawing towards the revolt of Mazzini; by the time *Songs before Sunrise* are completed (in 1871) he is altogether under the influence of Victor Hugo, while Rome has become to him "first name of the world's names." But, if Mr Swinburne's inspiration was derivative, his manner was in no sense imitative; he brought to poetry a spirit entirely his own, and a method even more individual than his spirit. In summing up his work we shall seek to indicate wherein his originality and his service to poetry has lain; meanwhile, it is well to distinguish clearly between the influences which touched him and the original, personal fashion in which he assumed those influences, and made them his own.

The spirit of Mr Swinburne's muse has always been a spirit of revolution. In *Poems and Ballads* the revolt is against moral conventions and restraints; in *Songs before Sunrise* the arena of the contest is no longer the sensual sphere, but the political and the ecclesiastical. The detestation of kings and priests, which marked so much of the work of his maturity, is now in full wing, and Mr Swinburne's language is sometimes tinged with extravagance and an almost virulent animosity. With *Bothwell* (1874) he returned to drama and the story of Mary Stuart. The play has fine scenes and is burning with poetry, but its length not only precludes patient enjoyment, but transcends all possibilities of harmonious unity. *Erechtheus* (1876) was a return to the Greek inspiration of *Atalanta;* and then in the second series of *Poems and Ballads* (1878) the French influence is seen to be at work, and Victor Hugo begins to hold alone the place possessed, at different times, by Baudelaire and Mazzini. At this time Mr Swinburne's energy was at fever height; in 1879 he published his eloquent *Study of Shakespeare,* and in 1880 no fewer than three volumes, *The Modern Heptalogia,* a brilliant anonymous essay in parody, *Songs of the Springtides,* and *Studies in Song.* It was shortly after this date that Mr Swinburne's friendship for Mr Theodore Watts-Dunton (then Mr Theodore Watts) grew into one of almost more than brotherly intimacy. After 1880 Mr Swinburne's life remained without disturbing event, devoted entirely to the pursuit of literature in peace and leisure. The conclusion of the Elizabethan trilogy, *Mary Stuart,* was published in 1881, and in the following year *Tristram of Lyonesse,* a wonderfully individual contribution to the modern treatment of the Arthurian legend, in which the heroic couplet is made to assume opulent, romantic cadences of which it had hitherto seemed incapable. Among the publications of the next few years must be mentioned *A Century of Roundels,* 1883; *A Midsummer Holiday,* 1884; and *Miscellanies,* 1886. The current of his poetry, indeed, continued unchecked; and though it would be vain to pretend that he added greatly either to the range of his subjects or to the fecundity of his versification during the twenty years from 1882 to 1902, it is at least true that his melody was unbroken, and his magnificent torrent of words inexhaustible. His *Marino Faliero* (1885) and *Locrine* (1887) have passages of power and intensity unsurpassed in any of his earlier work, and the rich metrical effects of *Astrophel* (1894) and *The Tale of Balin* (1896) are inferior in music and range to none but his own masterpieces.

Besides this wealth of poetry, Mr Swinburne was active as a critic, and several volumes of fine impassioned prose testify to the variety and fluctuation of his literary allegiances. His *Note on Charlotte Brontë* (1877) must be read by every student of its subject; the *Study of Shakespeare* (1880) is full of vigorous and arresting thought, and many of his scattered essays are rich in suggestion and appreciation. His studies of Elizabethan literature are, indeed, full of "the noble tribute of praise," and no contemporary critic has done so much to revive an interest in that wonderful period of dramatic recrudescence, the side-issues of which have been generally somewhat obscured by the pervading and dominating genius of Shakespeare. Where his enthusiasm is heart-whole, Mr Swinburne's appreciation is stimulating and infectious, but the very qualities which give his poetry its unique charm and character are antipathetic to his success as a critic. He has very little capacity for cool and reasoned judgment, and his criticism is often a tangled thicket of prejudices and predilections. He is, of course, a master of the phrase; and it never happens that he touches a subject without illuminating it with some lightning-flash of genius, some vivid penetrating suggestion that outflames its shadowy and confused environment. But no one of his studies is satisfactory as a whole; the faculty for sustained exercise of the judgment is denied him, and even his best appreciations are disfigured by error in taste and proportion. On the other hand, when he is aroused to literary indignation the avalanche of his invective sweeps before it judgment, taste, and dignity. His dislikes have all the violence of his affections, and while both alike present points of great interest to the analyst, revealing as they do a rich, varied, and fearless individuality, the criticism which his hatreds evoke is seldom a safe guide.

But whatever may be said in criticism of his prose, there is at least no question of the quality of his poetry, or of its important position in the evolution of English literary form. To treat first of its technique, it may safely be said to have revolutionized the whole system of metrical expression. It found English poetry bound in the bondage of the iambic; it left it revelling in the freedom of the choriambus, the dactyl, and the anapæst. Entirely new effects; a richness of orchestration resembling the harmony of a band of many instruments; the thunder of the waves, and the lisp of leaves in the wind; these, and a score other astonishing poetic developments were allied in his poetry to a mastery of language and an overwhelming impulse towards beauty of form and exquisiteness of imagination. In *Tristram of Lyonesse* the heroic couplet underwent a complete metamorphosis. No longer wedded to antithesis and a sharp cæsura, it grew into a rich melodious measure, capable of an infinite variety of notes and harmonies, palpitating, intense. The service which Mr Swinburne rendered to the English language as a vehicle for lyrical effect is simply incalculable. He revolutionized the entire scheme of English prosody. Nor was his singular vogue due only to this extraordinary metrical ingenuity. The effect of his artistic personality was in itself intoxicating, even delirious. He was the poet of youth insurgent against all the restraints of conventionality and custom. The young lover of poetry, when first he encounters Mr Swinburne's influence, is almost bound to be swept away by it; the wild, extravagant licence, the apparent sincerity, the vigour and the verve, cry directly to the aspirations of youth like a clarion in the wilderness. But, while this is inevitable, it is also true that the critical lover of poetry outgrows an unquestioning allegiance to the Swinburnian mood more quickly than any other of the diverse emotions aroused by the study of the great poets. It is not that what has been called his "pan-anthropism"—his universal worship of the holy spirit of man—is in itself an unsound philosophy; there have been many creeds founded on such a basis which have impregnably withstood the attacks of criticism. But the unsoundness of Mr Swinburne's philosophy lies in the fact that it celebrates the spirit of man engaged in a defiant rebellion that leads nowhere; and that as a "criticism of life" it has neither finality nor a sufficiently high seriousness of purpose. Walt Whitman preaches very much the same gospel of the "body electric" and the glory of human nature; but Whitman's attitude is far saner, far more satisfying than Mr Swinburne's. For it is concerned with the human spirit realizing itself in accordance with the unchangeable laws of nature; while Mr Swinburne's enthusiasm is, more often than not, directed to a spiritual revolution which sets the laws of nature at defiance. It is impossible to acquit his poetry of the charge of an animalism which wars against the higher issues of the spirit—an animalism sometimes of love, sometimes of hatred, but, in both extremes, out of centre and harmony.

Yet, when everything has been said that can be said against the unæsthetic violences of the poet's excesses, his service to contemporary poetry outweighs all disadvantages. No one has done more to free English literature from the shackles of formalism; no one, among our contemporaries, has pursued the poetic calling with so sincere and resplendent an allegiance to the claims of absolute and unadulterated poetry. Some of our poets have turned preachers; others have been seduced by the attractions of philosophy; but Mr Swinburne has always remained an artist absorbed in a lyrical ecstasy, a singer and not a seer. When the history of Victorian poetry comes to be written, it will be found that his personality has been among the most potent of his time; and, as an artistic influence, it will be pronounced both inspiring and beneficent. The topics that he has touched are often ephemeral; the causes that he celebrated will, many of them, wither and desiccate; but the magnificent freedom and lyrical resource which he introduced into the language will enlarge its borders and extend its sway so long as English poetry survives.

Swindon, a municipal borough (1900) and important railway junction in the Cricklade parliamentary division of Wiltshire, England, 77 miles west of London. The Great Western Railway works employ about 11,000 hands. Numerous churches and Nonconformist chapels have arisen. Other recent erections are a market, a central club and institute, a theatre, a Victoria Hospital, the Great Western Medical Fund Society's building, and an isolation hospital. A recreation ground of 30 acres is connected with the Great Western Railway Mechanics' Institute, which has been enlarged, as has also the accident hospital. The Wilts and Berks canal has been dredged and repaired, and three bridges have been built over it. Area, 4246 acres. Population (1851), 4876; (1881), 19,904; (1891), 33,001; (1901), 44,996.

Swinemünde, a seaport town and seaside resort of Prussia, province of Pomerania, situated at the east extremity of the island of Usedom, and on the left bank of the river Swine, which connects the Stettiner Haff with the Baltic, serves as the outer port of Stettin (*q.v.*), from which it is 42 miles distant by water. The entrance to the Swine is protected by two breakwaters, 3600 feet and 5250 feet long respectively; and in 1897 the river continuation of the Kaiserfahrt, known as the cut through the Mellin, was opened to navigation. Further, the waterway between the Haff and the Baltic was deepened to 24 feet in 1900–1901, and in other ways improved. The connexion between Swinemünde and Stettin is kept open in winter by ice-breakers. This port was cleared by 4967 vessels of 1,706,488 tons in 1899, the bulk of them having previously cleared from Stettin. The industries are principally connected with shipping. A monument to the Emperor William I. was unveiled in 1895. Population (1777), 1804; (1895), 9391; (1900), 10,251.

SWITZERLAND.

I. Geography and Statistics.

In 1902 the area of Switzerland was officially estimated at 15,990 square miles. Of this 71·6 per cent., or 11,461 square miles, were classed as "productive," 3250 square miles being covered by forests and 127 square miles by vineyards. Of the "unproductive" 4529 square miles (28·4 per cent. of the total area), 710 square miles were covered by glaciers, 518 square miles by lakes, 129 square miles by the beds of rivers and streams, and 66 square miles by towns, villages, and buildings. The Grisons, Bern, and the Valais occupy together 7456 square miles, while if we add the next three in size (Vaud, Ticino, and St Gall) the amount is raised to 10,570 square miles. The three smallest (whole) cantons are Schaffhausen (113½ square miles), Geneva (107 square miles), and Zug (92·3 square miles).

The following table gives the (1902) official details as regards the fifteen principal Swiss lakes:—

Name of Lake.	Area in Square Miles.	Mean Height above Sea-Level in Feet.	Greatest Depth in Feet.
1. Geneva . .	223·0	1230¼	1014
2. Constance . .	207·8	1309	827
3. Neuchâtel . .	92·4	1420½	505
4. Maggiore . .	82·7	646½	1197
5. Lucerne . .	44·5	1434	702
6. Zürich . .	33·8	1342	469
7. Lugano . .	19·4	899	945
8. Thun . .	18·4	1837¼	712
9. Bienne . .	16·2	1417¼	246
10. Zug . . .	14·7	1368	649
11. Brienz . .	11·5	1857	853
12. Morat . .	10·5	1420½	151
13. Walensee . .	8·9	1388	495
14. Sempach . .	5·5	1663½	285
15. Hallwyl . .	3·9	1483	157

Of these lakes *Geneva* is divided between Vaud (123½ square miles), Geneva (11½ square miles), and the Valais (4·7 square miles), the rest (83·2 square miles) belonging to France. *Constance* is partly in Thurgau (59·7) and St Gall (21½), but mostly belongs to Würtemberg, Bavaria, Baden, and Austria. *Neuchâtel* is owned by Neuchâtel (36½), Vaud (33·1), Fribourg (20·7), and Bern (2). *Maggiore* is in Ticino for part of its area (16·2) only, the rest (66½) belonging to Italy. *Lucerne* is much divided, as Lucerne has 15½ square miles, Nidwalden 12·9, Uri 7·6, Schwyz 7½, and Obwalden ·9, so that this lake is rightly named the "Lake of the Four Forest Cantons." *Zürich* is owned by Zürich (20·9), Schwyz (8·8), and St Gall (4·1); but of *Lugano*, Ticino has 7½ square miles only, the rest (11·9) being Italian. *Bienne* is divided between Bern (15·8) and Neuchâtel (·4), *Zug* between Zug (10·1), Schwyz (3·7), and Lucerne (·9), and *Morat* between Fribourg (6·8) and Vaud (3·6). The *Walensee* is owned jointly by St Gall (7·1) and Glarus (1·8), and *Hallwyl* by Aargau (3·3) and Lucerne (·6). The following are the dates at which steamers first plied on the twelve principal Swiss lakes:—1823 (Geneva), 1824 (Constance), 1826 (Maggiore), 1827 (Neuchâtel, Bienne, and Morat), 1835 (Thun, Lucerne, and Zürich), 1839 (Brienz), 1852 (Zug), and 1856 (Lugano).

The following is the number of the *resident* inhabitants in Switzerland according to the various censuses:—

1850.	1860.	1870.	1880.	1888.	1900.
2,392,740	2,510,494	2,655,001	2,831,787	2,917,754	3,315,443

According to the census of 1888, the rate of density in Switzerland was 219 inhabitants to each square mile of *dry* land (*i.e.*, excluding from the total area of Switzerland all lakes of over 1 square kilometre (·3 square miles) in extent. In 1888 Lucerne and the Valais both had 101 males to 100 females, while Obwalden had 100 of each, though in Geneva there were but 87 males to 100 females, in urban Basel but 83, and in Ticino but 79, these three cantons showing the lowest proportion of males to females. As regards ages per 1000 of the total Swiss population, the figures for 1888 are respectively 322 (under 15), 584 (15–59), and 94 (60 and upwards). Though, as pointed out above, there are so many more females than males in Switzerland (in 1888 there were 1,002,144 females of marriageable age, and but 864,076 males), yet the proportion of marriages in each sex is almost the same—of 1000 persons of marriageable age in 1888, 609 males and 607 females were actually married. The annual average number of divorces (almost wholly in the Protestant cantons of course) was 994 between 1876 and 1880, 927 between 1881 and 1885, and 882 between 1886 and 1890; in 1895 there were 897, and in 1899, 1091. The number of illegitimate births between 1886 and 1890 was 4009 a year, fell to 3855 in 1890, but in 1895 was again 4009, and in 1899 it rose to 4518; in every year the male children so born exceeded the female children.

Table showing Principal Changes since the Earlier Article was compiled.

Name of Canton.	Date of Present Cantonal Constitution.	Area in English Square Miles.	Population (Resident).		Density per Square English Mile (1900).	Cantonal Capitals.	Population of Cantonal Capitals (1900).
			1888 (Census).	1900 (Census).			
1. Grisons	1892	2,773·3	94,810	104,520	38	Coire . . .	11,513
2. Bern	1893	2,657·3	536,679	589,433	222	Bern . . .	63,994
3. Valais	1875	2,025·3	101,985	114,438	56	Sion . . .	6,059
4. Vaud	1885	1,247·6	247,655	281,379	228	Lausanne . .	46,407
5. Ticino	1892	1,087·9	126,751	138,638	127	Bellinzona . .	5,047
6. St Gall	1890	779·3	228,174	250,385	322	St Gall . . .	33,087
7. Zürich	1869	665·2	337,183	431,036	649	Zürich . . .	150,703
8. Fribourg . . .	1857	646·2	119,155	127,951	198	Fribourg . . .	15,766
9. Lucerne . . .	1875	579·3	135,360	146,519	254	Lucerne . . .	29,203
10. Aargau	1885	541·9	193,580	206,498	381	Aargau . . .	7,824
11. Uri	1888	415·3	17,249	19,706	47	Altdorf . . .	3,134
12. Thurgau . . .	1869	387·8	104,678	113,221	292	Frauenfeld . .	7,735
13. Schwyz	1876 (1898)	350·6	50,307	55,385	158	Schwyz . . .	7,398
14. Neuchâtel . . .	1858	311·8	108,153	126,279	405	Neuchâtel . .	20,781
15. Soleure	1887 (1895)	305·5	85,621	100,762	329	Soleure . . .	10,053
Unterwalden—							
16. Obwalden . . .	1867	183·2	15,043	15,260	83	Sarnen . . .	3,950
17. Nidwalden . . .	1877	112·1	12,538	13,070	116	Stans . . .	2,794
18. Glarus	1887	266·8	33,825	32,349	121	Glarus . . .	4,896
Basel—							
19. Urban	1889	13·8	73,749	112,227	8063	Basel . . .	109,169
20. Rural	1892	163·8	61,941	68,497	418	Liestal . . .	5,390
Appenzell—							
21. Outer	1876	100·5	54,109	55,281	548	Herisau . . .	13,491
22. Inner	1872	61·3	12,888	13,499	221	Appenzell . .	4,569
23. Schaffhausen . .	1876	113·5	37,783	41,514	365	Schaffhausen . .	15,286
24. Geneva	1847	106·9	105,509	132,609	1247	Geneva . . .	105,517
25. Zug	1894	92·3	23,029	25,093	274	Zug . . .	6,471
Total . .	...	15,978·5	2,917,754	3,315,817	208		

The following table gives by periods of five years the average number of marriages, births, and deaths per each 1000 inhabitants of the total population:—

Years.	Marriages.	Births.	Deaths.
1881–95 . . .	6·9	30·0	21·4
1886–90 . . .	7·1	28·8	20·5
1891–95 . . .	7·4	29·2	20·1

Between 1871 and 1890, in Switzerland, the average number of marriages per 1000 inhabitants was 7·4 (the rate for Great Britain and Ireland being 7·2), of births was 29·4 (Great Britain and Ireland, 32·6), and of deaths 22·1 (Great Britain and Ireland, 19·9).

The numbers of non-Swiss residents in the Confederation was 229,650, according to the census returns of 1888 (392,896 in 1900). By nationality they were principally distributed as follows in 1888: natives of Germany, 112,342 (including 6814 from Alsace-Lorraine); Austria, 13,737 (and also 444 Hungarians); Italy, 41,881; France, 53,627; Great Britain and Ireland, 2577; Russia, 1354; United States of America, 986.

Emigration.—The following numbers show that the tide of emigration from Switzerland to lands over the seas has, with some slight fluctuations, greatly decreased. In 1888 there were 8346 emigrants, in 1893, 6177; in 1895, 4268; in 1897, 2508; in 1898, 2288; in 1899, 2493; but in 1900 there were 3816. By far the great majority find their way to the United States of America.

Civic and Rural Population.—Of the 3185 "political communes" existing in Switzerland in 1888, only 18 had a population above 10,000, 36 between 5000 and 10,000, and 24 between 4000 and 5000—in all 78 with populations exceeding 4000; and there were 428 with populations between 1000 and 2000. Of these 3185 "communes" 50 are above 1500 metres (4931 feet in altitude). The lowest "commune" in Switzerland is that of Ascona, 202 metres (663 feet) on the Lago Maggiore, and the highest, Avers, 1949 metres (6395 feet)—herein is Juf, 2133 metres (6998 feet), the highest permanently inhabited village not merely in Switzerland, but in the entire chain of the Alps.

Religion.—The figures for 1888 are:—1,716,548 Protestants (58·8 per cent.), 1,183,828 Roman Catholics (40·6 per cent.), 8069 Jews (·3 per cent.), and 9309 (3 per cent.) miscellaneous or unknown. The following cantons in 1888 had more Protestants than Roman Catholics:—Zürich, Bern, Glarus, Outer Rhodes of Appenzell, the Grisons, Aargau, Thurgau, Vaud, and Neuchâtel—in all 8½. The other 16½ had a Roman Catholic majority, and among these was in 1888 that of Geneva. The Jews are most numerous in Zürich (1349), Bern (1195), and urban Basel (1051), nowhere else exceeding 740 (Neuchâtel). In 1900 there were (among the actual as opposed to the resident population) 1,918,197 Protestants, 1,383,135 Roman Catholics, and 12,551 Jews.

Languages.—By the Federal Constitutions of 1848 and 1874, French, German, and Italian are formally recognized as "national languages," so that debates in the Federal Parliament may be carried on in any of the three indifferently, while all laws and Federal Acts appear in three versions. The old historical dialect of the Romonsch or Ladin (nearly confined to the Grisons, *q.v.*) enjoys no political recognition, and is largely maintained by artificial means in the shape of special societies for its preservation. In 1900 German was spoken by 2,319,105, French by 733,220, Italian by 222,247, Romonsch by 38,677. The first linguistic censuses of individuals were those of 1880 and 1888, as shown in the following table:—

German.		French.		Italian.		Romonsch.	
1880.	1888.	1880.	1888.	1880.	1888.	1880.	1888.
2,030,792 (71·3)	2,083,097 (71·4)	608,007 (21·4)	634,613 (21·8)	161,923 (5·3)	155,130 (5·7)	38,705 (1·4)	38,357 (1·3)

In 1880 there were 6675 (2 per cent.), and in 1888 6557 (2 per cent.) persons in Switzerland whose mother-tongue was other than the four mentioned above, Vaud, Geneva, and Zürich heading the list in this respect. For fuller details see the various cantons. Here it need only be noted that there is a German-speaking majority in all the cantons save five, thus showing that historically the Swiss Confederation is a German-speaking state with which have been united fragments of lands speaking other tongues, these, however, having no *political* rights till after the French Revolution. Of the non-German-speaking five cantons, four (Fribourg, Vaud, the Valais, and Geneva) had a French-speaking and one (Ticino) an Italian-speaking majority. Of the Romonsch-speaking inhabitants there were in the Grisons 37,794 out of 38,705 in 1880, and 37,036 out of 38,357 in 1888; in no other canton were there in either year over 97, save in St Gall (239 in 1880, and 392 in 1888) and Zürich (150 and 217 respectively).

Climate.—The minimum rainfall between 1864 and 1893 was at Sierre in the canton of the Valais (per year 565 millimetres, or 22¼ inches), while the maximum (certainly over 7½ feet) occurs in the higher parts of the alps of Bern, Uri, Ticino, and the Grisons.

Mineral Products.—The output of salt from the five salt-mines of Switzerland increased about 20 per cent. between 1882 and 1896.

Animals.—As regards game, the extent of the "district francs" or "Bannbezirke" in 1896 was 1887 square kilometres. The most extensive district is that in the Titlis range (195 square kilometres), taking in parts of Uri and Unterwalden, followed by that of the Faulhorn range in the canton of Bern (172 square kilometres), while the smallest (11 square kilometres) is near Thusis in the Grisons. Yet there is a great deal of unlawful hunting in these districts, as the game licences are very expensive.

In 1899–1900 there were 150 fish hatcheries, in which all the cantons shared save Uri and the Inner Rhodes of Appenzell. From these hatcheries in the year quoted 33 millions of fish were placed in lakes and rivers. The old Federal law of 1875 was replaced in 1888 by a stricter code.

In live stock the following table contains the definitive results of the censuses of live stock taken in 1886, 1896, and 1901:—

	1886.	1896.	1901.
1. Total number of owners of live stock of all kinds	289,274	287,430	Not given.
2. Cattle[1]	1,212,538	1,306,696	1,340,375
3. Swine	394,917	566,974	555,261
4. Goats	416,323	415,817	354,634
5. Sheep	341,804	271,901	219,438
6. Horses	98,622	108,969	124,896
7. Mules	2,742	3,125	3,077
8. Asses	2,046	1,740	1,789
9. Beehives	207,384	254,109	242,544

Alpine Pastures.—The "alps" are the high mountain pastures used by cattle during the summer, and are held as common property by different communes (33 per cent.), or else by individuals (54 per cent.), or by one and the other or by "corporations" jointly (12 per cent.), or finally by the State or monasteries (1 per cent.). It has been estimated that there are in all 4778 different "alps," capable of supporting 270,389 cows, and of an estimated capital value of 81½ million francs. Bern (836), the Grisons (646), and Ticino (435) have the greatest number of "alps," while Neuchâtel has but 245. In view, however, of returns now in course of publication, these figures must be accepted with some reserve.

Forests.—The Federal Constitution of 1874 gave to the Federal Government the right of supervision, &c., over forests and the damming of torrents only in the *high mountains.* But in 1897 an amendment struck out this limitation, so that *all* torrents and forests are now cared for by the Federal Forest Department.

Industries.—The following table gives the round value (in millions of francs) of the products of the three chief Swiss industries exported between 1898 and 1900:—

	1898.	1899.	1900.
1. Embroideries	83·6	108·7	119
2. Silk (raw)	99·7	109·2	110
3. Watches and clocks	108	112·6	123

The cheese industry (save as regards Germany, France, and Russia) has decreased of late years, while the condensed milk industry has risen but slightly, and that chiefly as regards England. The production of beer has enormously increased, but only a very small quantity is exported.

Commerce.—The following table shows the round value (in millions of francs, the figures in parentheses giving the percentage of the total import, or export, trade in 1898) of the trade of Switzerland, with its principal customers, between 1896 and 1898:—

	Imports into Switzerland.			Exports from Switzerland.		
	1896.	1897.	1898.	1896.	1897.	1898.
1. Germany	305	306¼	314½ (29½)	172¼	175½	194 (26·8)
2. France	177½	192½	204 (19·1)	81	83½	83¼ (11½)
3. Italy	137¼	149¾	155¾ (14·6)	39¼	30	38¾ (5·3)
4. Austria-Hungary	71½	66¾	66¼ (6·2)	40½	41¼	42 (5·8)
5. Russia	65¼	67	61 (5·7)	24½	24½	30½ (4.2)
6. Great Britain	51¾	54	51 (4·7)	147	146	148¼ (20·4)
7. Belgium	24	24½	26¼ (2·4)	11¼	13	12¼ (1·7)
Total Europe	876½	897¾	911¼ (85½)	551½	560½	586¾ (81)
Total Africa	15½	13	13½ (1·2)	5½	6	5¾ (·8)
Total Asia	31¾	38½	36½ (3·4)	31¼	30	32¼ (4·4)
United States	39¼	51½	73 (6·8)	70½	71	73¾ (10·1)
Total America	65¼	77	98 (9·2)	93¼	90½	92½ (12·7)
Total Australia	4¾	5	6 (·5)	2¼	3	3¼ (·4)
Grand total	993¾	1031¼	1065¼	688	693¼	723¾

The grand totals for 1899 were:—Imports, 1160; exports, 796; and for 1900—imports, 1111; exports, 836.

The next table shows the trade between Great Britain and Switzerland, the figures, as before, denoting round millions of francs:—

Year.	Imports into Switzerland.	Exports from Switzerland.
1894	43	117½
1895	47½	130
1896	51¾	147
1897	54	146
1898	51	148¼
1899	56½	166
1900	62¼	175½

In 1900 the principal articles imported from Great Britain, with their value in round millions of francs, were: cotton goods (26½), woollen goods (8½), and sheet iron (12) and machines (2); while in the same year the chief exports to Great Britain were: woven silk goods (48⅘), ribbons (21), embroideries (30¼), watches and clocks (24⅗), and condensed milk (17½). It is explained below (in the sketch of modern Swiss history) how Switzerland, though by nature a free-trade country, has become for the present a protectionist country, the customs duties having been raised very much of recent years. In 1850 the import duties amounted only to 3,613,763 francs, and even as lately as 1870 were but 8,111,349 francs. But in the next twenty years the rise was rapid: in 1875 to 16,622,254, in 1880 to 16,535,907, in 1885 to 20,792,905, and in 1890 to 30,816,425. The figures for the next few years are instructive: 1891, 31,114,059; 1892, 35,589,858; 1893, 37,927,974; 1894, 40,752,543; 1895, 42,838,518; 1896, 45,817,457; 1897, 47,434,151; 1898, 48,314,099; 1899, 50,578,684; 1900, 47,491,704; and 1901, 46,472,000.

Health Stations.—Almost every little mountain village now calls itself a "health resort" or "air cure." As far back as 1880 it was reckoned that there then existed in Switzerland 1002 inns built expressly for visitors, containing 58,137 beds, and of an estimated capital value of 320 million francs. Of these inns 283 were situated above 3400 feet, while 14 stood at a height of above 6562 feet. In 1894 the number of such inns had risen to 1693 (with 88,634 beds) and in 1899 to 1896 (with 104,876 beds), while their capital value was respectively 519 and 550½ millions of francs.

Finances.—The following table gives (in francs) the revenue, expenditure, and public debt of the Swiss Confederation at the periods stated:—

Year.	Revenue.	Expenditure.	Public Debt.
1880	42,511,848	41,038,227	37,442,029
1885	48,392,697	46,278,686	35,713,485
1890	67,621,251	66,688,381	71,112,031
1895	81,005,586	70,402,631	83,889,439
1896	87,262,389	79,559,657	80,870,764
1897	91,556,543	87,317,364	83,891,688
1898	95,277,453	94,109,942	84,392,065
1899	100,476,336	98,052,644	...
1900	101,033,716	102,757,837	...
1901	101,924,682	105,533,089	...

The figures last given show a great advance upon the first budget (1848) of the infant Confederation, which showed a revenue of 4,770,000 francs and an expenditure of 4,822,000. The finances of the cantons are of more or less local interest, but the state revenues of all the cantons together rose from (round) 65 million francs in 1885 to 105¾ million francs in 1897, or nearly 63 per cent., and the total cantonal state expenditure from 66 millions in 1885 to 105 millions in 1897 (a rise of 59 per cent.), while the state cantonal debts rose from 247¾ million francs in 1885 to nearly 344 million francs in 1897.

Education.—There is now a movement in favour of making the primary schools financially dependent on the Confederation only, but this idea is strenuously opposed by those who desire to retain some shadow of cantonal sovereignty. In 1896 there were 671 (759 in 1899) "kindergarten" schools, with an attendance of 32,419 (in 1899, 38,918) children and 914 (in 1899, 955) mistresses. The primary schools in 1896 were 4396 (in 1899, 4643) in number, and were attended by 236,792 (in 1899, 235,277) boys and 233,985 (in 1899, 237,481) girls, in all 470,677 (in 1899, 473,058); the male teachers in that year numbering 6359 (in 1899, 6439) and the female teachers 3305 (in 1899, 3667). The expense of maintaining these schools was in 1896, 25,895,054 francs—per scholar, 55 francs —(in 1897, 30,036,338 and 63 francs), of which 17,190,764 francs (in 1899, 19,059,672 francs) were paid by the "communes" and 8,704,290 francs (in 1899, 10,978,666 francs) by the respective cantons. In 1896 the secondary schools numbered 484 (in 1899, 523), and had an attendance of 18,501 boys (in 1899, 19,396) and 14,950 (in 1899, 15,532) girls, in all 33,451 (in 1899, 34,928), with 1108 (in 1899, 1238) male and 185 (in 1899, 163) female teachers. The expense in 1896 of maintaining the secondary schools amounted to 4,788,794 francs (in 1899, 5,261,122 francs), of which 2,267,279 francs (in 1899, 2,373,684 francs) fell on the "communes" and 2,521,515 francs (in 1899, 2,887,438 francs) on the respective cantons. In 1896 the "continuation schools" had 71,069 (in 1898, 76,859) scholars, private schools 14,393 (in 1898, 16,277), and "gymnasiums" 7611 (in 1899, 5788), while the 38 "normal schools" (30—29 in 1899—supported by the State, the others private enterprises) had 2453 (in 1897, 2339) pupils. There are also a considerable number of special schools, *e.g.*, industrial, commercial, agricultural, technical, veterinary, &c. It was estimated that in 1896 the cantons spent 18,925,875 francs (in 1899, 23,196,482 francs), and the "communes" 21,665,274 francs (in 1899, 20,924,570 francs) for educational purposes, or 13·9 francs (in 1899, 14·8 francs) per head of the population. In the same year the "subventions" granted by the Confederation for education amounted to 1,939,927 francs (in 1897, 2,410,531 francs), this sum including as its largest item 922,598 francs (in 1899, 987,172 francs) for the Federal Polytechnic School at Zürich. Besides the four universities named, there are two new ones at Lausanne and Fribourg, as well as an "Académie" at Neuchâtel.

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[1] Of which 663,102, 688,052, and 739,922 in the respective years were cows.

Army.—The Swiss army (which, save in the case of officers, is a militia, as Article 13 of the Federal Constitution of 1874 forbids the existence of a standing army) consists of three main sections—the "Auszug" or "Elite" (men between 20 and 32), the "Landwehr" or "first reserve" (men between 32 and 44), and the "Landsturm" or "second reserve" (men above 44). These three sections numbered on 1st January 1901, 152,122 Auszug, 88,126 Landwehr, and 278,556 Landsturm men, in all 502,254. Railway, steamboat, postal, and telegraph officials are exempt from military service while holding those posts. But these, as well as other men disqualified for physical reasons, are bound to pay a special tax yearly, this tax amounting to 6 francs a man, plus a variable sum based on his private means. In 1897, 35,889 (in 1901, 33,116) young men were medically examined to ascertain if they were physically fit to serve in person as recruits; of this number 18,740 (in 1901, 16,234), or 52·2 per cent. (in 1901, 40 per cent.), were passed, while 7116 (in 1901, 5717) were remanded for one or two years, and 10,033 (in 1901, 11,155) absolutely rejected. Owing to cantonal jealousy, the Confederation remains responsible for the arming and instruction of the soldiers, while the cantons pay all charges (recouped ultimately by the Confederation) of clothing and equipping their respective contingents. Yet the Federal military expenditure in 1897 amounted to (round) 24½ million francs (in 1900 to 27¾ millions), this heavy burden being greatly resented by the people, while vast sums have been spent on fortifying the St Gothard Pass and the defile of St Maurice, as well as the Furka Pass leading from the one to the other.

Railways.—The first Swiss railway was the Swiss bit of the line from Strasburg to Basel, comprising but 1¼ mile, which was opened in 1844; but the first line in the interior of Switzerland was that from Zürich to Baden (14½ miles), opened in 1847. At the beginning of 1901 the total length of all lines open in Switzerland was 2484 miles. Of recent years the light mountain railways have greatly increased in number, and one was in 1901 being built to the summit of the Jungfrau. The St Gothard Railway—one of the grandest triumphs of man over Nature—was opened in 1882, while the piercing of the Simplon and Albula tunnels is now nearly completed. Railway politics have loomed large in Switzerland of recent years, and Winterthur (*q.v.*) has greatly suffered thereby, while the land has been overbuilt with railways, so that many failures have occurred. From 1852 to 1872 the cantons granted concessions for the building of railways to private companies; from 1872 to 1898 these concessions were granted on other conditions, and under Federal supervision; while in 1898 by a popular vote it was decided to purchase for the Confederation the five chief lines, this decision to take effect in 1903, but in 1909 only for the St Gothard line. The problem of finding the money wherewith to meet this tremendous expenditure (estimated at a thousand million francs, or 40 million pounds sterling) is the chief thing that now engages the attention of Swiss financiers.

Roads.—Among the most remarkable of the newer roads over mountain passes are those over the Grimsel Pass (opened in 1895) and the Umbrail Pass, 8242 feet, the highest carriage road in the country (opened in 1901), one of the latest of a series of engineering triumphs that began with the road over the Simplon (made in 1801–07). The Gemmi track of 1740–41 was simply an improvement of a much older path in the same spot.

Telegraphs and Telephones.—The public telegraph service dates from 1852, and that of the telephone from 1881. In 1900 the telegraph lines were 4288½ miles in length (wire 12,531¾ miles), the number of offices 2108 (with 2981 officials), while the home telegrams numbered 1,577,974, and the foreign telegrams (sent and received) 1,694,371, besides 677,817 despatches that passed through Switzerland on the way elsewhere. In 1900 the receipts of the telegraph service were 3,031,583 francs, and the expenses 3,044,952 francs. In 1900 the figures for the telephone service were: length of lines 82,392½ miles, number of stations 41,801, and of subscribers 37,761. The purely local traffic amounted to 20,878,866 messages, and that between different towns to 4,511,753, while 232,275 telegrams were transmitted by the telephone. The receipts in 1900 of the telephone service were 6,229,857 francs, the capital expenditure and all other expenses 7,115,206 francs.

Post Office.—The postal administration is most admirably organized in Switzerland, but its work increases very rapidly, as is shown by the following table:—

In round millions.	1885.	1890.	1895.	1900.
1. No. of Letters (home) .	52½	62¾	83¼	99¼
2. No. of Letters (foreign)	12	13	16¼	21
3. Postcards (home) .	8¼	13	16	38¾
4. Postcards . . .	3	4	5¼	9½
5. Parcels . . .	8½	11½	15	19¼
6. Net profits . . .	1½	2¼	1½	2¾

Banks.—In 1891 the Swiss people accepted the principle of a State bank with a monopoly of note issue, but as yet no scheme for organizing such a bank has succeeded in securing popular assent. In 1899 there were 35 legalized banks of issue in Switzerland; the average circulation of notes rose from 152½ million francs in 1890 to 179¼ millions in 1895, and 216¾ millions in 1900. The note issue of seven banks has been called in since 1896. At the end of 1900 the 35 banks of issue had the right of issuing 229½ million francs of notes, all of which, save 435,000 francs, was actually in circulation. In 1896 there were 377 (in 1897, 373) savings banks proper with 208½ million (in 1897, 214,158,532) francs deposits in that year. There were also 153 (in 1897, 157) school savings banks with 164,241 (in 1897, 153,244) francs deposits in 1896, and 36 (in 1897, 34) factory savings banks with 210,315 (in 1897, 280,116) francs deposits in 1896. In all these 566 (in 1897, 564) institutions there were in 1896, 1,254,355 (in 1897, 1,311,946) depositors, 3274 (in 1897, 3574) of whom were in the factory savings banks and 11,038 (in 1897, 17,867) in the school savings banks.

Authorities.—Official publications of the Swiss Government, *e.g.*, the annual reports of the Agricultural, Commercial, &c., Departments, the detailed censuses from 1850 to 1888, and official periodicals, such as the *Statistisches Jahrbuch d. Schweiz* (from 1891), the *Jahrbuch d. Unterrichtswesen in der Schweiz* (from 1887), the *Zeitschrift f. schweiz. Statistik* (from 1865), the *Landwirthschaftliches Jahrb. d. Schweiz*, and *Die schweiz. Alpenpässe*, 1893. Consult also *Alpstatistik, Schweiz* (Soleure, in course of publication since 1894).—Felix Anderegg. *Illustriertes Lehrbuch f. das gesamte schweiz. Alpwirthschaft.* Bern, 1897–98.—John Ball. *Hints and Notes for Travellers in the Alps.* London, 1899.—F. Berghoff-Ising. *Die sozialistische Arbeiterbewegung in d. Schweiz.* Leipzig, 1895.—H. A. Berlepsch. *Schweizerkunde.* 2nd edition, Brunswick, 1875.—G. Berndt. *Der Föhn*, 2nd edition, Göttingen, 1896.—A. Bürkli-Meyer. *Die Geschichte d. zürcher. Seidenindustrie.* Zürich, 1884.—W. H. Dawson. *Social Switzerland.* London, 1897. *Finanz-Jahrbuch, Schweiz* (from 1899). Bern.—A. Furrer. *Volkswirthschafts-Lexikon d. Schweiz*, 3 vols. Bern, 1885–92.—T. Geering and R. Hotz. *Wirthschaftskunde d. Schweiz* (with full bibliography). Zürich, 1902.—*Die industrielle und kommerzielle Schweiz beim Eintritt ins xx. Jahrhundert* (monographs on chief Swiss industrial establishments), in parts from 1900. Zürich.—J. Hann. *Einführung in die Meteorologie der Alpen.* Vienna, 1882.—A. le Cointe. *Inventaire des institutions économiques et sociales de la Suisse à la fin du 19eme siècle.* Geneva, 1900.—A. von Miaskowski. *Die schweizerische Allmend* (Leipzig, 1879) and *Die Verfassung der Land-, Alpen-, und Forstwirthschaft d. deutschen Schweiz* (Basel, 1878).—G. Schanz. *Die Steuern der Schweiz* (historical), 5 vols. Stuttgart, 1890.—R. Schatzmann. *Alpwirthschaftliche Volksschriften.* New edition, 2 vols. Aarau, 1887.—Max Wirth. *Allgemeine Beschreibung und Statistik der Schweiz*, 6 parts. Zürich, 1870–73.—F. von Wyss. *Abhandlungen zur Geschichte des schweiz. öffentlichen Rechts.* Zürich, 1892.—Emil Hofmann. *Die Schweiz als Industriestaat.* Zürich, 1902.

II. History and Politics, 1874–1900.

The late M. Numa Droz (who was for seventeen years —1876 to 1892—a member of the federal executive, and twice president of the Swiss Confederation) expressed the opinion shortly before his death in December 1899, that while the dominant note of Swiss politics from 1848 to 1874 was the establishment of a federal state, that of the period extending from 1874 to 1899 was the direct rule of the people, as distinguished from government by elected representatives. Whether this distinction be just or not, it is certain that this advance towards democracy in its true sense is due indirectly to the monopoly of political power in the federal Government enjoyed by the Radical party from 1848 onwards: many were willing to go with it some part of the way, but its success in maintaining its close monopoly has provoked a reaction against it on the part of those who desire to see the Confederation remain a Confederation, and not become a strongly centralized state, contrary to its past history and genius. Hence after 1874 we find that democratic measures are not advocated as we should expect by the Radicals, but by all the other political parties with a view of breaking down this Radical monopoly, for it is a strange fact that the people elect and retain Radical representatives, though they reject the measures laid before them for their approval by the said Radical representatives. For these reasons the struggle between Federalists and Centralists (the two permanent political parties in Switzerland), which up to 1874 resulted in favour of the Centralists, is turning more and more in favour of the Federalists, and that because of the adoption of such democratic institutions as the Referendum and the Initiative. Such are the general lines on which Swiss politics ran during the last quarter of the 19th century. The details may be most conveniently summarized under three headings—the working of the political machinery, the principal political events, and then the chief economical and financial features of the period since 1874. But it must be always borne in mind that all the following remarks relate only to *federal* politics, those of the several cantons being much more intricate, and of course turning more on purely local differences of opinion.

1. *Political Machinery.*—The federal constitution of 1848 set up a permanent federal executive, legislature, and tribunal, each and all quite distinct from and independent of any cantonal government. This system was a modified revival of the state of things that had prevailed from 1798 to 1803, and was an imitation of the political changes that had taken place in the cantonal constitutions after 1830. Both were victories of the Centralist or Radical party, and it was therefore but natural that this party should be called upon to undertake the federal government under the new constitution, a supremacy that it has kept ever since. To the Centralists the *Council of States* (two members from each canton, however large or small) has always been a stumbling-block, and they have mockingly nicknamed it "the fifth wheel of the coach." In the other house of the federal legislature, the *National Council* (one member per 20,000, or fraction of over 10,000 of the entire population), the Radicals have always since its creation in 1848 had a majority. Hence, in the Congress formed by both houses sitting together, the Radicals have had it all their own way. This is particularly important as regards the election of the seven members of the federal executive which is made by such a Congress. Now the federal executive (*Federal Council*) is in no sense a cabinet, *i.e.*, a committee of the party in the majority in the legislature for the time being. In the Swiss federal constitution the cabinet has no place at all. Each member of the federal executive is elected by a separate ballot, and holds office for the fixed term of three years, during which he cannot be turned out of office, while as yet but a single instance has occurred of the rejection of a federal councillor who offered himself for re-election. Further, none of the members of the federal executive can hold a seat in either house of the federal legislature, though they may appear and speak (but not vote) in either, while the Federal Council as such has not necessarily any common policy, and never expresses its views on the general situation (though it does as regards particular legislative and administrative measures) in anything resembling the "speech from the Throne" in England. Thus it seems clear that the federal executive was intended by the federal constitution of 1848 (and in this respect that of 1874 made no change) to be a standing committee of the legislature as a whole, but *not* of a single party in the legislature, or a "cabinet," even though it had the majority. Yet this rule of a single political party is just what has taken place. Between 1848 and the end of 1899, 36 federal councillors were elected (23 from German-speaking, 11 from French-speaking, and 2 from Italian-speaking Switzerland, the canton of Vaud heading the list with 7). Now of these 36 two only were not Radicals, viz., M. Ceresole (1870–75) of Vaud, who was a Protestant Liberal-Conservative, and Herr Zemp (elected in 1891), a Romanist Conservative; yet the Conservative minority is a large one, while the Romanists form about two-fifths of the population of Switzerland. But despite this predominance of a single party in the Federal Council, no true cabinet system has come into existence in Switzerland, as members of the council do not resign even when their personal policy is condemned by a popular vote, so that the resignation of Herr Welti (a member of the Federal Council from 1866 to 1891), in consequence of the rejection by the people of his railway policy, caused the greatest amazement and consternation in Switzerland.

The chief political parties in the federal legislature are the Right, or Conservatives (whether Romanists or Protestants), the Centre (now often called "Liberals," but rather answering to the Whigs of English political language), the Left (or Radicals), and the Extreme Left (or the Socialists). In the Council of States there is always a federalist majority, since in this house the smaller cantons are on an equality with the greater ones, each indifferently having two members. But in the National Council (147 elected members) there has always been a Radical majority over all other parties, the numbers of the various parties after the triennial elections of 1899 being roughly as follows:—Radicals, 86; Socialists, 9; Centre, 19; and the Right, 33. The Socialists long worked under the wing of the Radicals, but now in every canton (save Geneva) the two parties have quarrelled, the Socialist vote having largely increased. In the country the anti-Radical opposition is made up of the Conservatives, who are strongest in the Romanist, and especially the Forest cantons, and of the "Federalists" of French-speaking Switzerland. There is no doubt that the people are really anti-Radical, though occasionally led away by the experiments made recently (see 2 below) in the domain of State socialism: they elect, indeed, a Radical majority, but very frequently reject the bills laid before them by their elected representatives. The following table shows what a curious state of things is revealed by all the popular votes that have taken place between 1874 and 1899 in federal matters:—

	Accepted.	Rejected.	Total.
1. Amendments to the Federal Constitution (Obligatory Referendum)	9	5	14
2. Federal Laws (Facultative Referendum at the demand of 30,000 citizens)	8	17	25
3. Initiative (at the demand of 50,000 citizens) . . .	1	2	3
	18	24	42

2. *Politics.*—The cantons had led the way before 1848, and they continued to do so after that date, gradually introducing reforms all of which tended to give the direct rule to the people. The Confederation was bound to follow this example. Hence, in 1872 a new federal constitution was drafted, but was rejected on a popular vote by a small majority, as it was thought to go too far in a centralizing direction, and so encountered the combined opposition of the Conservatives and of the Federalists of French-speaking Switzerland. The last-named party was won over by means of concessions as to military matters and the proposed unification of cantonal laws, civil and criminal, and especially by strong provisions as to religious freedom, since the "Kulturkampf" was then raging in French-speaking Switzerland. Hence a revised draft was accepted in 1874 by a considerable popular majority, and this is the existing federal constitution. But it bears marks of its origin as a compromise, and no one party has ever been very eager to support it as a whole. At first all went smoothly, and various very useful laws carrying out in detail the new provisions of the constitution were drafted and accepted. But divisions of opinion arose when it was proposed to reform the military system at a very great expenditure, and also as to the question of the limitation of the right to issue bank-notes, while (as will be seen under 3 below) just at this time grave financial difficulties arose with regard to the Swiss railways, and in consequence of Prince Bismarck's anti-free-trade policy, which threatened the prosperity of Switzerland as an exporting country. Further, the disturbed political state of the canton of Ticino (or Tessin) became more or less acute from 1873 onwards. There the Radicals and the Conservatives are nearly equally balanced. In 1872 the Conservatives obtained the majority of this canton, and tried to assure it by some certainly questionable means. The Radicals repeatedly appealed to the federal Government to obtain its armed intervention, but in vain. In 1876 the Conservatives at a rifle match at Stabio fired on the Radicals, but in 1880 the accused persons were acquitted. The long-desired detachment of Ticino from the jurisdiction of the foreign dioceses of Como and Milan was effected in 1888 by the erection of a see at Lugano, but this event caused the Radicals to fear an increase of clerical influence. Growing impatient, they finally took matters in their own hands, and in September 1890 brought about a bloody revolution. The partial conduct of the Radical federal commissioner was much blamed, but after a State trial at Zürich in 1891 the revolutionists were acquitted, although they loudly boasted of their share in this use of force in political matters.

From 1885 onwards Switzerland had some troubles with foreign powers owing to her defence of the right of asylum for fugitive German Socialists, despite the threats of Prince Bismarck, who maintained a secret police in Switzerland, one member of which, Wohlgemuth, was expelled in 1889, to the Prince's huge but useless indignation. From about 1890, as the above troubles within and without gradually subsided, the agitation in the country against the centralizing policy of the Radicals became more and more strongly marked. By the united exertions of all the opposition parties, and against the steady resistance of the Radicals, an amendment was introduced in 1891 into the federal constitution, by which 50,000 Swiss citizens can by the "Initiative" *compel* the federal legislature and executive to take into consideration some point in the federal constitution which, in the opinion of the petitioners, requires reform, and to prepare a Bill dealing with it which must be submitted to a popular vote. Great hopes and fears were entertained at the time as to the working of this new institution, but both have been falsified, for the Initiative has as yet only succeeded in inserting (in 1893) in the federal constitution a provision by which the Jewish method of killing animals is forbidden. On the other hand, it has failed (in 1894) to secure the adoption of a Socialist scheme by which the State was bound to provide work for every able-bodied man in the country, and (also in 1894) to carry a proposal to give to the cantons a bonus of two francs per head of the population out of the rapidly growing returns of the customs duties.

The great rise in the productiveness of these duties (see 3 below) has tempted the Swiss people of late years to embark on a course of State socialism, which may be also described as a series of measures tending to give more and more power to the central federal Government at the expense of the cantons. So in 1890 the principle of compulsory universal insurance against sickness and accidents was accepted by a popular vote, in 1891 likewise that of a State or Federal bank, and in 1898 that of the unification of the cantonal laws, civil and criminal, into a set of federal codes. In each case the federal Government and legislature were charged with the preparation of laws carrying out in detail these general principles. But in 1897 their proposals as to a federal bank were rejected by the people, while at the beginning of 1900 the suspicion felt as to the insurance proposals elaborated by the federal authorities was so keen that a popular demand for a popular vote was signed by 115,000 Swiss citizens, the legal minimum being only 30,000: they were rejected (20th May 1900) on a popular vote by a two to one majority. The preparation of the federal codes has progressed quietly, drafts being framed by experts and then submitted for criticism to special commissions and public opinion. But this method, though the true one to secure the evolving of order out of chaos, takes time. By a popular vote in 1887 the federal authorities were given a monopoly of alcohol, but a proposal to deal similarly with tobacco has been very ill received (though such a monopoly would undoubtedly produce a large amount), and would pretty certainly be refused by the people if a popular vote were ever taken upon it. In 1895 the people declined to sanction a State monopoly of matches, even though the unhealthy nature of the work was strongly urged, and have also resolutely refused on several occasions to accept any projects for the centralizing of the various branches of military administration, &c. Among other reforms which have recently been much discussed in Switzerland are the introduction of the *obligatory* Referendum (which hitherto has applied only to amendments to the federal constitution) and the Initiative (now limited to piecemeal revision of the federal constitution) to *all* federal laws, &c., and the making large federal money grants to the primary schools (managed by the several cantons). The former scheme is an attempt to restrain important centralizing measures from being presented as laws (and as such exempt from the compulsory referendum), and not as amendments to the federal constitution, while the proposed school grant is part of the Radical policy of buying support for unpopular measures by lavish federal subventions, which it is hoped will outweigh the dislike of the cantons to divest themselves of any remaining fragments of their sovereignty.

Besides the insurance project mentioned above, two great political questions have recently engaged the attention of the Swiss people.

(*a*) *State Purchase of the Railways.*—In 1891 the purchase of the Central railway was rejected by a popular vote, but in 1898, by the aid of various baits thrown out, the people were induced to accept the principle of the purchase by the Confederation of the five great Swiss railway lines—four in 1903, viz. the Central, the North-Eastern, the Jura-Simplon, and the United Swiss lines, and one (the Gothard line) in 1909, this delay being due to international conventions that still have some years to run. It was estimated that the debt thus incurred might be paid off in 1960, but the price of purchase—to be fixed partly by agreement, partly by the federal tribunal—seems likely far to exceed the original estimates, and to mount up to at least a milliard of francs, or £40,000,000. Further, very important economical consequences, *e.g.*, as to strikes, may be expected to result from the transformation of all railway officials of whatever grade into State servants, who may naturally be expected to vote (as in other cases) for their employers, and so greatly increase the strength of the Centralist political party.

(*b*) *The "Double Initiative*."—This phrase denotes two purely political reforms that have been coupled together, though in reality they are by no means inseparable. One is the introduction of proportional representation into the elections for the National Council of the federal Parliament, the object being thus to secure for several large minorities a number of M.P.'s more in accordance with the size of those minorities in the country than is now possible under the régime of pure majorities: naturally these minorities would then receive a proper share of political power in the senate house, instead of merely exerting great political influence in the country, while if they were thus strengthened in the legislature they would soon be able to claim the right of naming several members of the federal executive, thus making both legislature and executive a mirror of the actual political situation of the country, instead of the preserve of one political party. The other reform is the election of the members of the federal executive by popular vote, the whole body of voters voting, not by cantons, but as a single electoral constituency. This would put an end to the "lobbying" that goes on previously to the election of a member of the executive by the two houses of the federal Parliament sitting jointly in Congress; but, on the other hand, it might stereotype the present system of electing members of the executive by the majority system, and so reduce large minorities to political impotence. The "double initiative" scheme was launched in the beginning of 1899, and by the beginning of the following July secured more than the requisite number of signatures (50,000), the first-named item having been supported by 65,000 citizens, and the second item by 56,000. Hence the federal Parliament was *bound* to take these two reforms into formal consideration, but in June 1900 it rejected both.

This notice of the recent legislation or political agitations in Switzerland will show that the struggle between the Centralists and the Federalists still goes on, and that the latter are (as before observed) inclined to "dish" their opponents by themselves supporting thorough democratic reforms with the intention of arousing the innate conservatism of the Swiss people in order to oppose the transformation of the Confederation into an ordinary centralized state. It should also never be forgotten that two steady and permanent characteristics of Swiss voters are a deep-seated dislike of a "bureaucracy," or army of State officials, and a notion that, if they can only manage their own affairs directly and not through representatives, this hated class will disappear. At all events, it is certain that the more business is heaped upon the federal or central authorites the larger must be the number of the "permanent officials" and the amount of "red tape."

3. *Economics and Finance.*—Soon after the adoption of the federal constitution of 1874 the economical and financial state of the Confederation became very unsatisfactory. The great financial crisis in Vienna in 1873 was a severe blow to Swiss commerce, which had taken a very great start after the Franco-German war of 1870–71. In the later 'seventies, too, the financial position of some of the great Swiss railway lines was very unfavourable: the bankruptcy of the National line ruined for the time (till a federal loan at a very low rate of interest was forced upon them) the four Swiss towns which were its guarantors; the North-Eastern line had to beg for a "moratorium" (a *legal* delay of the period at which it had to pay its debts) from the federal Government; the Bern–Lucerne line was actually put up to auction, and was bought by the canton of Bern. Further, the expenses of constructing the Gothard railway vastly exceeded all estimates, and in 1876 over 100 million francs more were required. Hence the subventions already granted had to be increased. Germany (which gave originally 20 million francs) and Italy (original contribution 45 million francs) each promised 10 million francs more, and the two Swiss railway lines interested (Central and North-Eastern) added 1½ millions to the 20 millions they had already agreed to give jointly with the cantons interested in the completion of this great undertaking. But these latter refused to add anything to their previous contributions, so that finally the federal Government proposed that it should itself pay the 6½ million francs most urgently required. This proposal aroused great anger in east and west Switzerland, but the matter was ultimately settled by the Confederation paying 4½ million francs and the interested cantons 2 millions, the latter gift being made dependent on a grant of 4½ million francs by the federal Government for new tunnels through the Alps in east and west Switzerland, and of 2 millions more for the Monte Ceneri tunnel between Bellinzona and Lugano. This solution of a most thorny question was approved by a popular vote in 1879, and the Gothard line was successfully completed in 1882. Gradually, too, the other Swiss railway lines attained a state of financial equilibrium, owing to the more careful management of new directors and managers.

Switzerland, by reason of natural conditions, is properly a free trade country, for it exports far more than it imports in order to supply the demand for objects that it cannot itself produce. But Prince Bismarck's protectionist policy in 1879 was imitated by France, Austria, and Italy, so that Switzerland was gradually shut in by a high wall of tariffs. Hence in 1891 the Swiss people approved, in sheer self-defence, a great increase of the customs duties. In 1880 these produced 17¼ million francs, in 1885, 21¼ millions, in 1890, 31¼ millions, and in 1891, 31½ millions; then came a rapid rise to 36 millions in 1892, 43¼ millions in 1895, nearly 49 millions in 1897, and 51 millions in 1899. (A truce was made with France in 1895, while the revision of other commercial treaties is to take place in 1903.) This huge increase in revenue naturally led to increased expenditure, which took the form of lavish subventions to all sorts of cantonal objects, magnificent federal buildings, most useful improvements in the post and telegraph services, and extensive and lamentable construction of military fortifications in Uri and the Valais against some unknown foe. In 1894 it was proposed to distribute part of this new wealth in giving a bonus to the cantons at the rate of 2 francs per head of the population, but this extravagant proposal (nicknamed the "Beutezug") was rejected, owing to the cool common sense of the Swiss people, by a majority of over two to one. These prosperous circumstances, however, contributed mainly to the adoption or suggestion of various measures of State socialism, *e.g.*, compulsory insurance, federal subvention to primary schools, purchase of the five great Swiss railway lines, giving a right to every able-bodied man to have work at the expense of the State, &c. All these schemes would cost money. It is estimated that the insurance scheme, if adopted, would cost 10 million francs a year, and the subvention to the primary schools 2 or 3 million francs a year, while the purchase of the railways will absorb at least 1000 million francs of capital, and no one dares to fix a limit to the wasteful military expenditure insisted on by the military caste. Add the yearly increasing subventions to cantonal objects, and it will be seen that the expenditure, actual and prospective, advances by huge leaps and bounds. As yet, it is true, there have been few deficits in the federal budget, but this is mainly due to the extraordinary elasticity of the customs revenue. But it is now generally allowed that, unless the duties themselves are increased, this elasticity has reached its highest point, while new sources of revenue are far to seek. Practically speaking, it would be impossible to increase the customs duties without doing harm to Swiss commerce, while the proposed most productive tobacco monopoly would certainly be rejected by a popular vote. Then, too, there is the enormous sum which must soon be obtained for the purchase of the railways, while the credit of the federal Government does not now stand as high as it did a few years ago. In section I. of this article a table is given in which are set down the revenue, expenditure, and public debt of the Swiss Confederation since its foundation in 1848. Here it may suffice to say that, while between 1885 and 1900 the revenue rose from 48½ million francs to 102¼ millions, and the expenditure from 46¼ millions to 103 millions, the public debt leaped from 35¾ millions in 1885 to 84½ millions in 1898, and has been since much increased. The balance of trade is more and more against Switzerland every year (181 million francs in 1893, and 341 million francs in 1898).

The clearest and most complete account of the history of Switzerland during the 19th century is that written by the late M. Numa Droz in vol. i. (1899) of *Die Schweiz im 19ten Jahrhundert* (also in French, published at Lausanne and Bern). Professor Hilty's *Politisches Jahrbuch d. Schweizerischen Eidgenossenschaft* (published annually at Bern since 1886), and many official publications of the federal Government, should also be consulted by any one desiring to obtain more detailed information.

Owing to the very local character of Swiss history, especially in the early days of the Confederation, many most valuable articles and essays appear in periodicals which often quite escape the notice of those to whom they would prove of great service. Hence every one interested in Swiss history hailed with joy the publication (at Basel in 1892) of Herr J. L. Brandstetter's *Repertorium über die in Zeit- und Sammelschriften der Jahre* 1812–1890 *enthaltenen Aufsätze und Mittheilungen schweizergeschichtlichen Inhaltes.* This is an admirably arranged list of all such articles as have been published in any periodical between 1812 and 1890 relating to Swiss history, and is thus indispensable to all students of that department of history. Among important articles dealing with constitutional Swiss history two in particular by Professor Œchsli deserve special attention, as well as the same writer's epoch-making work on the early history of the Confederation up to 1316. The posthumously published book by Professor G. von Wyss, entitled *Geschichte d. Historiographie in der Schweiz* (Zürich, 1895), gives a most excellent account of all the original sources (chronicles, &c.) for Swiss history from the earliest times to the present day, and is a most useful supplement to Wattenbach's *Deutschlands Geschichtsquellen,* which takes in the whole of Germany. Amid the mass of recent essays and articles relating to the very early history of the Swiss Confederation three cannot be passed over here. One is by Professor H. Bresslau, and appeared under the title of "Das älteste Bundniss der Schweizer Urkantone" in vol. xx. (1895) of the *Jahrbuch f. Schweizerische Geschichte.* It shows most conclusively, by a careful examination of surviving documents, that the "antiqua confœderatio" mentioned in the League of 1291 cannot possibly refer to the events of 1245 *sqq.*, for the simple reason that at that time Uri, Schwyz, and Unterwalden took different sides in the great strife between Pope and Emperor, Schwyz and Obwalden supporting the Emperor, while Uri and Nidwalden stood by the Pope. It is further shown that the "antiqua confœderatio" was not formed against the Habsburgs, but was simply an ordinary agreement to preserve peace and quiet in that particular district, having probably been made during the interregnum in the empire (1254–1273), and that it is possible in the existing text of the League of 1291 to distinguish the main features of the old League as well as the additions made in 1291. The second noteworthy publication is an essay (Zug, 1895) by Herr Bürkli, which proves decisively that the battle of Morgarten took place *not* in the gorge of Schornen, but on the south-east shore of the lake of Ægeri. Dr Th. von Liebenau has also shown (in an article reprinted from the *Katholische Schweizerblätter* in the *Bollettino Storico della Svizzera Italiana* for 1899) that in 1283 the Emperor Rudolf of Habsburg gave the right of receiving the tolls for escort over the St Gothard Pass to his sons, the dukes of Austria. The levying of these tolls gave rise to various disputes between the men of Uri and the bailiffs of the dukes of Austria, and by 1319 (if not already in 1309) the claim to levy them was silently given up. But these facts show (what could not hitherto be proved) that at the time when legend places the rising of Uri, Tell exploit, &c., the dukes of Austria really had disputes with Uri. The note on p. 795 requires correction. At present (1900) in the twenty-five whole or half cantons the two members of the "Ständerath" are elected by the people in sixteen, and by the cantonal legislature in nine. The terms of office vary from one year (in twelve) to two (valais), three (in eleven), and even four (Zug) years, the matter being entirely in the hands of the cantons themselves.

III. LITERATURE.

After the death of Gottfried Keller in 1890, the chief literary figure in German-speaking Switzerland was for some years Conrad Ferdinand Meyer (1825–1898), a member of an old Zürich family: in his early days he was a poet, *Huttens Letzte Tage* being his masterpiece, while later he wrote many historical novels relating to St Thomas à Becket, George Jenatsch, Pescara; and Jakob Frey (1824–1874) of Aargau wrote tales of peasant life like those of Bitzius. Of living Swiss writers the chief are J. V. Widmann, a poet and littérateur (in charge of the literary department of the *Bund,* one of the principal Swiss newspapers), Adolf Frey the poet, Isabella Kaiser, poetess and writer of stories, and Arnold Ott the dramatist. Among historical writers G. von Wyss (died 1893), Karl Dändliker, Wilhelm Œchsli, G. Meyer von Knonau, E. Blösch (died 1900), Paul Schweizer, Johannes Dierauer, P. C. von Planta, Hermann Wartmann, Rudolf Hoppeler deserve to be named, as well as Rudolf Maag, who died in 1899 at an early age. J. R. Rahn and H. Angst represent the history of art, while Andreas Heusler, L. R. von Salis, and F. von Wyss have devoted themselves to more severe studies in the history of institutions. Among the poets of the Suisse Romande, Juste Olivier (1807–1876), specially in his *Chansons Lointaines* (1855), is generally given the first place. But to the outer world the name of the philosopher Amiel and his *Journal Intime* are far better known. Eugène Rambert (1830–1886) in his *Alpes Suisses* (1868), and Emile Javelle (1847–1883) in his *Souvenirs d'un Alpiniste* (1886), did much by their writings to make known the beauties of the Alps, while Félix Bovet described admirably his journey to the Holy Land, and Marc Monnier represented modern cosmopolitanism. Among novelists Urbain Olivier, Auguste Bachelin, "T. Combe" (the "nom de guerre" of Mlle Adèle Huguenin), Samuel Cornut, and Edouard Rod are the best known; the latter writer is, indeed, since the death of V. Cherbuliez (1899), the most prominent literary figure in the Suisse Romande. Louis Duchosal, Philippe Godet, and Virgile Rossel represent poetry and literary history, while among historical writers we may name B. van Muyden, P. Vaucher (died in 1898), Edouard Rott, B. de Mandrot, and above all J. Gremaud (died 1897), one of the most learned men that Switzerland has ever produced. The chief literary organ of the Suisse Romande is the *Bibliothèque Universelle,* founded in 1816.

Italian Switzerland is best known by its artists, while its literature naturally is rather Italian than Swiss. Stefano Franscini (1796–1857) in history and statistics, Luigi Lavizzari as a writer of travel sketches, Angelo Baroffio and Emilio Motta, both historians, are perhaps the best known names. There is a swarm of poets, such as Pietro Peri, J. B. Buzzi, Giovanni Airoldi, and Carlo Cioccari, while two younger men are F. Chiesa and M. A. Nessi. The art of novel writing does not flourish in Ticino. The *Bollettino Storico della Svizzera Italiana* (from 1879 onwards), though mainly historical, devotes a good deal of space to literary and artistic matters. In the canton of the Grisons alone does Romonsch, the laggard sister of the other Romance tongues, still linger, though it can scarcely be said to flourish, despite attempts by the Societad Rhæto-Romanscha in the Engadine and the Romania in the Vorder Rhine valley to infuse into it an artificial vitality. It is called "Romansch" in the "Bündner Oberland," or Vorder valley of the Rhine, and

"Ladin" in the Engadine, these being the two chief dialects. The first poem (by Johann v. Travers) known to have been written in this quaint language dates from 1527, though not published till 1865: the first book printed in it was issued in 1552, and the next a translation of the Bible in 1560. Most of the works in Romansch and Ladin are translations of religious or scholastic works. But Theodor v. Castelberg, Cadisch, Huonder, and Muoth have written in Romansch both poems and novels, while in Ladin we have the poems of Flugi, Valentin, Juvalta, and especially Caderas. Zacharias Pallioppi, besides poems, compiled an excellent Ladin dictionary, published (after his death) in 1895.

The above summary has been mainly based on the sections of chap. iv. (dealing with literature) in vol. ii. (1899–1900) of *Die Schweiz im 19ten Jahrhundert*, each chapter being written by a distinguished specialist. Consult also J. Bächtold. *Geschichte d. deutschen Litteratur in d. Schweiz.* Frauenfeld, 1892.—P. Godet. *Historie littéraire de la Suisse Romande.* Neuchâtel and Paris, 2nd edition, 1895.—F. Rausch. *Geschichte d. Litteratur d. Rhäto-Romanischen Volkes.* Frankfort-on-the-Main, 1870.—Virgile Rossel. *Histoire littéraire de la Suisse Romande,* 2 vols. Geneva and Paris, 1889–91. (W. A. B. C.)

Swords.—In the article Swords in the earlier volumes of this work (ninth edition) the subject has been generally treated. It is only proposed in the following article to deal with the sword as at present used in most European countries, to touch briefly on the causes which lead to the adoption of particular forms, and to give a short description of the method of manufacture now in common use. The present military swords are descended from the straight "back-sword" and the Eastern scimitar or tulwar. The difference between the curved "sabre" and straight "sword" has been preserved abroad, not only in fact but in name (*e.g.*, in German *Degen* stands for the straight, and *Sabel* for the curved, sword), though in English the single word "sword" covers both varieties. The shape of the sword has varied considerably at different times; this is due to the fact that it is practically impossible to decide by trial whether a straight or a curved sword is the better under all circumstances. The trooper can use his sword in three different ways—to cut, to guard, and to point; and his success depends upon the training of his horse, his skill in horsemanship, and, above all, upon the dexterity and methods of his adversary. Thus the effect the cavalryman can produce in combat depends upon much besides his arm or arms, and those other conditions cannot be reproduced accurately enough to make trustworthy tests. The result is that changes have often been made in cavalry armament under the erroneous impression that the arm used has been the main cause of success. The Ottoman cavalry up to the end of the 18th century was regarded as one of the best in Europe, and so much was it dreaded that the Russians in their wars with Turkey at one time carried "chevaux-de-frise" to protect their infantry against these redoubtable horsemen. The curved European cavalry sabre so long in use may undoubtedly be traced to this cause, the superiority of the Turks being put down to their curved scimitars, though there can be no doubt that horsemanship and dash were really the dominating factors. The Turkish cavalry of the 19th century, trained on Western models, is an inferior force.

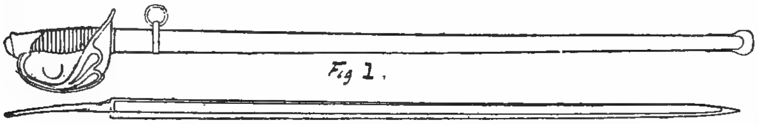


Fig 1.

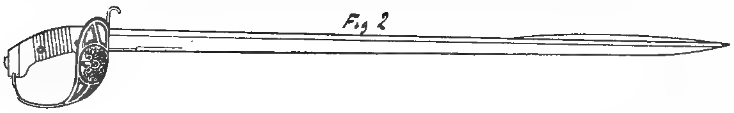


Fig 2

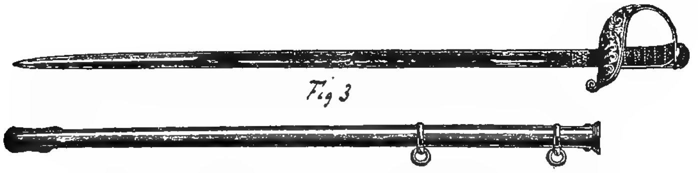


Fig 3

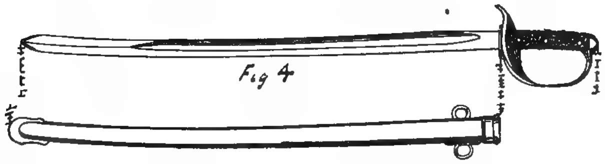


Fig 4

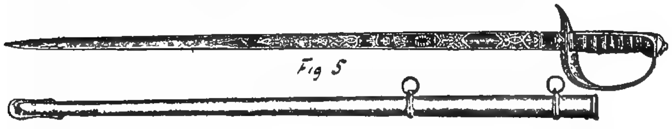


Fig 5

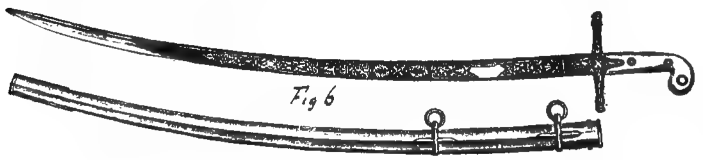


Fig 6

Fig.		Length of Blade from Hilt to Point.	Weight without Scabbard.		Material of Scabbard.
		Inches.	lb	oz.	
1	French cavalry sword (men), pattern 1898 .	85	2	6	Steel with wood lining.
2	German ,, ,, ,, ,, 1889 .	82½	2	8½	
3	British ,, ,, (officers) . .	85	2	0	
4	,, ,, ,, (men), ,, 1899 .	88½	2	10¼	
5	,, infantry ,, (officers) . . .	82½	2	8	
[illegible]	,, general officers' sword . .	82½	1	12	

For figures 3, 5, and 6 the writer is indebted to Messrs Wilkinson and Co.

The shape of the sword to be chosen depends obviously on the purpose for which it is mainly intended. If for cutting a curved blade, and for thrusting a straight and pointed one, will be adopted. The question naturally arises as to which is the better plan to adopt, and it is improbable that a definite answer can ever be given to it. The French, for instance, in 1822 adopted a curved blade for a short time for all their cavalry, and in 1882 again for a short time a straight blade, and in 1898 again a straight blade. In this much-debated matter the facts appear to be as follows:—A determined thrust, especially when delivered by a horseman at full speed, is difficult to parry: if it gets home, it will probably kill the recipient outright or disable him for the rest of the campaign. That this is the case is borne out by the very large proportion of killed as compared with wounded in the British cavalry when engaged with that of the French in the Peninsular war, the French making much use of the point, and their heavy cavalry being armed with a long straight sword. On the other hand, to deliver a bold thrust, while disregarding the uplifted sword of the adversary, and leaving one's own body and head open to an impending blow, demands complete confidence that the thrust will get home before the blow can descend, or that the adversary's cut will probably be weakened by a momentary uncertainty as to whether it would not be better to convert the intended cut into a parry. Such confidence, it is argued with much truth, can only be the fruit of long training, especially as it is the natural tendency of all men to cut when excited; therefore, as the trooper in modern armies will often be a reservist who has not been able to keep up his swordsmanship, or a young soldier liable to lose his head and forget the lessons of peace in the excitement of the *mêlée*, it is considered by many most unwise to adopt a sword with which a powerful cut cannot be delivered as well as an effective thrust. The swords recently adopted by most nations have represented a compromise. They have blades which are nearly straight, but of sufficient weight towards their points to enable an efficient cut to be delivered with them. France alone in 1898 decided on a long straight sword designed wholly for thrusting (see Fig. 1).

As regards the swords worn by officers and men of corps other than cavalry, no remarks are necessary. As long as they are worn they should be efficient; but with the officer the sword is largely a badge of rank, and, in the opinion of many, should only be used for ceremonial purposes; while with certain corps, notably the Horse Artillery, it is difficult to see on what grounds a sword is carried by the men at all.

A good sword should be elastic, so as to stand bending or a heavy blow without breaking or permanent deformation, and yet stiff enough to deliver a powerful thrust without yielding too readily from the straight; it must also be as light as is possible consistently with strength, and well balanced. All four desiderata are met in the main by the use of a suitable steel, properly treated and disposed, but balance is also dependent on the weight and form of the hilt. As regards the effect of disposition, grooving or "fullering" the flats of the blade reduces weight without impairing strength, and is now very largely adopted.

The operations of manufacture, as carried out at the Royal Smalls Arms Factory at Enfield, are briefly as follows:—The steel "blank" (about $17'' \times 1\frac{1}{4}'' \times \frac{1}{2}''$ in the case of the cavalry sword, pattern 1899) is heated and drawn out to about double its length under a mechanical hammer. It is then re-heated and rolled out between rolls suitably shaped, and the "fullers" formed. The "tang," to which the hilt and "grips" are ultimately attached, is then formed by stamping under a machine hammer, and the blade cut to length and roughly pointed. The blade, which, though approximately in its finished form, is still straight, is now heated for hardening, and, when hot, set by pressure to the required curve, and immediately all except the tang plunged into, and well stirred in, a bath of oil kept cool by a water-jacket. On removal from the bath the blade is "dead hard," and so brittle that it can be broken by a light blow, and consequently has to be "let down" by tempering. This is accomplished by heating it in a bath of molten lead until the steel assumes a particular colour; if now removed from the bath and allowed to cool slowly it is known by experience that the blade will have the correct temper and possess the requisite combination of stiffness and elasticity. While still hot from tempering the blade is "set" by hand, the processes of hardening and tempering altering the curve and frequently the straightness of the blade. It is now ground to size, and the tang, which though not hardened purposely (see above), is harder than is desirable for machining, is softened by annealing—that is, by heating in the lead bath and then slow cooling—and machined to the required form. The blade is then "finish ground," finally set, polished, and completed by the attachment of the hilt and grips of compressed leather roughened by "chequers" to afford a firm hold. During, and at the completion of, manufacture the blade is tested as follows:—When tempered and set before polishing, it is fixed in a machine and caused to strike an oak block with a blow of 120 ℔ with both its edge and back, and similar blows, but with a force of 60 ℔, with both flats. These tests detect flaws, and over or under tempering, by the breakage or distortion of the blade, the blows by the flats being particularly searching tests. If the blade passes the above tests, it is then placed vertically in a machine and shortened one inch by bending. It must recover perfect straightness, and at the same time raise a weight of 35 ℔ bearing on its tang. This tests the stiffness of the blade. Passing this test, it is next twice shortened 5 inches by bending towards each flat and must recover perfect straightness. This tests the elasticity of the blade. After polishing it is again tested for stiffness as above, and must recover perfect straightness, but only under 32℔, and for elasticity by a further shortening by 5 inches, but towards one flat only. The complete sword is tested for firmness of hilting by two blows on an oak block, one by the edge and the other by the back, delivered by hand. The weight, balance, &c., are also tested. To arrive at the tests described above, a number of swords are made to meet the conditions required on service, and then handed over to the troops for practical tests. If the swords prove satisfactory, the mechanical tests to which further supplies must conform are based on those which the experimental swords have passed.

The introduction of the system of manufacture described above has greatly simplified, cheapened, and raised the average excellence of manufacture, while the severe and certain tests by mechanical means have increased the standard of efficiency of the swords in the hands of the troops. It is certainly true that excellent blades were occasionally turned out by hand, but they were exceedingly costly, and the average merit of sword blades when turned out in numbers by hand was poor. It must not, however, be supposed that the regular methods described have eliminated the necessity for personal skill. The steel can still be spoilt by over or under-heating, whether for rolling or hardening; tempering and setting require much experience and skill, and blades can be easily injured both in form and temper by unskilful grinding. Sword-making, therefore, though not the somewhat uncertain art it once was, still requires skilled craftsmen for its successful accomplishment.

(H. W. B.)

Sybel, Heinrich von (1817–1895), German historian, sprang from a Protestant family which had long been established at Soest, in Westphalia. He was born on 2nd December 1817 at Düsseldorf, where his father held important posts in the public service both under the French and the Prussians; in 1831 he had been raised to the hereditary nobility. His home was one of the centres for the vigorous literary and artistic life for which at that time Düsseldorf was renowned. Sybel was educated at the gymnasium of his native town, and then at the University of Berlin, where he came under the influence of Savigny and Ranke, whose most distinguished pupil he was to become. After taking his degree he settled down as *privat-docent* in history at the University of Bonn. He had already made himself known by critical studies on the history of the Middle Ages, of which the most important was his *History of the First Crusade* (1841), a work which, besides its merit as a valuable piece of historical investigation, according to the critical methods which he had learnt from Ranke, was also of some significance as a protest against the vaguely enthusiastic attitude towards the Middle Ages encouraged by the Romantic school. Lady Duff Gordon published in 1861 an English translation of part of this book, to which are added lectures on the Crusades delivered in Munich in 1858, under the title *History and Literature of the Crusades.* This was followed by a study on the *Growth of German Kingship* (1844), after which he was appointed supernumerary professor. In the same year he came forward prominently as an opponent of the Ultramontane party. The exhibition of the Holy Coat at Trèves had attracted enormous numbers of pilgrims. Indignant at what appeared to him an imposture, with Gildemeister, his colleague, he published an investigation into the authenticity of the celebrated relic, *The Holy Coat of Trèves and the Twenty other Holy Seamless Coats* (1844). From this time he began to take an active part in contemporary politics and controversy, as a strong though moderate Liberal. In 1846 he was appointed professor at Marburg, and though the small university (there were only 200 students) offered little scope to his activities as a teacher, a seat in the Hessian Landtag gave him his first experience of political affairs. In 1848 he was present at the *Vor-Parliament* in Frankfort, but did not succeed in winning a seat for the National Assembly; his opposition to the extreme democratic and revolutionary party made him unpopular with the mob, who broke his windows, as his Liberalism made him suspected at Court. He sat in the Erfurt Parliament of 1850, and was attached to the Gotha party, who hoped for the regeneration of Germany by the ascendancy of Prussia. During the years that followed all political activity was impossible; but he was fully occupied with his great work, *The History of the Period of the French Revolution*, for which he had made prolonged studies in the archives of Paris and other countries. (Vols. i.–iii., 1855–60; vol. iv., 1870–71; vol. v., 1874–77. The later editions of the earlier volumes are much enlarged and altered. English translation of vols. i.–iii., 1867–69: Murray.) In this work he for the first time showed the close connexion between the internal and external history of France; he was also the first, by a systematic study of the records, to check and correct the traditional account of many episodes in the internal history. His demonstration that letters attributed to Marie Antoinette were not genuine roused much interest in France. For the history of German thought it was of the greatest importance that a well-known Liberal from the Rhine, by a systematic history of the Revolution, attempted to overthrow the influence which the Revolutionary legend, as expounded by French writers, had acquired over the German mind, and the book was an essential part of the influences which led to the formation of a National Liberal school of thought. He had been much influenced by Burke, on whom he had published two essays. The work was in fact the first attempt to substitute for the popular representations of Thiers and Lamartine the critical investigation which has been carried on with such brilliance by Taine and Sorel. In 1856, at the recommendation of Ranke, he accepted the post of professor at Munich, where King Maximilian, a wise and generous patron of learning, hoped to establish a school of history. He found here a fruitful field for his activity. Besides continuing his work on the Revolution and on the Middle Ages, he was occupied with the *Historical Seminar* which he instituted, in the newly established Historical Commission, and in the *Historische Zeitschrift* which he founded, the original and model of the numerous technical historical publications which now exist. Political differences soon interfered with his work; as an adherent of Prussia and a Protestant, especially as a militant champion against the Ultramontanes, he was from the first an object of suspicion to the Clerical party. In the political excitement which followed the war of 1859 he found that he could not hope for the unreserved support of the king, and therefore in 1861 he accepted a professorship at Bonn, which he held till 1875. He was at once elected member of the Prussian Lower House, and during the next three years was one of the most active members of that assembly: in several important debates he led the attack on the Government, and opposed the policy of Bismarck, not only on the budget, but also on the Polish and Danish affairs. In 1864 he did not stand for re-election, owing to an affection of the eyes, but in 1866 he was one of the first to point out the way to a reconciliation between Bismarck and his former opponents. He had a seat in the Constituent Assembly of 1867, and while he joined the National Liberals, distinguished himself by his opposition to the introduction of universal suffrage, the effects of which he, as did many other Liberals, much distrusted. In 1874 he again accepted a seat in the Prussian Parliament, in order to support the Government in their conflict with the Clericals, and after 1878 with the Socialists. In two pamphlets, by an analysis of the teaching of the Socialists and a survey of Clerical policy during the 19th century, he explained and justified his opinions. In 1880 he retired, like so many other Liberals, disheartened by the change in political life, which he attributed to universal suffrage.

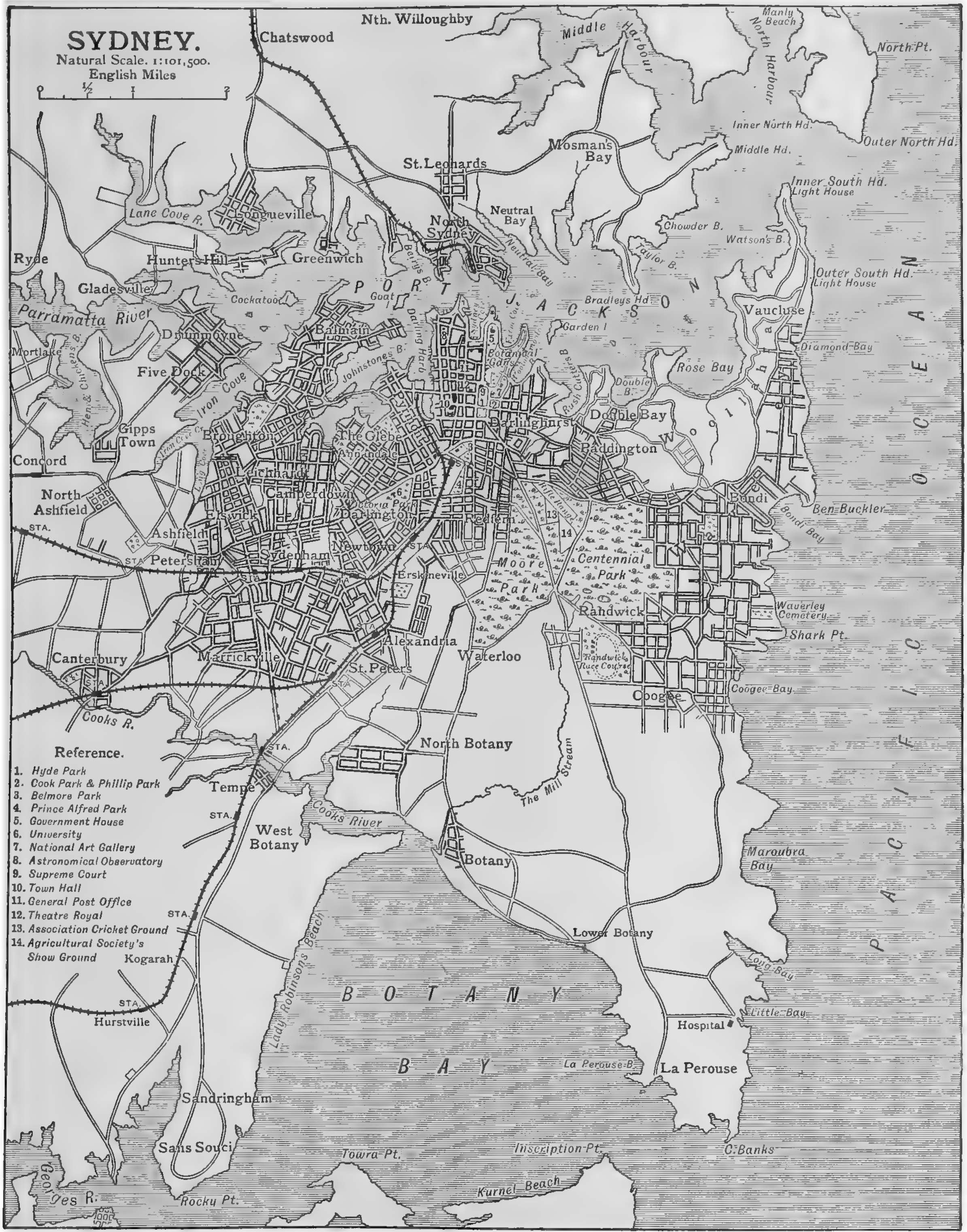
In 1875 he had been appointed by Bismarck to the post of Director of the Prussian Archives. Under his superintendence was begun the great series of *Publications from the Prussian Archives*, besides that of the *Correspondence of Frederick the Great*, in the editing of which he himself took part. His last years were occupied on his great work, *The Foundation of the German Empire* (5 vols., 1889; vols. vi.–vii., 1894: there is an English translation, published in America, of vols. i.–iii.), a work of great importance, for he was allowed to use the Prussian State papers, and was therefore enabled to write a history of the greatest events of his own time with full access to the most secret sources of information. As a history of Prussian policy from 1860 to 1866 it is therefore of incomparable value. After the fall of Bismarck the permission to use the secret papers was withdrawn, and therefore vols. vi. and vii., which deal with the years 1866 to 1870, are of less importance. He did not live to write the account of the war with France, dying on 1st August 1895.

Sybel left two sons, one of whom is an officer in the Prussian army; the other, LUDWIG VON SYBEL, professor of archæology in the University of Marburg, is the author of several works dealing with Greek archæology. Some of Sybel's numerous historical and political essays have been collected in *Kleine Historische Schriften*, (3 vols., 1863, 1869, 1880); *Vorträge und Aufsätze* (1874); and *Vorträge und Abhandlungen*, published after his death with a biographical introduction by C. VARRENTRAPP (1897).

(J. W. HE.)

Sydney, the capital of New South Wales, and the principal seaport of Australia. It is situated on the east coast of the Island Continent, in 33° 51′ 41″ S., and 151° 12′ 23″ ($10^{h.}$ $4^{m.}$ 49·553) E., and lies on the southern shore of the magnificent harbour of Port Jackson, on the South Head of which stands a splendid lighthouse, fitted with a powerful revolving electric arc light, visible for 25 miles at sea. The harbour proper has an area of water surface of 15 square miles, and the shore line is 165 miles in circuit. The private wharves on the east side of Darling Harbour were resumed by the State in 1900, and the Government thus acquired the control of wharfage amounting to 12,000 feet. The total wharfage in Port Jackson belonging to the Government is about 30,000 feet, and has connected with it shipping appliances and many stores. Sydney Cove is still the busiest of the bays as far as shipping is concerned, and besides the ferry traffic running to North Sydney, Mosman's Bay, Neutral Bay, Manly Beach, Watson's Bay, &c., the four great deep-sea mail steamship companies bring their vessels up to the wharves. From the city area proper largely populated suburbs have spread away in all directions, and are connected with the city by railways, cable, electric or steam trams. The old system of steam trams has been superseded by electric trams, on the overhead wire system. From North Sydney a line of railway recently built has brought into existence a series of northern suburbs, named respectively Chatswood, Lindfield, Gordon, Pymble, Wahroonga, and Hornsby. In a southerly direction are the important suburbs of Darlington, Redfern, Alexandria, Waterloo, and Botany, the latter situated on the shores of Botany Bay. The principal streets are George Street, Pitt Street, running parallel, and King Street, running at right angles to those two streets. As an example of modern efforts in the direction of widening thoroughfares, Sydney has only Moore Street, which was created under statutory powers out of a narrow slum lane, the open space in front of the General Post Office being extended as far as Castlereagh Street at a uniform width of 100 feet. The public buildings and principal business places, warehouses, churches, &c., are built of Pyrmont freestone. This supplies an admirable building material, being easily worked, and hardening by exposure to the air.

In view of the enormous growth of the city and suburbs, and the increase of population, the residents may congratulate themselves upon the situation and extent of the city parks and open spaces. No other city can boast such advantages in proportion to population. First comes the harbour, which, being situated in the very midst of the city, which has spread on both the north and south shores, may be regarded as the principal open space. Next comes Hyde Park, which was the original racecourse of the city, about 40 acres in extent. As adjuncts to this fine park there are two small parks—Cook Park and Phillip Park—of about 7 acres, and then the Domain, which extends to the shores of Woolloomooloo Bay and Farm Cove, and has an inner botanic garden, running down to a semicircular sandstone sea wall on the shores of the harbour. These, together with the Government House grounds, contain about 150 acres. Belmore Park occupies 10 acres. Wynyard Square is a small garden on



Walker & Cockerell sc.

Map of Sydney.

a hill in York Street, and on the Flagstaff Hill, where the Astronomical Observatory is situated, there is a picturesque little public garden. Moore Park, lying to the south-east of the city, is about 378 acres in extent. On it are the rifle range, the Agricultural Society's show ground, and the Association Cricket Ground, where the principal cricket matches are played. Prince Alfred Park is another fine open space of 18 acres. Grose Farm, on the south-west of the city, was the site of one of the earliest attempts at Government farming. It is an undulating and elevated piece of land, and is divided amongst the university and the affiliated colleges of St Paul, St John, and St Andrew, the Prince Alfred Hospital, and Victoria Park. The latest addition to the open spaces is that magnificent expanse of land of 530 acres, now called the Centennial Park, which was formerly used in connexion with the water supply. Fine drives, riding and bicycle tracks have been made, and it is now one of the finest parks in the world. The citizens owe this great gift to the late Sir Henry Parkes, who, while Premier of the colony, conceived and carried out the idea of converting the old water reserve into a park.

Sydney is municipally governed by a city council and a large number of municipal councils. For municipal purposes .the city proper is divided into twelve wards, each returning two aldermen. It is behind many cities of Europe and the other colonies in its municipal development. Powers which are usually retained and exercised by municipal bodies have been parted with in Sydney, or never acquired. The control of traffic is handed over to the police. The administration of the water and sewerage department, the parks, and city improvement have been handed over to boards and trusts. The council has no control over wharves or police, and the tramways belong to and are managed by the State Government. The gas supply is in the hands of a private company, which pays nothing for the use of the streets. Electric lighting is passing into the hands of private firms, and already several blocks of city streets are lighted by such companies. A movement is on foot for the establishment of one central council to manage the municipal destinies of Greater Sydney, but so far little progress has been made. This movement may be hastened by the plague, which broke out in Sydney early in 1900 and again in 1902.

The population has increased with marvellous rapidity. In 1861 it was (city and suburbs inclusive) 95,000; in 1881, 237,300; in 1891, 399,270; and in 1901, 487,900. The proportion of city dwellers to suburban is as follows: in 1901—city, 112,137; suburbs, 369,693; total, 487,900. The incorporated area of the metropolitan district is about 142 square miles, or 91,220 acres, so that the average density of population was 5·35 persons per acre, some of the more immediate suburbs being more densely populated than the city itself.

The suburbs comprise forty-one distinct municipalities, of which the populations at the census of 1901 were as follows:—Alexandria, 9341; Annandale, 8349; Ashfield, 14,329; Balmain, 30,076; Bexley, 3079; Botany, 3383; North Botany, 3772; Burwood, 7521; Camperdown, 7931; Canterbury, 4226; Concord, 2818; Darlington, 3784; Drummoyne, 2843; Enfield, 2497; Erskineville, 6059; Five Dock, 1401; Glebe, 19,220; Hunter's Hill, 4232; Hurstville, 4019; Kogarah, 3892; Lane Cove, 1918; Leichhardt, 17,454; Manly, 5035; Marrickville, 18,775; Marsfield, 713; Mosman, 5691; Newtown, 22,598; North Sydney, 22,040; Paddington, 21,984; Petersham, 15,307; Randwick, 9753; Redfern, 24,219; Rochdale, 7857; Ryde, 3222; St Peters, 5906; Strathfield, 2991; Vaucluse, 1152; Waterloo, 9609; Waverley, 12,342; Willoughby, 6004; Wollahra, 12,351.

For parliamentary purposes the city was formerly divided into three electorates—East, West, and South, returning four members each. Since the Parliamentary Electorates and Elections Act of 1893, these large electorates have been divided into four small electorates, returning a single member each. The principal suburbs are nearly all electorates for parliamentary purposes.

Sydney is now supplied with water by the "Upper Nepean scheme." By this scheme the water is brought from the sources of supply, a distance of 40 miles, to Prospect Reservoir, and from thence to Sydney and suburbs, over 20 miles farther. The average daily consumption of water during the year ended June 1901 was 21,583,000 gallons. The cost of this scheme was about four millions sterling.

The new scheme of drainage is nearly completed. The works will drain the northern slopes of the city and suburbs into the Pacific Ocean; and the drainage of the southern slopes will be discharged at a sewage farm on the shores of Botany Bay.

"Sydney," says the Government Statistician of New South Wales, "now stands as the second city of the British Empire, as estimated by the annual value of its rateable property." The total value of all rateable property in the whole metropolitan area in 1902 was £90,060,600. In trade Sydney is in a most important position, the tonnage entered and cleared in the year 1900 being 6,569,824 tons, and the value £42,695,771. "The comparative importance of the trade of Sydney may be realized," says the authority above quoted, "by viewing it in connexion with the trade of the chief ports of the United Kingdom. In absolute tonnage Sydney is surpassed by only five English ports—London, Liverpool, Cardiff, Hull, and Newcastle; though in point of value the trade of Sydney exceeds that of any port in Great Britain, London, Liverpool, and Hull excepted." The jurisdiction of the port was until 1899 in the hands of a Marine Board, of which three members were elected by the shipping interest, and three others and the president were nominated by the Government. But by the Act No. 32 of 1899 the Marine Board was abolished, and the various powers and duties of the board are transferred to an officer called the Superintendent of the Department of Navigation, acting under the control of the Colonial Treasurer. A court of marine inquiry is created, consisting of one or more district court judges, assisted by the assessors. This new authority will have control of the pilot service, which is entirely a Government department. Port Jackson is the headquarters of the naval squadron in Australasia, the residence of the Admiral of the Australian station, and the chief Imperial naval depôt in these seas. With respect to dock accommodation, Sydney is well off, having three graving docks, five floating docks, and three patent slips, with all necessary machinery.

Sydney has many public institutions, including the university and affiliated colleges; deaf and dumb asylum, three lunatic asylums, a free public library and reading room, with a lending branch; a technical college, three large hospitals, besides cottage hospitals in various suburbs; a benevolent asylum, an institute for destitute children at Randwick, a training ship for boys, two soup kitchens and refuges; a bacteriological experimental institute at Rose Bay, a school of arts with library and class-rooms, a Government astronomical observatory, a museum, an art gallery, &c.; and a leper lazarette at Little Bay. A women's college was opened in 1892 in connexion with the university. There were at the university in 1901 62 professors and lecturers and 657 students (573 male and 84 female). The revenue in that year was £35,766, of which £9800 represented Government aid. Many donations have been made to the university; one of £180,000 has been increased to £250,000, and the present capital value of all donations is probably not less than £460,000. The technical college is not connected with the university. There were in 1899 7647 students attending the college and its branches, and the State expenditure on technical instruction was £19,218.

None of the public institutions mentioned above, though situated in and around Sydney, are under the control of the municipal council. They are controlled by the State Government. Of institutions purely municipal there are several, such as the central markets, a pretentious building in George and York Streets, the fish-market, and the large markets at the Haymarket, known as the Belmore Market. In the metropolitan area there are sixty-four licensed slaughter-houses for the supply of beef to the inhabitants. The principal slaughter-houses are the abbatoirs, Glebe Island; they are under the supervision of the Board of Health.

Sydney has several public monuments and statues. The principal statues are those of Queen Victoria, at the top of King Street, and Prince Albert, at the gate of Hyde Park; Captain Cook and the Right Hon. W. P. Dalley, P. C., in Hyde Park; Governor Phillip, in the Palace Gardens, Domain; Governor Richard Bourke, at the Domain gates; Mr Mort, in Macquarie Place; and the Rev. Dr Lang, in Wynyard Square Gardens.

The National Art Gallery is situated in the Outer Domain, and the building is at yet incomplete. It contains a splendid collection of pictures by the greatest modern artists, some statuary, and a number of artistic pottery, medallions, and a fine Chinese tapestry. It is open on Sundays (as is also the free public library), and is a very popular resort, the average Sunday attendance being 1773, and on week days 575.

Sydney possesses several fine theatres, viz., the Theatre Royal, the Lyceum Theatre, Her Majesty's Theatre, the Criterion Theatre, the Opera House, the Palace Theatre, and the Tivoli Music Hall.

There are innumerable places of resort for the citizens. Many of the bays in the harbour are largely visited on Sundays and holidays. The most popular resorts are Manly Beach, Chowder Bay, and Watson's Bay, in the harbour; Cabarita, on the Parramatta river; Middle Harbour; and Coogee Bay and Bondi, on the ocean beach; Botany, Lady Robinson's Beach, Sandringham, and Sans Souci on Botany Bay. Besides these there are two splendid national reserves, an hour's ride by rail from Sydney, viz., National Park, comprising an area of 36,810 acres, surrounding the picturesque bay of Port Hacking; and Kurringai Chase, with an area of 35,300 acres.

The two principal cemeteries are at Waverley and Rookwood. The former is most picturesquely situated on the cliff overlooking the Pacific Ocean. The latter is on the Western railway line. Both contain many fine monuments.

Amongst the principal public buildings are the Law Courts, though these are not important from an architectural standpoint. They are nearly all situated at the top of King Street. In one building there are comprised the Banco Court, the Divorce Court, and various Jury Courts. Towards Macquarie Street, in King Street, are the Equity Court, the District Court, and the Probate Offices. The Central Criminal Court is a massive stone building in Darlinghurst, in proximity to the gaol.

As a manufacturing centre Sydney occupies a fairly important position. Those industries which are peculiar to a great seaport exist, with the notable exception of shipbuilding, which at one period was assuming flourishing proportions, but has fallen away to nothing. Ship-repairing, however, could hardly fail in such a favourable position to assume large proportions, and it has. Large numbers of hands are employed in the Government railway workshops, where the locomotives and rolling stock for the Government railways are manufactured. There are several large tobacco factories, boot factories, flour-mills, a large sugar refinery, tanneries, boiling-down works, glue and kerosene oil factories, and a large English firm have established a branch of a soap manufactory. There are also clothing factories, tweed factories, and a great number of minor industries. The number of hands employed in the metropolitan district in 1900 was 38,668. Towards the close of 1901 coal of excellent quality was struck near the shore of the harbour.

The mean temperature is 62·9°, and corresponds with that of Barcelona in Spain and of Toulon in France. The mean summer temperature is slightly under 71°, and that of winter 56°. The range is thus 15° Fahrenheit, while the mean yearly average for a period of thirty-eight years was 63°. The greatest temperature ever experienced was 108·5° in the shade in 1896, and the lowest winter was 35·9°, giving a range of 72·6°. The average rainfall is 49·66 inches. (J. D. F.)

Sydney, the chief town of Cape Breton county, Nova Scotia, on a good harbour, the eastern terminus of the Intercolonial railway, 285 miles north-east of Halifax. The town contains many fine buildings, among which are seven churches, an academy, court house and post office, and custom house. The Dominion Iron and Steel Company have built immense works for the manufacture of iron and steel, in consequence of which the population has more than doubled. For 1901 the exports were $1,262,903 and the imports $2,850,607. Population (1901), 9909.

Sylhet, a town and district of British India, in the Surma Valley division of Assam. The town is on the right bank of the river Surma. Population (1881), 14,407; (1891), 14,027; municipal income (1897–98), Rs.33,650. There are manufactures of mats, carved ivory and shells, and furniture. An unaided college, founded in 1892, and mainly supported by a native gentleman, had 27 students in 1896–97; two high schools had 608 pupils. There are two dispensaries and an English church. The great earthquake of 12th June 1897 destroyed every substantial building, but caused very little loss of life.

The district of Sylhet has an area of 5414 square miles; population (1881), 1,969,009; (1891), 2,154,593, showing an increase of 9 per cent.; average density, 398 persons per square mile, comparing with 112 for the province generally. Classified according to religion, Hindus in 1891 numbered 1,016,134; Mahommedans, 1,123,984; Christians, 643, of whom 277 were Europeans; hill tribes, 13,818; "others," 14. In 1901 the population was 2,238,892, showing a further increase of 4 per cent. Land revenue, Rs.7,66,638, the incidence of assessment per acre being R.0.2.5 on the permanently settled and R.0.10.7 on the temporarily settled tract; number of police, 547; number of boys at school (1896–97), 39,077, being 23·66 per cent. of the male population of school-going age; number of girls at school, 3690, being 2·33 per cent.; registered death-rate (1897), 52·93 per 1000. Tea cultivation is a flourishing industry in the southern hills. In 1897 the number of gardens was 137, with 70,200 acres under tea, employing 145,804 persons, of whom 13,115 had been imported under contract, and yielding more than 26 million ℔, or 474 ℔ per acre, by far the highest rate in the province. There are two printing-presses, issuing a fortnightly newspaper in Bengali. The Assam–Bengal railway now runs through the district, but trade is still largely river-borne. Great damage was done by the earthquake of June 1897.

Sylvester, James Joseph (1814–1897), English mathematician, was born in London on 3rd September 1814. He went to school first at Highgate and then at Liverpool, and in 1831 entered St John's College, Cambridge. In his Tripos examination, which through illness he was prevented from taking till 1837, he was placed as second wrangler, but being a Jew and unwilling to sign the Thirty-nine Articles, he could not compete for one of the Smith's prizes and was ineligible for a fellowship, nor could he even take a degree: this last, however, he obtained at Trinity College, Dublin, where religious restrictions were no longer in force. After leaving Cambridge he was appointed to the chair of natural philosophy at University College, London, where his friend De Morgan was one of his colleagues, but he resigned in 1840 in order to become professor of mathematics in the University of Virginia. There, however, he remained only six months, for certain views on slavery, strongly held and injudiciously expressed, entailed unpleasant consequences, and necessitated his return to England, where he obtained in 1844 the post of actuary to the Legal and Equitable Life Assurance Company. In the course of the ensuing ten years he published a large amount of original work, much of it dealing with the theory of invariants, which marked him as one of the foremost mathematicians of the time. Still, his reputation among those competent to judge of his attainments did not extend to the dispensers of academic patronage, and he failed to obtain either of two posts—the professorships of mathematics at the Royal Military Academy and of geometry in Gresham College—for which he applied in 1854, though he was elected to the former in the following year on the death of his successful competitor. At Woolwich he remained until 1870, and although he was not a great success as an elementary teacher, that period of his life was very rich in mathematical work, which included remarkable advances in the theory of the partition of numbers and further contributions to that of invariants, together with an important research which yielded a proof, hitherto lacking, of Newton's rule for the discovery of imaginary roots for algebraical equations up to and including the fifth degree. In 1874 he produced several papers suggested by Peaucellier's discovery of the straight line link motion associated with his name, and he also invented the skew pentagraph. Three years later he was appointed professor of mathematics in the Johns Hopkins University, Baltimore, stipulating for an annual salary of 5000 dollars, to be paid in gold. At Baltimore he gave an enormous impetus to the study of the higher mathematics in America, and during the time he was there he contributed to the *American Journal of Mathematics*, of which he was the first editor, no less than thirty papers, some of great length, dealing mainly with modern algebra, the theory of numbers, theory of partitions, and universal algebra. In 1883 he was chosen to succeed Professor Henry Smith in the Savilian chair of geometry at Oxford, and there he produced his theory of reciprocants, largely by the aid of his "method of infinitesimal variation." In 1893 loss of health and failing eyesight obliged him to give up the active duties of his chair, and a deputy professor being appointed, he went to live in London, where he died on 15th March 1897. Sylvester's work suffered from a certain lack of steadiness and method in his character. For long periods he was mathematically unproductive, but then sudden inspiration would come upon him and his ideas and theories poured forth far more quickly than he could record them. All the same his output of work was as large as it was valuable. The scope of his researches was described by Cayley, his friend and fellow-worker, in the following words: "They relate chiefly to finite analysis, and cover by their subjects a large part of it—algebra, determinants, elimination, the theory of equations, partitions, tactic, the theory of forms, matrices, reciprocants, the Hamiltonian numbers, &c.; analytical and pure geometry occupy a less prominent position; and mechanics, optics, and astronomy are not absent." Sylvester was a good linguist, and a diligent composer of verse, both in English and Latin, but the opinion he cherished that his poems were on a level with his mathematical achievements has not met with general acceptance.

Symonds, John Addington (1840–1893), English critic and poet, was born at Bristol, 5th October 1840, the only son of John Addington Symonds, M.D., and Harriet, eldest daughter of James Sykes of Leatherhead. He was a delicate boy, and at Harrow, where he was entered in 1854, took no part in school games and showed no particular promise as a scholar. In 1858 he proceeded to Balliol as a commoner, but was elected to an exhibition in the following year. The Oxford training and association with the brilliant set of men then at Balliol called out the latent faculties in Symonds, and his university career was one of continual distinction. In 1860 he took a first in "Mods," and won the Newdigate with a poem on *The Escorial;* in 1862 he was placed in the first class in Literæ Humaniores, and in the following year was winner of the Chancellor's English Essay. In 1862 he had been elected to an open fellowship at Magdalen. The strain of study unfortunately proved too great for him, and, immediately after his election to a fellowship, his health broke down, and he was obliged to seek rest in Switzerland. There he met Janet Catherine North, whom, after a romantic betrothal in the mountains, he married at Hastings 10th November 1864. He then attempted to settle in London and study law, but his health again broke down and obliged him to travel. Returning to Clifton, he lectured there, both at the college and to ladies' schools, and the fruits of his work in this direction remain in his *Introduction to the Study of Dante* (1872) and his admirably vivid *Studies of the Greek Poets* (1873–76). Meanwhile he was occupied upon the work to which his talents and sympathies were especially attracted, his *Renaissance in Italy,* which appeared in seven volumes at intervals between 1875 and 1886. The *Renaissance* had been the subject of Symonds's prize essay at Oxford, and the study which he had then given to the theme aroused in him a desire to produce something like a complete picture of the reawakening of art and literature in Europe. His work, however, was again interrupted by illness, and this time in a more serious form. In 1877 his life was in acute danger, and upon his removal to Davos Platz and subsequent recovery there, it was felt that this was the only place where he was likely to be able to enjoy life. From that time onward he practically made his home at Davos, and a charming picture of his life there will be found in *Our Life in the Swiss Highlands* (1891). Symonds, indeed, became in no common sense a citizen of the town; he took part in its municipal business, made friends with the peasants, and shared their interests. There he wrote most of his books—biographies of Shelley (1878), Sidney (1878), Ben Jonson (1886), and Michelangelo (1893), several volumes of poetry and of essays, and a fine translation of the *Autobiography of Benvenuto Cellini* (1887). There, too, he completed his study of the *Renaissance,* the work by which he will be longest remembered. He was assiduously, feverishly active throughout the whole of his life, and the amount of work which he achieved was wonderful when the uncertainty of his health is remembered. He had a passion for Italy, and for many years resided during the autumn in the house of his friend, and ultimately biographer (1895), Mr Horatio F. Brown, on the Zattare, in Venice. He died at Rome, 19th April 1893, and was buried close to Shelley. Two works from his pen, a volume of essays, *In the Key of Blue,* and a monograph on *Walt Whitman,* were published in the year of his death. His activity was unbroken to the last. In life Symonds was morbidly introspective, a Hamlet among modern men of letters, but with a capacity for action which Hamlet was denied. Robert Louis Stevenson described him, in the Opalstein of *Talks and Talkers,* as "the best of talkers, singing the praises of the earth and the arts, flowers and jewels, wine and music, in a moonlight, serenading manner, as to the light guitar." But under his excellent good-fellowship lurked a haunting melancholy. Full of ardour and ambition, sympathy and desire, he was perpetually tormented by the riddles of existence; through life he was always a seeker, ardent but unsatisfied. This side of his nature stands revealed in his gnomic poetry, and particularly in the sonnets of his *Animi Figura,* where he has portrayed his own character very subtilly. His poetry is perhaps rather that of the student than of the inspired singer, but it has moments of deep thought and emotion. It is, indeed, in passages and extracts that Symonds appears at his best. Rich in description, full of "purple patches," his work has not that harmony and unity that are essential to the conduct of philosophical argument. He saw the part more clearly than the whole; but his view, if partial, is always vivid and concentrated. His translations are among the finest in the language; here his subject was found for him, and he was able to lavish on it the wealth of colour and quick sympathy which were his characteristics. He was a lover of beauty, a poet and a philosopher; but in his life and his work alike he missed that absolute harmony of conviction and concentration under which alone the highest kind of literature is produced. (A.WA.)

Symons, George James (1838–1900), English meteorologist, was born in Pimlico, London, on 6th August 1838. In 1860 he obtained a post in the meteorological department of the Board of Trade under Admiral Fitzroy, who was then deeply interested in the subject of storm-warnings, and in the same year he published the first annual volume of *British Rainfall* which contained records from 168 stations in England and Wales, but none from Scotland or Ireland. Three years later he resigned his appointment at the Board of Trade, where his rainfall inquiries were not appreciated, at least not as a prior study to storm-warnings, and devoted his whole energies to the organization of his wonderful band of volunteer observers for the collection of particulars of rainfall throughout the British Isles. So successful was he in this object that by 1866 he was able to show results which gave a fair representation of the distribution of rainfall, and the number of recorders gradually increased until the last volume of *British Rainfall* which he lived to edit (that for 1899) contained figures from 3528 stations—2894 in England and Wales, 446 in Scotland, and 188 in Ireland. Apart from their scientific interest, these annual reports are of great practical importance, since they afford engineers and others engaged in water supply much-needed data for their calculations, the former absence of which had on some occasions given rise to grave mistakes. Symons himself devoted special study not only to rainfall, but also to the evaporation and percolation of water as affecting underground streams, and his extensive knowledge rendered him a valuable witness before parliamentary committees. In other branches of meteorology also he took a keen interest, and he was particularly indefatigable, though consistently unsuccessful, in the quest of a genuine thunderbolt. The history of the science too attracted his attention, and he possessed a fine library of meteorological works, which passed to the Meteorological Society at his death. Of that society he became a member when only eighteen, and he retained his connexion with it in various official capacities up to the end of his life. He served as its president in 1880, and in view of the celebration of its jubilee was re-elected to that office in 1900, but the illness that caused his death prevented him from acting. He died in London on 10th March 1900.

Syra, or Hermoupolis, the principal seaport of the Greek Cyclades, on the east side of the island of Syros, nearly midway between Piræus and Samos. It is conveniently situated as a port of call, and for coaling, for vessels going to and from Constantinople and the Black Sea. But since the energetic development of Piræus, Syra has ceased to be the chief commercial entrepot and distributing centre of this part of the Levant, and consequently its trade has seriously declined. Whereas in 1890 the foreign commerce was valued at £1,313,730, in 1900 it only amounted to £408,350. Coal, textiles, and iron and steel goods figure prominently amongst the imports, and emery, leather, lemons, sponges, flour, valonea, and iron ore amongst the exports. Syra is the seat of several industries, as tanneries, flour and cotton mills, ropewalks, factories for confectionery ("Turkish delight"), hats, kerchiefs, furniture, pottery, and distilleries. The port is entered and cleared by some 900,000 tons of shipping annually. The harbour, which is protected by a breakwater 273 yards long, has a uniform depth of 25 feet, diminishing to 12 feet. Population (1896), 17,894.

Syracuse (Italian, *Siracusa*), a city of Italy, on the east coast of Sicily, capital of the province of Syracuse, 80 miles south by west of Messina, occupying a small island (Ortygia) which projects south towards the peninsula of Massolivieri. There is a trade averaging in the aggregate £274,000 per annum—exports, £130,000; imports, £144,000. The principal exports are olive oil, oranges and lemons, including peel, wine, rock asphalt, locust beans, linseed, almonds, &c. In 1899 the port was entered by 782 vessels of 404,100 tons. Population (1881), 21,739; (1900), 32,074.

Syracuse, a city of New York, U.S.A., capital of Onondaga county. It is situated in lat. 43° 02′, long. 76° 14′, near the south end of Onondaga Lake, on the Erie Canal, and on the Delaware, Lackawanna and Western, the New York Central and Hudson River, and the West Shore railways, in the central part of the state, at an altitude of 400 feet. It has a level site, a somewhat irregular street plan, and is divided into nineteen wards. It has an excellent water-supply drawn from Skaneateles Lake, the works being owned by the city, and is well sewered. Its streets are well paved, mainly with asphalt and brick. There is a city library of nearly 30,000 volumes, and many fine public buildings, among which are the United States Building, the Court House, and the City Hall. The city contains many charitable and educational institutions. Among the latter is Syracuse University, which in 1899 had a faculty of 109 professors and instructors, and was attended by 770 students, including 219 women. Syracuse is a manufacturing city of importance. In 1900 it contained 1383 establishments, with a total capital of $31,358,055. They employed 14,917 hands, and the product had a value of $31,948,055. The principal articles of manufacture were clothing, carriages and waggons, chemicals, foundry and machine-shop products, iron and steel, bicycles, boots and shoes, furniture, hosiery, and malt liquors. Salt, formerly the principal product, is now of little importance, having been driven out of the market by the competition of that of Michigan. In 1899 the assessed valuation of real and personal property was $80,759,234, the net debt of the city was $7,379,329, and the rate of taxation was $19.33 per $1000. The total income of the city from all sources, exclusive of loans, was $2,239,035, and the expenditure for maintenance and operation was $1,745,014. Population (1890), 88,143; (1900), 108,374, of whom 23,757 were foreign-born and 1034 negroes. Of 32,499 males 21 years of age and over, 1071 were illiterate (unable to write).

Syria.—The Tell el-ʿAmarna letters show that in the 14th century B.C. all Syria belonged to Egypt, and they describe in some detail the breaking up of the Egyptian power in the reign of Akhenaten and the progress of the conquering Amorites and Hittites (Khíta). The German excavations at Sinjerli, east of the Giaour Dagh, have made known the existence of a principality in that district, Samál, which was ruled in the 8th century B.C. by dynasts named Panammu, and was absorbed in the following century by the growing power of Tiglath Pileser III. In the same place was found a stele recording the victories of Esarhaddon over Egypt and Tyre. Interesting results, not yet published, have also been obtained by the German excavations at Baálbek. The railroad from Beirút to Damascus has already been noticed (see Lebanon), and at the end of 1901 about 180 miles of the Damascus–Mecca railway were completed. There are good roads from Beirút to Damascus, Beirút to Tripoli, Tripoli to Hums and Baálbek, and from Alexandretta to Aleppo, on which wheeled transport is used; but the volume of trade has not greatly increased. The total trade by sea amounts from six to seven millions sterling. In 1900 the imports, which embrace cottons and woollens, sugar, leather, timber, petroleum, silks, glass, rice, fezzes, &c., were valued at £4,000,000; and the exports, the chief items of which were silk thread, &c., cocoons, lemons, oranges, and other fruit, wool, cereals, and sponges, at £2,655,000. There are no accurate returns of the population, but for the whole of Syria, including Lebanon and Palestine, it may be roughly estimated at about 3½ millions, of whom about one-third are Christians.

Authorities.—Hartmann. "Beiträge zur Kenntniss der Syrischen Steppe," in *Zeitsch. d. Deutsch. Pal.-Vereins*, xxii., xxiii.—Maspero. *Hist. Ancienne des peuples de l'Orient classique.*—Von Oppenheim. *Vom Mittelmeer zum Persischen Golf.* 1900.—Petrie. *Syria and Egypt from the Tell el-Amarna Letters.* 1898.—Sachau. *Am Euphrat und Tigris.* 1900.—Von Luschan. *Ausgrabungen in Sendjerli.*—Baedeker–Socin. *Handbook to Syria and Palestine.*—Murray's *Handbook to Asia Minor, &c.*—Post. *Flora of Syria and Palestine.*

Syriac Gospels.—The most important and far-reaching discovery of recent times in regard to the text of the Gospels is undoubtedly the Syriac palimpsest, which was unearthed on Mount Sinai by Mrs Lewis and her sister, Mrs Gibson, in the year 1892. The upper writing of this MS. is a collection of lives of women saints, made by a monk in the monastery of Beth Mari, in the town of Mearath Mezrin, near Antioch, as its colophons show, and written towards the end of the 8th century: a collection of small literary value, unless it should be for the fact that it contains a new Syriac text of the story of Susanna. The erased underwriting is, however, some four centuries earlier, and contains a text whose critical worth for the student of the Gospels is wellnigh inestimable. When the volume first came under Mrs Lewis's notice the pages were compacted together, through age and disuse, so that the steam from a kettle had to be used to separate them: finding that the erased text was very ancient and contained the Gospels, Mrs Lewis photographed the whole of the MS. and brought the results back to Cambridge, where her suspicions as to the antiquity of the text were speedily confirmed by Professor Bensly and Mr Burkitt, who recognized the characteristic traits of the old Syriac version, hitherto only known by the imperfect recension that bears the name of Cureton. In the year 1893 Mrs Lewis and her sister returned to the convent on Mount Sinai, bringing with them three transcribers for the text, Professor Bensly, Mr Burkitt, and Dr J. Rendel Harris. From 8th February to 20th March they laboured on the transcription, and brought the results back to Cambridge for publication. Professor Bensly, however, did not live to take part in this work, but died almost immediately upon his return. His transcripts were placed in the hands of Mr Burkitt, and the text, so far as recovered, was published, with a preface by Mrs Lewis, by the Syndics of the University Press.[1]

For further details as to the discovery and transcription of the text, see Mrs Gibson's *How the Codex was Found* and Mrs Lewis's *A Translation of the Four Gospels from the Syriac of the Sinaitic Palimpsest.* The account attached to Merx's German translation of the Syriac Gospels is not always trustworthy.

When the transcribers left Sinai, they imagined that the work had been done with tolerable completeness, and had expressed themselves to the effect that they had not left much for the Germans; but palimpsest reading is rarely final, and in 1895 Mrs Lewis and her sister were again at Sinai, where they revised the text in doubtful places, re-read the codex from end to end, and, by a combined result of the fresh scrutiny with the further judicious use of the chemical reagent which had been employed in 1893, succeeded in adding nearly a fifth to the already published matter—a critical triumph that can hardly be paralleled in the history of palimpsest reading. As a result of this visit, Mrs Lewis published a re-transcription[2] of a number of pages of the Syriac text, and re-edited her first translation of the text, under the title, *Some Pages of the Four Gospels re-transcribed from the Sinaitic Palimpsest with a Translation of the Whole Text,* by Agnes Smith Lewis (London, C. J. Clay and Sons, 1896). A fourth visit to the convent made in 1897 enabled the untiring sisters to examine a number of doubtful passages, and to add a few further readings to the total result. These will be found in the pages of the *Expositor* for 1897 (pp. 111–119; see also p. 472).

It should be observed that the discovery of the original home of the MS., before it came into the possession of the Sinai monks (see Mrs Lewis in *Expositor* for 1900, pp. 415–421[3]), has rendered the title "Sinaitic Syriac" no longer suitable. It must be called "Antiochene Syriac," or, following the analogy of the Cureton text, the "Lewis Syriac." Probably the latter is the better term, as we do not know whether "Antiochene" may not have to be further replaced by "Edessan."

There can be no doubt that these arduous labours on the part of the discoverers and transcribers of the text have been abundantly justified by the published results, for the recovered text is in some respects superior to anything that had hitherto been known of the text of the Gospels, and gives us frequent vistas over the untravelled country that lies between our most ancient uncial texts and the Gospel archetypes. It is not only free from those expansions which critical science has already condemned in the *Textus Receptus,* and from most of its conflations of contending types of text, but it is also singularly free from those expansions which do so much to discredit the so-called Western text, with which it is otherwise in substantial agreement; and generally speaking, its brevity appears to be defensible, not only in such cases as the *Pericope de Adultera* (John vii. 53–viii. 11) and the last twelve verses of Mark, but in a number of less conspicuous places, where it betrays to us the fact that the Gospels have come down to us through a long sequence of editorial revisions, of which accretion is certainly one conspicuous feature. Even the order of the text, where apparent displacements occur, can frequently be justified, *e.g.,* Mark xvi. 4, where the words, "For it was very great," used of the stone at the sepulchre, are carried back to their right place in Mark xvi. 3, and the transposition is further verified by the fact that the same order is given in the Gospel of Peter. At other times the relative displacement of passages in the Lewis text is a key to the finding of the shorter text which underlies all existing copies, as in Luke xxii. 17–20, where all texts are in excess and the removal of the accretions had already been commenced by Westcott and Hort. Critically the Lewis text must be described as Western, but it is Western of great antiquity and purity, and the combination of this text with earlier evidence of the same kind from the old Latin versions is one that it will be difficult to resist.

Of the innumerable questions that have arisen with regard to the new text, the two that have provoked most interest are (*a*) the relation of the new Gospel to the Diatessaron of Tatian; (*b*) its theological orthodoxy or unorthodoxy.

With regard to (*a*) no final agreement has yet been reached, though there is a strong phalanx of experts for the opinion that the Lewis Gospels represent a Syriac text which antedates Tatian. There are traces of a Jewish hand in the translation, as when the temple is called the Holy House (John x. 22), or when the phylacteries are called by their Jewish name of Tephillin (Matt. xxiii. 5). On the other hand, there are slight suggestions of Encratism (Matt. xxii. 4, Luke ii. 36), as well as a number of harmonistic touches which seem to recall Tatian. And between the Separated Gospels or Gospels of the Mepharrashe, as they call themselves, and the Combined Gospels or Gospels of the Mehallete, there is some nexus that is not yet perfectly explored. We incline to the belief that the Lewis text is not the daughter of the Tatian Harmony, but its parent, and that traces of the latter in the former are due to textual contamination.

With regard to (*b*), the orthodoxy of the codex has been impugned on account of an extraordinary reading in the genealogy of Matthew, which appears to make Joseph the direct parent of Jesus [Matt. i. 16, *Joseph,* to whom the Virgin Mary was espoused, *begat Jesus*]. There are also traces of what may perhaps best be described as a recrudescence of Adoptionist Theology. Notably, there are singular cases of the tendency to call Christ the Elect of God, a title which, as a result of editorial revision, had almost disappeared from the New Testament, but which is now to be read in Luke ix. 35, Luke xxiii. 35, John i. 34, John iii. 18 (as recently verified for the Lewis text by Mr Burkitt), and perhaps elsewhere. The reading, whether we choose to call it Adoptionist or not, is certainly pre-Catholic, as may be conclusively shown from Justin, *Trypho,* § 67, where Trypho argues, against the Catholic position of Justin, that Jesus became the Christ, by election, as a result of his perfect obedience and life (*κατηξιῶσθαι τοῦ ἐκλεγῆναι εἰς χριστὸν . . . ἐκλελέχθαι αὐτὸν καὶ χριστὸν γεγενῆσθαι . . .*). The restored reading in John iii. 16 furnishes in Syriac the very word which is used to describe the Elect Servant in Isa. xlii. 1, and it is probable that this verse of Isaiah was much more closely imitated in the primitive account than is shown by the canonical record. Mrs Lewis has perhaps been too ardent a defender of the orthodoxy of her MS. before ecclesiastical tribunals, to which there is no need to make a reference, as the text is certainly anterior to the period of exact theological definition.

It is probable that the genealogy in Matthew, while restored to a more early form by the Lewis MS. than is found in the edited texts, is not yet in its final shape. And it is certain that both it and the account of the birth of Christ which follows it have undergone revision with a view to the avoiding of misunderstanding. In any case the evidence of this MS. is of the first importance for both the critic and the theologian.

AUTHORITIES.—*The Four Gospels in Syriac, transcribed from the Sinaitic Palimpsest.* By the late ROBERT L. BENSLY, M.A.,

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[1] This may be quoted as the Syndics' edition.

[2] This may be quoted as Mrs Lewis's edition. The parts added by Mrs Lewis are printed in blue ink.

[3] The colophon which betrayed the secret to Mrs Lewis had been read by Professor Bensly, as appears from a transcript since found amongst his papers.

J. Rendel Harris, M.A., and F. Crawford Burkitt, M.A., with an introduction by Agnes Smith Lewis. Cambridge, at the University Press, 1894.—*How the Codex was Found.* By Margaret D. Gibson. Macmillan, 1893.—*A Translation of the Four Gospels from the Syriac of the Sinaitic Palimpsest.* By Agnes S. Lewis. Macmillan, 1894.—*Some Pages of the Four Gospels retranscribed from the Sinaitic Palimpsest, with a Translation of the Whole Text.* By Agnes Smith Lewis. London, C. J. Clay and Sons, 1896.—"The New Syriac Gospels" by J. Rendel Harris in *Contemporary Review*, 1894; *The Academy* for November and December 1894 and for January 1895; *The Guardian* for 31st October 1894 (F. C. Burkitt).—*Collatio Codicis Lewisiani.* By Albert Bonus.—*Die vier Kanonischen Evangelien* (trans. by Merx from the Sinai palimpsest, Berlin, 1897).—*Die altsyrische Evangelienübersetzung.* By Hjelt (Leipzig, 1901). (J. R. HA.)

Szabadka (*Maria-Theresiopel*), a municipal town of Hungary, in the county of Bács-Bodrog, 25 miles south-west of Szegedin, with 73,526 inhabitants in 1891 and 82,122 in 1901. To its territory belongs Lake Palics, a favourite watering-place and summer establishment. It contains a burgher school for boys and girls, public hospital, almshouse, municipal music school. Its inhabitants are mostly engaged in agriculture; there is no important industry. The town has an immense territory (369 square miles). Its fruit trade and turkey breeding are considerable; the latter is the most important in the country. In 1889 the *honvéd* commemorative monument was inaugurated.

Szalay, Ladislas (1813–1864), Hungarian historian, was born in 1813. After the completion of legal and historical studies, he took part in the great revolution of 1848–49, and was obliged to seek refuge in Switzerland, where, at Rorschach, on the Lake of Constance, he wrote his *Magyarország története* (History of Hungary). It extends to 1707 and, in six volumes, tells chiefly the constitutional history of Hungary and her dependencies. Szalay himself admitted that he could not claim for his work the merits of thorough and original research in all its parts; it was meant as a great political programme, enlightening the nation about their historical rights against the pretensions of the Habsburgs. The style of the work is somewhat rigid, but thoughtful; a manly and profound conviction of Hungary's historical vocation animates its every page. Szalay also wrote remarkable studies on Pitt, Fox, Mirabeau, and other statesmen, and contributed very considerably to the codification of Magyar law.

See Joseph Szinnyei in the *Magyar Helikon* of 1886, and Alexander Flegler, *Szalay Làszló*, a biography (in *Olcsó Könyvtár*, 1878).

Szamos-Ujvár (*Gherla*), a corporate town of Hungary, in the county of Szolnok-Doboka, 23 miles north-east of Klausenburg, with 5798 inhabitants in 1891 and 6363 in 1901. Its ancient fort now serves for a prison. It is the seat of a Greek Catholic bishopric, and has a seminary for Greek Catholic priests, a State upper gymnasium, an orphanage, a Franciscan convent, and a distillery. It was founded by the Armenians, who are known as skilful and wealthy traders. There is a fine Armenian cathedral, with an altar-picture by Rubens.

Szawly (Russian, *Schavli*), a district town of Russia, in the government and 77 miles N.N.W. of the town of Kovno on the railway from Vilna to Libau. It has several distilleries, flour-mills, and tobacco factories, and carries on a brisk trade with Libau (105 miles) in grain and linseed. Its population in 1897 was 15,914 (nearly 22,000 with the suburbs).

Szeged, a municipal town of Hungary, on the right bank of the Theiss, just below the confluence of the Maros, 100 miles south-east of Budapest. Population 87,410 in 1891, and 102,991 in 1901. Centre of the commerce and industry of the great Hungarian Alföld, this town has recently developed considerably and has been much improved, so that now it is one of the finest cities of Hungary. There are many educational establishments. In 1898 a State gymnasium was opened. It contains a training institute for teachers and several special industrial schools. Among its industrial establishments may be mentioned saw-mills, match, sausage, red pepper (*paprika*), leather, and spirit factories, an iron-foundry, &c. Several statues adorn the town, among which is the monument of the Hungarian poet, Andreas Dugonics.

Szegzárd, chief town of the county of Tolna, near the right bank of the Danube, 80 miles S. by W. of Budapest, Hungary, with 14,325 inhabitants in 1891 and 13,895 in 1901. Its most important buildings are the county hall, the castle of Baron Augusz, the Roman Catholic church, and the hospital. There are a rich county museum and the central inspectorship of silk-production. Its inhabitants are largely engaged in producing silk and fruits. In its vicinity is produced the celebrated red wine of Szegzárd.

Székesfchérvár, a municipal town of Hungary, capital of the county of Fejér, 37 miles south-west of Budapest, with 28,942 inhabitants in 1891 and 32,167 in 1901. Besides the administrative offices of the county, there are a county and a district court of justice, a chamber of advocates, a large episcopal library, a museum, a theatre, an archæological association, a hospital, and numerous other public institutions. It is an important centre of national horse-breeding. It is one of the oldest towns of Hungary, founded by St Stephen, first king of Hungary.

Szerencs, an old Hungarian market-town in the county of Zemplén, in the vicinity of the hills of Tokaj, 125 miles north-east of Budapest, with 4339 inhabitants in 1891 and 5272 in 1901. It is an important railway junction, and contains the largest sugar-refinery of Hungary, in which 1350 workmen are employed, and which produces yearly above 10,000 tons of fine sugar.

Szombathely (*Steinamanger*), a corporate town of Hungary, capital of the county of Vasvar (Eisenburg), 68 miles south of Pozsony (Pressburg), with 17,270 inhabitants in 1891 and 24,751 in 1901. It is an important railway and industrial centre, having a State railway workshop, two manufactories of agricultural machinery, a foundry, a steam mill, &c. On its site stood the Roman *Sabaria*. Numerous remains of these are in the civic museum.

Taaffe, Eduard Francis Joseph von, Count [11th Viscount Taaffe and Baron of Ballymote, in the peerage of Ireland] (1833–1895), Austrian statesman, was born at Vienna on 24th February 1833. He was the second son of Count Ludwig Taaffe (1791–1855), a distinguished public man who was minister of justice in 1848 and president of the court of appeal. As a child Taaffe was one of the chosen companions of the young archduke, afterwards emperor, Francis Joseph. In 1852 he entered the public service; in 1867 he was Statthalter of Upper Austria, and the emperor offered him the post of minister of the interior in Beust's administration. In June he became vice-president of the ministry, and at the end of the year he entered the first ministry of the newly organized Austrian portion of the monarchy. For the next three years he took a very important part in the confused political changes, and probably more than any other politician represented the wishes of the emperor. He had entered the ministry as a German Liberal, but he soon took an intermediate position between the Liberal majority of the Berger ministry and the party which desired a federalistic amendment of the constitution and which was strongly supported at Court. From September 1868 to January 1870, after the retirement of Auersperg, he was president of the cabinet. In 1870 the Government broke up on the question of the revision of the constitution: Taaffe with Potocki and Berger wished to make some concessions to the Federalists; the Liberal majority wished to preserve undiminished the authority of the Reichsrath. The two parties presented memoranda to the emperor, each defending their view, and offering their resignation: after some hesitation the emperor accepted the policy of the majority, and Taaffe with his friends resigned. The Liberals, however, failed to carry on the Government, as the representatives of most of the territories refused to appear in the Reichsrath: they resigned, and in the month of April Potocki and Taaffe returned to office. The latter failed, however, in the attempt to come to some understanding with the Czechs, and in their turn had to make way for the Clerical and Federalist cabinet of Hohenwart. Taaffe now became Statthalter of Tirol, but once more on the breakdown of the Liberal Government in 1879 he was called to office. At first he attempted to carry on the Government without change of principles, but he soon found it necessary to come to an understanding with the Feudal and Federal parties, and he was responsible for the conduct of the negotiations which in the elections of this year gave a majority to the different groups of the National and Clerical opposition. In July he became minister president: at first he still continued to govern with the Liberals, but this was soon made impossible, and he was obliged to turn for support to the Conservatives. It was his great achievement that he persuaded the Czechs to abandon the policy of abstention and to take part in the Parliament. It was on the support of them, the Poles, and the Clericals that his majority depended. His avowed intention was to unite the nationalities of Austria: Germans and Slavs were, as he said, equally integral parts of Austria; neither must be oppressed; both must unite to form an Austrian Parliament. Notwithstanding the growing opposition of the German Liberals, who refused to accept the equality of the nationalities, he kept his position for thirteen years. Not a great creative statesman, he had singular capacity for managing men; a very poor orator, he had in private intercourse an urbanity and quickness of humour which showed his Irish ancestry. The history of his administration will be found in the article on AUSTRIA. Beneath an apparent cynicism and frivolity Taaffe hid a strong feeling of patriotism to his country and loyalty to the emperor. It was no small service to both that for so long, during very critical years in European history, he maintained harmony between the two parts of the monarchy and preserved constitutional government in Austria. The necessities of the parliamentary situation compelled him sometimes to go farther in meeting the demands of the Conservatives and Czechs than he would probably have wished, but he was essentially an opportunist: in no way a party man, he recognized that the Government must be carried on, and he cared little by the aid of what party the necessary majority was maintained. In 1893 he was defeated on a proposal for the revision of the franchise, and resigned. He retired into private life, and died two years later at his country residence, Ellerschau, in Bohemia, on 29th November 1895.

By the death of his elder brother Charles (1823–1873), a colonel in the Austrian army, Taaffe succeeded to the Austrian and Irish titles. He married in 1862 Countess Irma Tsaky, by whom he left four daughters and one son, Henry. The family history presents points of unusual interest. From the 13th century the Taaffes had been one of the leading families in the north of Ireland. In 1628 Sir John Taaffe was raised to the peerage as Baron Ballymote and Viscount Taaffe of Corven. He left fifteen children, of whom the eldest, Theobald, took a prominent part in the Civil War, accompanied Charles II. in exile, and on the Restoration was created earl of Carlingford. He was sent on missions to the duke of Lorraine and to the emperor, by which was established the connexion of his family with Hapsburg and Lorraine, which has continued to this day. His eldest son was killed in the Turkish wars. He was succeeded in the title by his second son Nicholas, who had served in the Spanish wars and was killed at the Boyne. The next brother Francis, the third earl, was one of the most celebrated men of his time: he was brought up at Olmütz, at the imperial court, and in the service of Duke Charles of Lorraine, whose most intimate friend he became. He rose to the highest rank in the Austrian army, having greatly distinguished himself at the siege of Vienna and in the other Turkish campaigns, and was a member of the Order of the Golden Fleece. He was sent on many important diplomatic missions, and at the end of his life was chancellor and chief minister to the duke of Lorraine. Notwithstanding the Jacobite connexions of his family, his title to the earldom of Carlingford was confirmed by William III., and the attainder and forfeiture of the estates incurred by his brother was repealed. This favour he owed to his position at the court of the emperor, William's most important ally. On his death the title and estates went to his nephew Theobald, whose father had fallen during the siege of Derry, and who himself had served with distinction in the Austrian army. On his death the title of earl of Carlingford became extinct; both the Austrian and Irish estates as well as the Irish viscountcy went to a cousin Nicholas (1677–1769). Like so many of his family, he was brought up in Lorraine and passed into the Austrian army; he fought in the Silesian war, rose to be field-marshal, and was made a count of the empire. His Irish estates were, however, claimed under the Act of 1703 by a Protestant heir: a lawsuit followed, which was ended by a compromise embodied in a private Act of Parliament, by which the estates were sold and one-third of the value given to him. With the money he acquired the castle of Ellerschau, in Bohemia; he had also inherited other property in the Austrian dominions. He was naturalized in Bohemia, and left on record that the reason for this step was that he did not wish his descendants to be exposed to the temptation of becoming Protestants so as to avoid the operation of the penal laws. His great-grandson was the father of the subject of this article. A Committee of Privileges of the House of Lords in 1860 recognized the right of the family to hold the Irish title.

See WURZBACH, *Biographisches Lexicon Oesterreichs. Memoirs of the Family of Taaffe.* Vienna, 1856. Privately printed.—Article in the *Contemporary Review*, 1893, by E. B. LANIN.

(J. W. HE.)

Taal, a town in the province of Batangas, Luzon, Philippine Islands, on the narrow neck of land which separates Bombon Lake from the Gulf of Balayan. It was formerly a beautiful town, noted for its fine houses and well-kept streets, but it was badly damaged by fire in 1900. It has a cool and very healthy climate. Extensive agricultural lands in its vicinity produce rice, Indian corn, pepper, cacao, and cotton, but the great coffee plantations which were formerly to be seen in its vicinity have been destroyed by an insect pest. Its inhabitants raise cattle and horses in considerable numbers. Taal is the only town in the Philippines where effective efforts have been made to exclude the Chinese. The hostility of the inhabitants towards them was such that none succeeded in establishing a residence there until the latter days of the revolution against the American Government. The language is Tagalog. Population, 33,000.

Tabasco, a state of Mexico, bounded on the N. by the Gulf of Mexico, on the E. by Campeche, on the S. by Chiapas, on the S.E. by Guatemala, and on the W. by Vera Cruz. Area, 10,075 square miles. Population, (1879), 104,747; (1900), 158,107. This state possesses the best hydrographic system of the republic. The climate is hot, the temperature ranging from about 62° to 80° F. The agricultural products are valued at about $8,000,000 (silver) a year. The leading products are cacao, sugar-cane, coffee, tobacco, maize, rice, fruits, rubber, pepper, vanilla, logwood, cedar, mahogany, dyewoods, and cabinet woods. There is little mineral wealth and no railways. The capital, San Juan Bautista, has

9604 inhabitants, and amongst the chief towns are Frontera, Balancan, Cardenas, Jalapa, Thapa, La Ermita, and Carrizal.

Tabor, the chief town of a government district in Bohemia, Austria, situated on an eminence between the Luschnitz, a tributary of the Moldau, and the Jordanteich, a small lake, 31 miles N.N.E. of Budweis. The town, which occupies the site of an ancient fortress of Kotnow, owes its origin to the Hussites, who constructed a fortified camp on the spot in 1420. It contains, both in its ancient buildings and in the municipal museum, numerous memorials of the Hussite period. The Late Gothic Rathhaus (1521) bears the city arms in a framework which includes statuettes of Ziska, Procopius, Huss, and Jerome of Prague, together with a group of Adamites. The Gothic Decanalkirche (1516) contains an interesting zinc baptismal font (1472), and on the ring is one of the stone tables at which the Taborites used to partake in the open air of the communion in both kinds. In the immediate vicinity is the ruined castle of Kotnow, and also a mineral spring and baths. The industries include the manufacture of cigars and tobacco in the State factory, and of mother-of-pearl buttons, cloth, cotton goods, machine embroidery, tanning, brewing, and the production of malt and corn-milling. It has also an important trade in corn. Population (1890), 8440; (1900), 10,692, all Czech; about 95 per cent. Catholic and 5 per cent. Jewish.

Tabríz, the capital of Azerbáïján, one of the five great provinces of Persia, situated at an elevation of 4420 feet in 38° 4′ N. and 46° 18′ E. In 1881 its population was estimated at 165,000, and is now said to be close upon 200,000.

The popular etymology of the name Tabríz, from *tab*=fever, *ríz*=pourer away (verb, *ríkhtan*=pour away, flow), hence "fever-destroying," is erroneous, and was invented in modern times. It is related that Zobeideh, the wife of Harún ar-Rashíd, founded the town in 791 after recovering there from fever, but the name Tabríz was known many centuries before her. In 1842 Hammer Purgstall correctly explained the name as meaning the "warm-flowing" (*tab*=warm, tepid) from some warm mineral springs in the neighbourhood, and compared it with the synonymous Teplitz in Bohemia. The name of Tiflis, in the Caucasus and the similar names of many places with warm mineral springs in Bohemia, Hungary, Moravia, &c., are etymologically identical. In old Armenian histories the name of Tabríz is Tavresh, which means the same.

Tabríz was for many years the emporium for the trade of Persia on the west, but since the opening of the railway through the Caucasus and greater facilities for transport on the Caspian, much of its trade with Russia has been diverted to Astara and Resht, while the insecurity on the Tabríz–Trebizond route since 1878 has diverted much commerce to the Baghdad road. During the years 1867–73 the average value of the exports and imports which passed through the Tabríz custom-house in a year was £593,800 and £1,226,660 (total value per annum £1,820,460); in the year 1877–78 (Russo-Turkish war) the value of the exports was only £270,900, and that of the imports £525,500 (total £796,400). The following table gives the exports and imports for later years:—

Year.	Exports.	Imports.	Total.
1893–94	£199,617	£411,541	£611,158
1894–95	162,808	350,339	513,147
1895–96	256,720	524,820	781,540
1896–97	227,530	648,920	876,450
1897–98	210,700	649,200	859,900
1898–99	219,930	682,330	902,260

There are reasons for believing that these values are considerably understated. For the year 1898–99 the writer obtained figures directly from the books kept by the custom-house official at Tabríz, and although, as this officer informed him, some important items had not been entered at all, the value of the exports and imports shown in the books exceeded that of the consular report by about 10 per cent. The figures in the books were: Exports, $59{,}975\frac{1}{2}$ bales or packages, value £227,492; imports, $101{,}748\frac{1}{2}$ bales, &c., value £766,394; total value of exports and imports 1898–99 £993,886; total of customs levied £30,846 (average $3\frac{1}{10}$ per cent.). British, Russian, French, Turkish, and Austrian consulates and a few European commercial firms are established at Tabríz, and the Imperial Bank of Persia has a branch there. (A. H.-S.)

Tacheometry, or rapid measuring, is the term given to a modern system of surveying by which the positions, both horizontal and vertical, of points on the earth's surface relatively to one another are determined without the necessity of chain or tape measurements and without the use of a separate levelling instrument. Until recent times, the usual instrumental method of determining the position of one point with respect to another was to centre a theodolite over one of the points and to read the horizontal angle to a pole at the other point from some zero of azimuth, such as the direction of a point already determined on a traverse line or some other known direction. The horizontal distance from one of the points to the other was measured directly by a chain or tape. These two measurements sufficed to locate one point with reference to the other on the plan, and the difference of height between the two was determined by a separate operation of levelling with a separate instrument. This method is fairly satisfactory when the ground is pretty clear of obstructions and not very precipitous, but it becomes extremely cumbrous when the ground is much covered with bush, or broken up by ravines—conditions which commonly have to be faced in new countries when it is desired to construct a railway or some other engineering work. Chain measurements are then both slow and liable to considerable error; the levelling, too, is carried on at great disadvantage in point of speed, though without serious loss of accuracy.

These difficulties led to the introduction of tacheometry, in which, instead of the pole formerly employed to mark a point, a staff similar to a level staff is used. This is marked with heights from the foot, and is graduated according to the requirements of the special form of tacheometer in use. The azimuth angle is determined as formerly. The horizontal distance is inferred either from the vertical angle included between two well-defined points on the staff and the known distance between them, or by readings of the staff indicated by two fixed wires in the diaphragm of the telescope. The difference of height is computed from the angle of depression or elevation of a fixed point on the staff and the horizontal distance already obtained. Thus all the measurements requisite to locate a point both vertically and horizontally with reference to the point where the tacheometer is centred are determined by an observer at the instrument without any assistance beyond that of a man to hold the staff. In this way a survey is effected in a rough country much more cheaply, more expeditiously, and more accurately than by the old method, and many points are included in the survey which would have been neglected formerly by reason of the extreme labour and difficulty of the measurements.

Subtense method.

The simplest system of tacheometry is that in which the instrument used is a theodolite without additions of any kind, and the horizontal and vertical distances are obtained from the angles of depression or elevation of two well-defined points on a staff at known heights from the foot, the staff being held vertically. In Fig. 1 let T be the telescope of a theodolite which is centred over the point C, and let AB be the staff, which is held truly vertical on the ground at A. Let

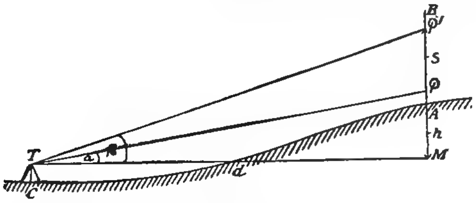

Fig. 1.

P and P′ be the two well-defined marks on the face of the staff, both of them at known heights above A, and enclosing a distance PP′$=s$ between them. Let (α) and (β) be the measured angles of elevation of P and P′, and let (d) be the horizontal distance TM of the staff from the theodolite, and (h) the height PM of P above T. Then

$$\mathrm{P'M}=d\,.\tan\beta \text{ and } \mathrm{PM}=d\tan\alpha,$$
$$\mathrm{S}=\mathrm{P'M}-\mathrm{PM}=d(\tan\beta-\tan\alpha).$$
$$\left.\begin{aligned}\therefore\ d&=\frac{s}{\tan\beta-\tan\alpha}\\ h&=\frac{s\,.\tan\alpha}{\tan\beta-\tan\alpha}\end{aligned}\right\}$$

If TC be the height of the rotation axis of the telescope above the ground, and TC$=q$, and if AP$=p$, then the height of A above C is $h-p+q$. If, as is usually the case, a number of points are determined from one station of the theodolite, and h_1, h_2, h_3, &c., be the values of (h) for the different points A_1, A_2, A_3, &c., then the difference of level of A_1 and A_2 will be h_2-h_1, that of A_1 and A_3 will be h_3-h_1, and so on. To ensure the essential condition that the staff is held vertical, it is usually provided with a small circular spirit-level, and the staff-holder must always keep the bubble in the centre of its run. No graduation of the staff is required beyond two well-defined black lines across the white face at P and P′, but the marks can be very usefully supplemented by wings fastened on the two sides of the staff, having their tops at right angles to the staff, at the same height as the points P and P′, and forming a continuation of the black lines. A convenient length for the staff is 12 feet, with the point P 2 feet from the foot, and the point P′ at the top of the staff, so that $s=10$ feet.

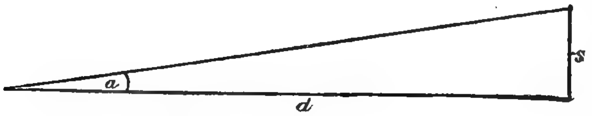

Fig. 2.

With the above arrangement the staff can easily be read with the telescope of a 5-inch theodolite at half a mile distance. But while it is frequently very useful to determine approximately points a long way off, the determinations will not be nearly so accurate as those of near points. Thus suppose that the distance of the staff is (d), and the intercept on the staff is (s), as in the annexed diagram (Fig. 2), and suppose that all the uncertainties of adjusting and reading, both personal and instrumental, amount to a small angle error ($\delta\alpha$) (α being the angle subtended by s at the telescope); then since

$$d=\frac{s}{\tan\alpha},\quad \frac{d(d)}{d\,\alpha}=-\frac{s}{\sin^2\alpha}=-s\,.\frac{1+\tan^2\alpha}{\tan^2\alpha},$$

or

$$\frac{d(d)}{d\alpha}=-s\cdot\frac{1+\dfrac{s^2}{d^2}}{\dfrac{s^2}{d^2}}=-\frac{1}{s}(s^2+d^2).$$

Therefore δd, the distance error, is given by the equation $\delta d=-\delta\alpha\,.\frac{1}{s}(s^2+d^2)$. But at distances of 5 chains or more (s^2) will be very small compared with (d^2) and may be neglected, so that $\delta d=-\delta\alpha\,.\frac{d^2}{s}$. And since $\delta\alpha$ may be considered as constant for all distances where the staff can be distinctly viewed and read, the distance error increases as the square of the distance, and will be four times as great at half a mile as at a quarter of a mile. With small theodolites, where special care has not been given to the graduating and reading of the vertical circle, $\delta\alpha$ will probably amount to about 20 seconds of arc. At a quarter of a mile excellent work can be done. In carrying on a traverse line by this method with stations 10 or 12 chains apart, the theodolite being set up at points about midway between the stations, the probable distance error in a mile is about 3½ feet, and the probable level error about 4 inches. In 25 miles these probable errors would correspond to about 18 feet and 20 inches respectively. This system of tacheometry is well adapted for distant readings, and from the great simplicity of the observations there is little likelihood of errors in the field. But the reduction work is rather heavier than is the case with some of the tacheometers to be described presently. Since the accuracy of the method depends entirely upon the accuracy with which the vertical angles are measured, it is advisable that the vertical circle should be as large as possible, very finely and accurately divided, and fitted with good verniers and microscopes.

In Eckhold's omnimeter, described in the 9th ed. of the *Ency. Brit.* (vol. xxii. p. 719), the vertical circle of the theodolite is dispensed with, and a saving of reduction work is effected by reading, not the vertical angles themselves, but the tangents of the angles.

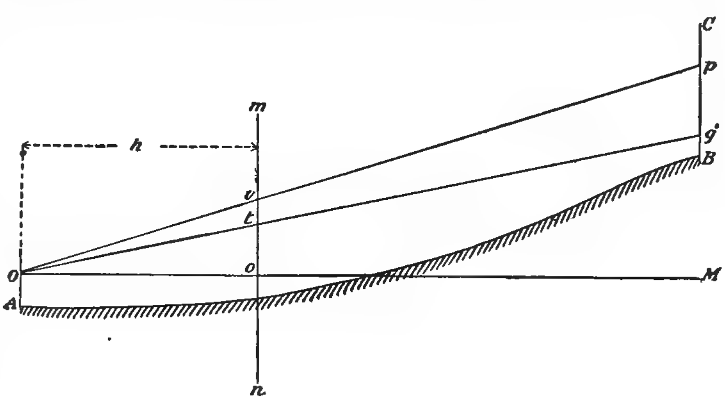

Fig. 3.

In the Ziegler-Hager tacheograph the tangents are read not horizontally but vertically, and the arrangement (which has been very carefully thought out) is as follows:—In Fig. 3 O is the axis of rotation of the telescope; mn is the axial line of a steel bolt, which carries on its top a knife-edge, on which the telescope rests by means of an agate plate. The bolt is carried by a slide in which it can be raised or lowered by a micrometer screw which is fitted with a graduated head. The slide plays between the vertical cheeks of a standard rigidly attached to the frame of the instrument, and it can be raised or lowered by a rack and pinion movement. The telescope, which rests on the knife-edge, follows the movement of the bolt. The slide carries on one side a vernier by which to read the divisions on a scale fixed to one of the vertical legs of the standard, and the zero point (o) of the scale is the point where the horizontal plane through O cuts the scale when the plane-table or upper plate of the theodolite is truly level. The scale is graduated in divisions, each of which is the $\frac{1}{100}$th part of the distance Oo, or (h). The head of the micrometer screw which raises or lowers the steel bolt in the slide is graduated with a zero mark and with marks corresponding to a vertical movement of the knife-edge of $\frac{h}{100}$, $\frac{h}{50}$, &c. The instrument is used as follows:—Let AB be the surface of the ground, and BC a staff held vertically at B, and let CB be produced to meet the horizontal line through O in M. Let the head of the micrometer screw be turned till the zero division is exactly under the pointer. Let (p) be the zero division on the staff, and let the slide and bolt be raised by the rack and pinion movement till the optical axis of the telescope is directed towards (p). Let (v) be the point where the line Op cuts $\overline{mn}$, and let the tangent reading $\overline{ov}$ be taken on the scale. Then let the telescope be lowered by the micrometer screw in the slide till the division on the head of the screw marked 1 is exactly under the pointer; the knife-edge of the bolt has then been lowered through a distance $\overline{vt}$ equal to $\frac{h}{100}$. Let (q) be the point on the staff where the line Ot cuts it, and let the reading at (q) be taken. Then since the triangles between O and $\overline{mn}$ and O and CM are similar to each other, and $\overline{vt}$ is $\frac{1}{100}$th of $\overline{\mathrm{O}o}$, therefore $\overline{pq}$ will be $\frac{1}{100}$th of OM, or OM$=100\times\overline{pq}$. This gives the horizontal distance of the staff from O, and the vertical distance pM of (p) above O is OM tan MOp=OM$\times\frac{\overline{ov}}{\mathrm{O}o}$, and since $\overline{ov}$ has been read in parts of which Oo contains 100, the distance pM is readily obtained. Suppose for example the staff is graduated in centimetres. Let the reading $\overline{ov}=26{\cdot}4$, so that tan MOp $=\frac{26{\cdot}4}{100}={\cdot}264$, and let the reading at (q) be 112·5, so that $\overline{pq}=112{\cdot}5$ centimetres. Then $OM=100\times112{\cdot}5=112{\cdot}5$ metres, and $pM=112{\cdot}5\times{\cdot}264=29{\cdot}7$ metres. If the difference of elevation of B and A be required, the height pM must be reduced by pB and increased by OA, both known quantities. By this arrangement the reduction work of the observations is rendered extremely simple, and can readily be performed in the field. The instrument is frequently used in connexion with the plane-table, for which purpose it is well adapted.

Stadia method.

Tacheometers in which the horizontal distance of the staff from the telescope is deduced from the readings of the staff indicated by two fixed wires in the diaphragm of the telescope will now be considered. In Fig. 4 BC is a diaphragm fixed in a tube having fine horizontal wires at B and C. Let the end E of the tube be closed by a disc which has a minute hole at E, to which the eye can be applied. If P and D be the points on a vertical staff at which the lines EB and EC are observed to cut the staff, so that the intercept PD is known, then from similar triangles $ED=\frac{EC}{BC}.PD$, and since EC and BC are constant, ED varies as PD. If for instance PD has a certain observed value when the staff is held at a certain distance ED, and has exactly half that value when the staff is held at another distance ED′, it would be at once inferred that the distance ED′ is one-half of the distance ED, and so on in proportion. The distance ED can be instantly inferred from the readings of the staff, if the latter be suitably graduated for the desired unit of measurement. If, for example, it be desired to know the distance ED in yards, and by construction the proportion $\frac{EC}{BC}=50$, then the intercept on the staff at 1 yard from E would be $\frac{1}{50}$th of a yard, or ·72 inch, the intercept at 2 yards from E would be 2 × ·72 inches, and so on. If therefore the staff be graduated with divisions of ·72 inch, and the intercept be 45 of such divisions, it would be inferred that the distance of the staff from E was 45 yards. The constant proportion $\frac{EC}{BC}$ can be easily checked by measuring 100 yards from E and observing whether the intercept is exactly 100 divisions or not. If it is not, the wire diaphragm must be shifted in the tube until it is. In Figs. 4, 5, 6, and 7 the distances are deduced from the readings of a central wire in the optical axis of the telescope and of a wire above it, for the sake of simplicity. The usual arrangement is to fit the diaphragm with a central wire and with one or two wires above and below it at equal distances from the central wire. The vertical angle of depression or elevation is fixed by directing the central wire to a well-defined division on the staff, and the distance of the staff is inferred from the readings given by the corresponding wires above and below the central wire.

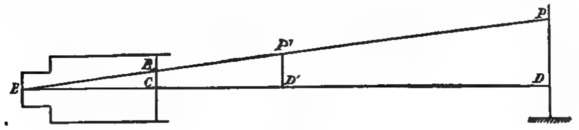

Fig. 4.

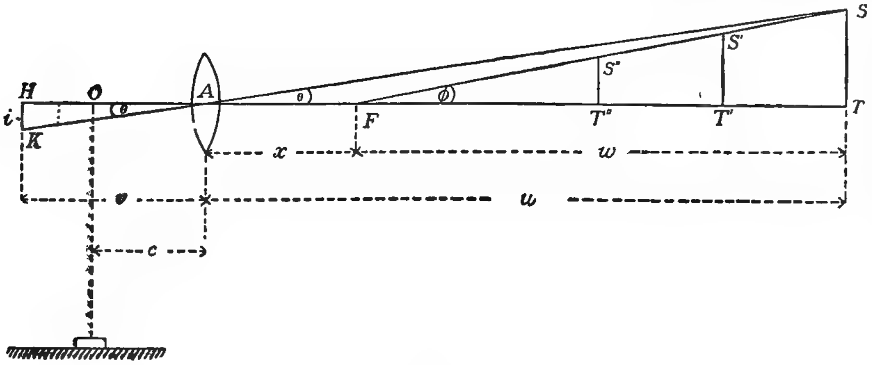

Fig. 5.

The foregoing elementary form of tacheometer has been given as illustrating the general principle of the class of tacheometers now under consideration, and as leading up to the practical form, in which the staff is viewed with a telescope mounted in the manner of a theodolite. The simplest form is that of Reichenbach's tacheometer, which may be investigated as follows:—In Fig. 5 let A be the object glass by which an image of the staff ST is formed at HK. The wire diaphragm is moved in the tube so as to coincide with the image, and the image and wires are viewed with an eye-piece (not shown) in the usual way. Let O be the point where the vertical axis of the instrument cuts the axis of the telescope, the instrument being centred over a peg, from which the distance to the staff is required. The object glass (of focal length $=f$) is at a distance (c) from O. Let $AT=u$ and $AH=v$, and the angle $SAT=HAK=\theta$. Then if (i) be the height of the image HK,

$$i=v\,.\,\tan\theta.$$

And $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$; whence $v=-\frac{uf}{u-f}$,

$$\therefore\ i=\frac{uf}{u-f}\cdot\tan\theta.$$

Let F be some point on AT such that $AF=x$ and $FT=u'$. And let the angle $SFT=\phi$. Then $u=u'+x$ and $\tan\theta=\frac{u'}{u'+x}\cdot\tan\phi$.

$$\therefore\ i=\frac{(u'+x)\,.\,f}{u'+x-f}\cdot\frac{u'}{u'+x}\cdot\tan\phi=\frac{f\,.\,u'}{u'+x-f}\cdot\tan\phi.$$

And, if $x=f$, $i=f\,.\,\tan\phi$.

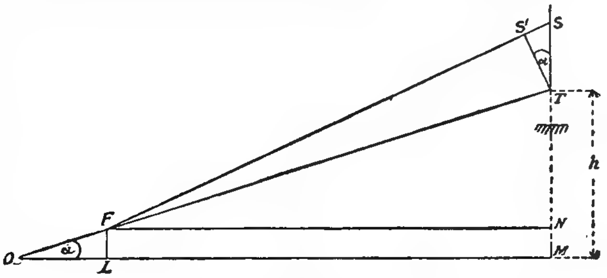

Fig. 6.

If therefore the point F be taken at a distance (f) from the object glass, every intercept of the staff for positions between T and F, such as S′T′, S″T″, &c., which are bounded by the line FS, and for which consequently (ϕ) is the same, will have the same height of image (i) at the diaphragm. Conversely, if K be a wire in the diaphragm it will cut the image of the staff for all positions of the staff between T and F in points that lie on the line FS. Now the intercept S″T″, half-way between F and T, will be one-half of ST, and therefore if the reading on the staff indicated by the wire in question be one-half of ST, it may be inferred that the position of the staff is half-way between F and T, and similarly for other distances. If the distance of ST from O is required, as is usually the case, a quantity $f+c$ must be added to every distance from F determined as above. It is of course very seldom that the line of sight AT of the telescope is at right angles to the staff. In general it is more or less inclined to the staff, which is almost always held vertical, and the horizontal and vertical distances of the staff from the axis of rotation of the telescope are found thus:—In Fig. 6 let ST be the observed intercept on the staff when the telescope is inclined at an angle (α) to the horizontal. Draw TS′ at right angles to OT. The angle TS′S will be very nearly a right angle, and STS′ may be taken as equal to (α). If there were (n) graduations (each corresponding to 1 yard in distance) in ST, there would be $n\,.\,\cos\alpha$ graduations in S′T, and therefore the distance of the staff from F, as inferred from the observed number of graduations in ST, must be multiplied by $\cos\alpha$ to give the true distance FT. Again $FN=FT\,.\cos\alpha$, so that the distance inferred from the observed number of graduations in ST must be multiplied by $\cos^2 \alpha$ to give the horizontal distance of F from T. To this must be added the distance $OL = OF \cos \alpha = (f+c) \cos \alpha$ to get the horizontal distance, OM, of O (the vertical axis of the instrument) from T. This value of OM must be multiplied by $\tan \alpha$ to obtain the value of (h) the vertical distance of T from O. Tables of the value of $\cos \alpha$, $\cos^2 \alpha$, and $\tan \alpha$ are necessary to facilitate these calculations.

The trouble caused by the fact that in the tacheometer last described the distances as inferred from the readings of the staff are the distances of the staff from F and not from O rendered it desirable to improve the instrument in this respect. This was done by M. Porro, who added a lens (called the anallattic lens) to the telescope, which has the desired effect. The arrangement of the telescope, as manufactured by Messrs Troughton and Simms, is as follows:—In Fig. 7 O is the point where the vertical axis of the instrument cuts the axis of the telescope. The object glass is fixed at a distance (c) from O, and the anallattic lens at a distance (d) from the object glass. The distances (c) and (d) are chosen to suit the constructive conveniences of the instrument. The diaphragm at K is movable so that it can be made to coincide with the image of the staff. The focal length (f_1) of the object glass is fixed arbitrarily, and the focal length (f_2) of the anallattic lens is determined from an equation of condition between c, d, f_1, and f_2, as will be seen presently. The image of the staff ST would be formed by the object glass at H, at a distance (v_1) from the object glass, were it not that the rays, after passing through the object glass, are received by the anallattic lens and the image of the staff is formed at K on the wire diaphragm, which is slid in the tube till it coincides with the position of the image. The image at K is viewed by an eye-piece in the usual way. Let T be the point where the image of the staff is cut by the central wire of the diaphragm, and S the point where the image is cut by one of the outer wires of the diaphragm. If (θ) and (ϕ) be the angles subtended by ST at the object glass and at the point O respectively, and if (i) be the height of the image at K, and (h) the height of the virtual image at H, then

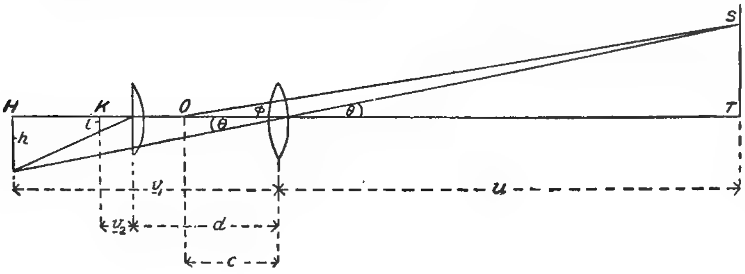

Fig. 7.

$$\frac{i}{h} = \frac{v_2}{v_1 - d}; \therefore i = \frac{v_2 \cdot h}{v_1 - d} = \frac{v_2 v_1}{v_1 - d} \cdot \tan \theta.$$

Again from optical considerations:

$$-\frac{1}{v_1} + \frac{1}{u} = \frac{1}{f_1}; \therefore -\frac{1}{v_1} = \frac{u - f_1}{u f_1}; v_1 = -\frac{u f_1}{u - f_1},$$

$$-\frac{1}{v_2} - \frac{1}{v_1 - d} = \frac{1}{f_2}; \therefore -\frac{1}{v_2} = \frac{v_1 - d + f_2}{f_2(v_1 - d)}; v_2 = -\frac{f_2(v_1 - d)}{v_1 - d + f_2}$$

$$\therefore i = \frac{u f_1}{u - f_1} \cdot \frac{f_2(v_1 - d)}{v_1 - d + f_2} \cdot \frac{1}{v_1 - d} \cdot \tan \theta = \frac{u f_1 f_2}{(u - f_1)(v_1 - d + f_2)} \cdot \tan \theta.$$

But $v_1 - d + f_2 = \frac{u f_1}{u - f_1} - d + f_2 = \frac{u f_1 - (d - f_2)(u - f_1)}{u - f_1}$

$$\therefore i = \frac{u f_1 f_2}{u f_1 - (d - f_2)(u - f_1)} \cdot \tan \theta.$$

Let $OT = u'$. Then $u' = u + c$, and $u = u' - c$. And $u' \tan \phi = (u' - c) \tan \theta$, and $\tan \theta = \frac{u'}{u' - c} \cdot \tan \phi$

$$\therefore i = \frac{(u' - c) f_1 f_2}{(u' - c) f_1 - (d - f_2)(u' - c - f_1)} \cdot \frac{u'}{u' - c} \cdot \tan \phi$$

$$= \frac{u' f_1 f_2}{u'(f_1 - d + f_2) - \{c f_1 - (c + f_1)(d - f_2)\}} \cdot \tan \phi$$

Let (f_2) be made such that $c f_1 - (c + f_1)(d - f_2) = 0$. Then

$$d - f_2 = \frac{c f_1}{c + f_1}, \text{ and } f_2 = \frac{d(c + f_1) - c f_1}{c + f_1}$$

And $i = \frac{f_1 f_2}{f_1 - d + f_2} \cdot \tan \phi = \frac{d(c + f_1) - c f_1}{f_1} \cdot \tan \phi.$

Therefore all the readings of the staff which would be given by the outer wire of the diaphragm will lie on the line OS (for all of which (ϕ) is the same), and the distance from O along OT will be proportional to the reading on the staff. Thus if the staff be suitably graduated, the distance from O can be immediately deduced from the reading. Also, as before, if the telescope be inclined at an angle (α) to the horizontal, the distance OT inferred from the number of graduations in ST must be multiplied by $\cos^2 \alpha$ to give the horizontal distance of O from T, and the horizontal distance so obtained must be multiplied by $\tan \alpha$ to obtain the vertical distance of T from O.

The inconvenience of the reduction work necessary to obtain the horizontal and vertical distances produced the Wagner-Feunel tacheometer, by which the distances can be read directly from the instrument. As is seen from Fig. 8, three scales are provided to measure the inclined distance, the horizontal distance, and the vertical distance respectively. All three are arranged in a plane parallel to the plane in which the telescope turns. The inclined scale is attached to the telescope exactly parallel to its line of collimation, and moves with it. The horizontal scale is fixed to the upper horizontal plate of the theodolite. The vertical scale is on the vertical edge of a right-angled triangle, which can be slid along on the top of the horizontal scale. The inclined scale carries a slide which is provided with two verniers. One of these is parallel to the inclined scale, and is for the purpose of setting-off on the scale (in terms of the divisions on the scale) the inclined distance of the staff from the axis of rotation of the telescope. The other turns on a pivot whose centre is accurately in the edge of the inclined scale at the point where the zero division of the inclined vernier cuts the edge, and is for the purpose of reading the vertical scale; it can be turned on its pivot so as to be vertical whatever may be the inclination of the telescope. Moreover, since the distance from the centre of the pivot to the zero of the vernier is always constant and known, the vertical scale can be graduated so that the reading of the vernier gives the height (in terms of the division on the scale) of the staff above the axis of rotation of the telescope. The horizontal scale attached to the horizontal plate of the theodolite is read by means of a vernier carried by the triangle. To ascertain the horizontal and vertical distances of the point on the staff which is cut by the middle wire in the diaphragm of the telescope from the rotation axis of the telescope, the inclined distance of the point on the staff is read by means of the wires, as in Porro's tacheometer. This distance (in terms of the divisions) is then set off on the inclined scale by means of the inclined vernier, and the vertical scale on the triangle is moved up to the vertical vernier, which is adjusted to its edge. With proper graduation of the horizontal and vertical scales the horizontal and vertical distances can be at once read off on the scales. This method, however, requires that the staff be held so that its face is perpendicular to the line of sight, which is more troublesome than holding the staff vertical.

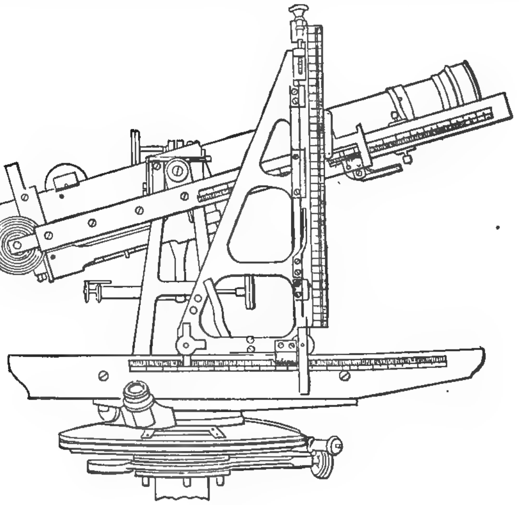

Fig. 8.

Photographic surveying is used in Canada and elsewhere for filling in details after a number of points have been determined trigonometrically. To do this a special camera is used which is provided with a telescope for sighting, as shown in Fig. 9. The camera being centred over one of the given points and set truly horizontal, photographs of the country are taken in different directions, which are defined by the azimuth angles from the direction of another of the given points. The camera is then removed to another of the given points, and a set of photographs is obtained as before. All the salient points which are common to both stations are sought out and marked on the photographs. The locating of these common points on the plan is done in the office. The azimuth angles of the salient points right or left of the vertical centre line on a photograph from the centre of the lens will be the same as the azimuth angles of the points themselves on the ground from the centre of the lens. Therefore to plot the directions of the salient points on the plan, a line is drawn from the station point in the exact direction in which the camera faced when one of the photographs was taken. Then the photograph is placed on edge at right angles to the lines so drawn at a distance from the station point equal to the known distance of the centre of the lens from the photograph at the time when it was taken. The directions of the salient points on the plan will be the azimuthal directions of the same points on the photograph, and lines can be drawn on the plan accordingly. In practice the distances of the salient points right and left of the centre line on the photograph are copied on the edge of a slip of paper which is placed flat on the plan in the position of the photograph, and is used instead of it to facilitate the drawing of the lines. In the same manner the direction lines of the same salient points (or as many of them as can be recognized) are plotted from a photograph taken from another of the station points. The intersections of these lines give the positions on plan of the salient points. Some information regarding the contour of the ground can also be obtained by noting where the horizon lines on the different photographs cut the hill slopes, &c. This method of surveying has the advantage that it does not require continuously fine weather to the same extent as surveying by the plane-table.

Photographic surveying.

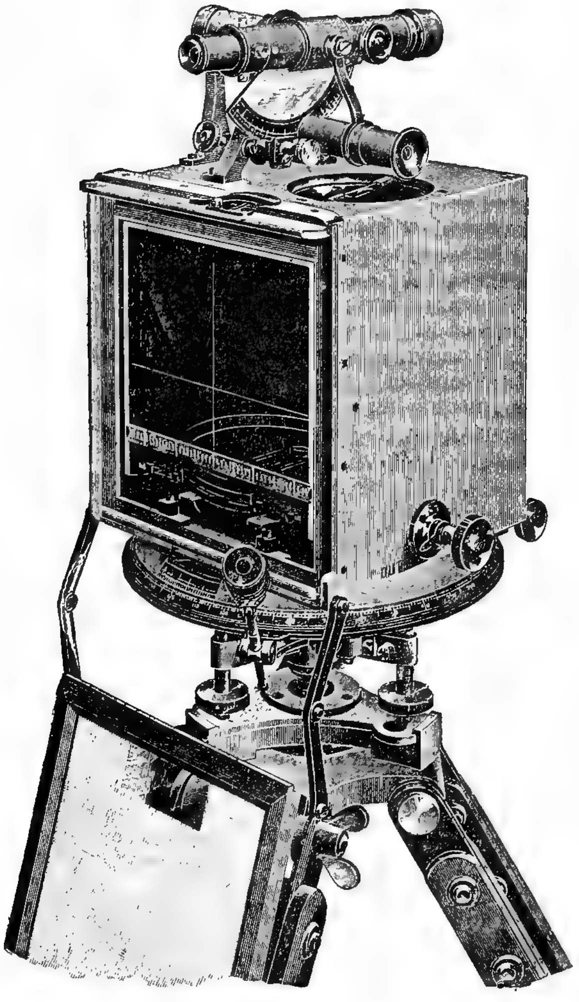

Fig. 9.

All the instruments that have been described have advantages peculiar to each, and, speaking generally, one is preferable to another only in consideration of the circumstances in which it is to be employed. The advantage of a light instrument over a heavy one is very great in the field, and tacheometers that depend upon the accurate reading of divisions on a staff require a larger telescope and a heavier construction than those in which the observation merely consists in bisecting a broad and well-defined mark on the face of a staff. It must be remembered too that the reduction work of the observations, if it is mainly effected, as in some of the tacheometers, by ingenious mechanical contrivances attached to the instrument, introduces delicate parts and delicate adjustments which require special care.

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(W. AY.)

Tachien-lu. See TIBET.

Tacna, or SAN PEDRO DE TACNA, a town of Chile, capital of the province and department of the same name. Population (1895), 9418. By the treaty of peace of 20th October 1883 with Peru, Chile came into possession of the territories of Tacna and Arica for a term of years, after which a plébiscite was to decide the final ownership of the country. In 1902 this had not yet been done (see CHILE, PERU). The Chilian Government by the law of 31st October 1884 organized the country temporarily as a province. Tacna is in communication with Arica by a railway. The province has an area of 8688 square miles, and population (1900), 25,031.

Tacoma, a city and seaport of Washington, U.S.A., capital of Pierce county, on Commencement Bay, at the head of Puget Sound, in the western part of the state. The business part of the city is situated on the steep face of bluffs rising some 200 feet from the water, while the residence part spreads over the rolling summit. It is regularly laid out, with broad streets, which are paved in the business quarter. It is divided into eight wards, has ample water-supply, and is well sewered. Among its fine buildings are the court house, city hall, chamber of commerce, Tacoma Hotel, and many business blocks. Tacoma is the principal western terminus of the Northern Pacific Railway, whence branches run to Seattle and Portland, and with its excellent harbour it is probably the chief commercial port on Puget Sound, excelling Seattle in foreign trade. Its exports consist in great part of wheat, flour, and lumber, and its imports, which are inconsiderable, of tea from China and Japan. In 1900 it contained 381 manufacturing establishments, with a total capital of $8,146,691. They employed 4347 hands, and the product was valued at $12,029,497. Of this $2,721,006 was the value of lumber manufactures, which was the largest item. It is the site of Puget Sound University, a Methodist Episcopal institution, opened in 1890. The assessed valuation of real and personal property was in 1900 $20,023,955, the net debt was $4,340,096, and the rate of taxation was $29 per $1000. Tacoma was laid out in 1863. In 1873 it was adopted as the terminus of the Northern Pacific railway. In 1880 it had a population of 720, but upon the completion of this railway a boom commenced, which increased the population to 36,006 in 1890; since which time the city has made but little growth, having in 1900 37,714 inhabitants, of whom 11,032 were foreign-born and 1244 coloured, including 307 negroes.

TACTICS.

I. Artillery.

Objects.

THE objects of artillery are primarily to commence an action by firing on the enemy at long ranges before the infantry comes into play, to break down and subdue the fire of the enemy's artillery by concentrating on it the largest number of guns available as early as possible, so as to prepare the way for the infantry attack, and then to support the latter by firing upon the enemy's infantry. To attain these objects, massing the guns in position as soon as the enemy comes within range is the principal aim of artillery tactics. The enemy will of course endeavour to do the same thing so that it must be sought to establish a superiority of guns from the earliest moment. To enable artillery to be thus employed it should march as closely as possible to the heads of the columns of troops and on the best roads, care being taken that there is always a sufficient force in front to protect it from attacks. When on the march, artillery will be protected by the troops marching with it, but the officer commanding should always employ his own scouts to ascertain that the front and flanks are clear of the enemy. Artillery while on the march is helpless, and at the mercy of even small bodies of cavalry and infantry. In addition to these scouts, it is most desirable to send out a specially selected officer with some non-commissioned officers or gunners to reconnoitre the ground. This officer and his party will march with the leading portion of the advanced guard. They should reconnoitre the ground so as to be able to select an artillery position as soon as the march of the advanced guard is checked and it has been decided to accept battle or to await the enemy's attack. The artillery commander, when he comes up, ought thus to have all information regarding the position and the objective.

Tactical unit.

In a European theatre of war the great range and accuracy of modern guns render the combined action of a group of batteries far more effective than was formerly the case, and this tends to increase the size of the tactical unit. Whereas formerly this tactical unit was the battery, now the brigade division, consisting of two batteries in the horse and three in the field artillery, under the command of a lieutenant-colonel, is the tactical unit in peace and in war; and this unit should as far as possible be always kept together in quarters and cantonments, on the march and on the battlefield. It will, however, nearly always be necessary, except in very open ground, for the batteries of a brigade division to move into position independently after the lieutenant-colonel has pointed out to the battery commander the position selected. The advance into action should, when possible, be continuous and simultaneous after the position and the objective have been decided on. The general officer commanding the army decides upon the plan of action, and therefore broadly on the position for the artillery. The choice of the actual position depends principally on tactical considerations, but there are also many technical objects to be regarded, such as a position difficult for the enemy to range on, no woods or folds in the ground either in the front or on the flanks, which would conceal an enemy and enable him to creep up unperceived There should also be cover for the waggons, limbers, and spare horses within a convenient distance of say not more than 400 yards in rear, and natural cover for the guns is also an obvious advantage. An ideal position should have command over the surrounding country and a clear view of all possible lines of advance of the enemy. There should be a gentle slope to the rear so as to allow of the guns being placed as far as possible out of sight, or entirely withdrawn under cover, in case they be temporarily overpowered by those of the enemy. There should be no obstacles to advance or retirement. The flanks should rest on natural obstacles such as a lake or river. The position for his guns having been selected by the artillery commander, the lieutenant-colonel fixes on the exact spot for his brigade division, which he either brings up himself or directs his adjutant to bring up from the "covered" or "rendezvous" position in which it has been waiting and preparing for an immediate advance into action. From this point the advance into action should be made continuously, and at as rapid a pace as is consistent with steadiness and the nature of the ground.

Choice of position.

Advance into position.

It may, however, sometimes be desirable to bring up the guns under cover by means of the horses, then unlimbering them and running them up by the gunners into the exact position selected for them. In the early phases of a battle, especially on the defensive, when time is available and the ground favourable, every possible means of concealing the guns and deceiving the enemy should be adopted. This deliberate or "creeping" method, as it has been called, is then suitable. But subsequently, when it is necessary to move in, to the support of infantry or to subdue the enemy's guns, the direct or "continuous" method is the only one by which to come into action. It is in the majority of cases the best method, and it is certainly the most in consonance with the traditions of the British artillery. When once the guns are in action they should so remain until it is necessary for them, through being marked or being unable to see the target, to take up a new position. Unless in imminent danger of being lost, guns in action should not be withdrawn without the consent of the officer commanding the force, as the retirement of guns has a bad effect on the *morale* of other troops.

As soon as a fresh advance becomes desirable, the commanding officer must ride rapidly forward and select another position which may possibly have been partially reconnoitred already. Before the brigade division moves, however, the new position and its approaches must be thoroughly scouted, and this duty should on no account be entrusted to the cavalry or infantry escort alone, but must be carried out by trained artillery scouts, or preferably by an officer. When a second position is taken up, the objective will usually be the enemy's attacking infantry, but the artillery commander must be prepared at any moment to renew the artillery duel and to maintain his superiority. He will, as soon as the enemy's artillery fire is subdued, turn his attention again to their infantry and cavalry. Should a counter attack be ordered, the artillery will usually advance with the force detailed for the purpose, giving it moral and physical support, and not shunning the closest ranges.

The war in South Africa has shown that in open country artillery cannot now approach within 2000 yards of unbroken infantry, which is not engaged with other troops, without suffering very severely in men and horses. During the decisive phase of a battle, however, the effective zone of infantry fire cannot be shirked, and regardless of risk and losses, artillery must go into close range and support the other arms up to the moment when success is practically assured. If, however, a retirement becomes necessary, and the army is driven back, the rôle of artillery becomes most important, but at the same time difficult and dangerous.

Retirements.

The general principle of the employment of artillery in retreat is to take up successive positions and delay the advance of the pursuing troops. In the case where the artillery finds an exceptionally strong position with the flanks secure from a turning movement, the rearguard need not confine itself to merely showing fight, but may resist an attack to the utmost of its ability. The artillery commander should, however, remember that the army is constantly retiring, and he should see that his guns do not remain in action so long as to endanger their capture.

Horse artillery with cavalry will often be employed to cover the retreat of a beaten army, and their mobility points them out as specially adapted for this duty. The action of a rearguard is one of the most difficult operations of war, especially when covering the retreat of a beaten army. The artillery of a rearguard should be very active, and have a large supply of ammunition. An advanced guard fights under favourable moral conditions, knowing that it can constantly expect reinforcements; orders need not be waited for, and risks may be freely incurred. A rearguard, on the other hand, knows that every moment the main body is marching away from it, that no reinforcements can come up, and that if it remains too long in position it is likely to be overwhelmed and its flanks turned. Cavalry and horse artillery are equally useful in the pursuit of a beaten enemy.

Artillery is seldom employed in the front line of outposts, except when a defile or important approach has to be defended, or when the front line of outposts is on the line of resistance. Its place will generally be with the reserve of outposts, and special precautions should be taken to guard against guns on outpost duty being suddenly rushed. If the outposts are intended to retire and not to hold their ground, any guns should be withdrawn before they are exposed to infantry fire. To extricate them might otherwise embarrass the action of the main force.

Wars with savages and with partly disciplined troops differ very much from each other and from campaigns in Europe; it is therefore necessary to adapt our equipment and our tactics to the customs of the enemy, and to the nature of the country in which operations are being carried on. If scouting and reconnaissance are necessary in presence of a European enemy, they are even more important, as was learnt by bitter experience, when dealing with the crafty hill-tribes of India and the rapidly-moving and artful Boers. The importance of taking proper precautions against surprise is obvious, and yet instances occur in almost every campaign of culpable neglect of this essential military requirement. As artillery is at the mercy of a sudden rush of savages or mounted irregular troops while on the march, it should never move until its intended route has been thoroughly reconnoitred.

Savage warfare.

The war in South Africa has demonstrated that forces acting on the defensive in a friendly country, and having a line of railway communicating with their base, can employ in the field much heavier guns than had been contemplated. The conditions of this war were, however, somewhat exceptional, and it is doubtful whether these long high-velocity guns with flat trajectory are so generally effective as the lighter howitzers which fire a heavier shell with a high explosive at larger angles of elevation. Most Powers have decided that a few howitzer batteries should always accompany their armies in the field. The British 5-inch howitzer, throwing a 50-℔ shell filled with lyddite, seems well adapted to dislodge troops from natural or artificial cover or villages, &c. (A. H. C. P.)

Use of heavy guns in the field.

II. CAVALRY.

In what manner the cavalry of the 20th century will differ from the hussars and cuirassiers of the 19th is undoubtedly, from a military point of view, one of the most interesting and most momentous questions of the day. Of the three arms, cavalry has undergone the least change since the introduction of gunpowder. The load upon the horse has been gradually lightened, but defensive armour has not yet been altogether discarded; and although the carbine and revolver have been added to the equipment of the trooper, there are armies in which weight, of both man and horse, is reckoned a more important attribute than either marksmanship or activity. Shock-tactics, the charge, and the hand-to-hand encounter are still the one ideal of cavalry action; and the power of manœuvring in great masses, maintaining an absolute uniformity of pace and formation, and moving at the highest speed with accurately dressed ranks, is the criterion of excellence. To such an extent has this teaching been carried that the efficiency of the individual, especially in those duties which are carried out by single men or by small parties, cannot fairly be said to have received due attention. When cavalry held the pride of place upon the battlefield, as in feudal times and even later, the mastery of both horse and weapons by the individual officer and trooper was the predominant factor. In the English Civil War, for instance, the horsemanship and skill at fence of both Cavalier and Roundhead were remarkable; and their encounters were far more hotly contested and much more bloody than any which have since been seen. That the Parliamentarians, after the first year or so of the war, were generally successful, is to be ascribed to Cromwell's introduction of a severer discipline in the ranks of the Ironsides, no less than to his admirable leading. His troopers were taught the value of co-operation; and the means of ensuring co-operation, *i.e.*, uniformity of pace and precision of movement when in mass, were constantly practised upon the training-grounds. Nor are we to suppose that Cromwell was blind to a further advantage derived from the capacity for manœuvring at speed. He had seen too much of cavalry fighting, at the time he first took over the command and training of a considerable force, not to understand the great moral effect of large bodies of horsemen, wheeling and forming with mechanical smoothness, covering the ground at a speed that almost made each attack a surprise, and charging in lines whose unbroken front produced a most powerful impression of solidity and

History.

resolution. He saw, as Rupert never saw, that the power of swift movement in mass conferred upon the troops possessing it the enormous advantage of tactical mobility; and the readiness with which his regiments and brigades were transferred from one quarter of the battlefield to the other, throwing in their whole weight, time after time, at the point where their presence was decisive, in contradistinction to the reckless and ill-managed onsets of the Royalists, which ended, as a rule, in a confusion which it took hours to abate, show that he had fully realized the practical value of steady and continuous drill. It is to be noted, however, that Cromwell built up his cavalry on a foundation of high individual efficiency.

As time went on and armies became larger, and skill at arms, as a national characteristic, rarer, drill, discipline, manœuvres in mass, and a high degree of mobility came to outweigh all other considerations; and when the necessity of arming the nations brought about short service, the training of the individual, in any other branch of his business than that of riding boot to boot and of rendering instant obedience to the word or signal of his superior, fell more and more into abeyance. Shock-tactics filled the entire bill, and the cavalry of Europe, admirably trained to manœuvre and to attack, whether by the squadron of 150 sabres or the division of 3000 or 4000, was practically unfitted for any other duty. The climax of incompetency may be said to have been reached during that cycle of European warfare which began with the Crimea and ended with the Russo-Turkish conflict of 1877–78. The old spirit of dash and daring under fire was still conspicuous. Discipline and mobility were never higher. The regiments manœuvred with admirable precision at the highest speed, and never had great masses of horsemen been more easily controlled. And yet, in the whole history of war, it may be doubted whether the record of the cavalry was ever more meagre. It is true that in the course of the campaign of 1870–71 the German cavalry learned something of scouting, and that, owing to the utter supineness of the enemy, it obtained a large amount of valuable information. But its failures in this respect, especially at the outset, were very many; and it is not too much to say that, so far as peace training is concerned, it was little, if at all, superior to the cavalry of any other European Power. Moreover, when called upon to act dismounted, and to meet the enemy with fire instead of with *l'arme blanche*, it proved absolutely useless. The carbine was a popgun; the troopers knew nothing whatever of fighting on foot; their movements were impeded by their equipment; and a few francs-tireurs, armed with the chassepôt, were enough to paralyse a whole brigade. That the cavalry so far screened the march of the armies in the rear that the French could obtain no information of the various movements is not to be gainsaid; but the efforts of the French to pierce the screen were feeble in the extreme, and there is no proof whatever that against a more active adversary the same result would have been achieved. In fact, to the student who follows out the operations of the cavalry of 1870–71 step by step, and who bears in mind its deficiencies in armament and training, it will appear very doubtful whether a strong body of mounted riflemen, of the same type as the Boers, or, better still, as Sheridan's or Stuart's cavalry in the last years of the War of Secession, would not have held the German horsemen at bay from the first moment they crossed the frontier.

Shock-tactics.

Had the successes gained by shock-tactics been very numerous, it might possibly be argued that the sacrifice of efficiency in detached and dismounted duties, as well as the training of the individual, was fully justified. But what are the facts? The successes gained by shock-tactics, where anything larger than a regiment was engaged, are confined to the following:—

1. The victory of the British Heavy Brigade at Balaklava.
2. The charges of some twenty squadrons at Custozza, manœuvring by brigades, which checked and partially routed three divisions of most indifferent infantry.
3. The charges of the Austrian cavalry at Königgrätz, which drove back the Prussian horse and enabled Benedek's defeated troops to get away in safety.
4. The charge of six squadrons at Mars-la-Tour, which went through a French army corps, largely composed of recruits.
5. The defeat of 2500 French horsemen, also at Mars-la-Tour, by about the same number of Germans.
6. The charge of the 11th and 17th German Hussars, near Vionville, against retreating infantry.
7. The charge of the German Brigade at Loigny-Poupry, when a small brigade charged down on the flank of a large body of half-trained French infantry and put them out of action for about three-quarters of an hour.

Such is the record: one great tactical success gained at Custozza; a retreating army saved from annihilation at Königgrätz; and five minor successes, which may or may not have influenced the ultimate issue; not one single instance of an effective and sustained pursuit; not one single instance, except Custozza, and there the infantry was armed with muzzle-loaders, of a charge decisive of the battle; not one single instance of infantry being scattered and cut down in panic flight; not one single instance of a force larger than a brigade intervening at a critical moment. And how many the failures! How often did the cavalry dash vainly in reckless gallantry against the hail of a thin line of rifles! How often were great masses held back inactive, without drawing a sabre or firing a shot, while the battle was decided by the infantry and the guns! How few the enterprises against the enemy's communications! How few men killed or disabled, even when cavalry met cavalry in the mêlée! Can it be said, in face of these facts, that the devotion to shock-tactics, the constant practice in massed movements, the discouragement of individualism, both in leaders and men, was repaid by results? Does it not rather appear that there was some factor present on the modern battlefield which prevented the cavalry, trained to a pitch hitherto unknown, from escaping the same harvest as the horsemen of previous eras? Was not the attempt to apply the same principles to the battle of the breech-loader and the rifled cannon, as had been applied successfully to the battles of the smoothbore, a mistake from beginning to end; and should not the cavalry, confronted by new and revolutionary conditions, have sought new means of giving full effect to the mobility which makes it formidable?

American new style.

The answer comes from across the Atlantic. It was as much the length of the War of Secession as native ingenuity which enabled the Americans to work out so many military problems to their logical conclusion. Their cavalry, in the beginning, was formed, so far as possible, on the European model. But before long it became a new type. It could manœuvre sufficiently well for all practical purposes. It was exceedingly mobile. It could charge home with the sabre or the revolver. In addition, it was so equipped that it could fight on foot as readily as in the saddle, and it was so armed and trained that when dismounted it was but little inferior to the infantry. Environment undoubtedly had much to do with its evolution. In the forests of the South there was seldom space for the manœuvres of a mass of horsemen, and obstacles were so numerous that a few men, armed with rifles, were generally able to beat back the charge of many squadrons. Nevertheless, the ground was not so cramped and difficult that shock-tactics were out of the question. Great cavalry combats, in which both sides rode at each other, were far more frequent than in any of the European campaigns referred to above; and the instances of cavalry charging infantry are so numerous as completely to disprove the common belief that the American horsemen were merely mounted infantry. The truth is that the Americans struck the true balance between shock and dismounted tactics. They were prepared for both, as the ground and the situation demanded; and, more than this, they used fire and *l'arme blanche* in the closest and most effective combination, against both cavalry and infantry. Due respect was paid to individualism. The veteran trooper, when in the last years of the war he attained the proficiency at which his great leaders had always aimed, was a good shot, a skilful skirmisher, a good horseman, and a useful swordsman. He could charge home, either mounted or dismounted. He had learned to scout, both in the saddle or on foot. His individualism was carefully cultivated; and if, for the purpose of manœuvring in large bodies, he was less well drilled than his European contemporary, as a fighting man, trained to all the exigencies of war, he was very much his superior. So brilliant were the achievements of the cavalry, Federal and Confederate, that in the minds of military students they have tended, in a certain measure, to obscure the work of the other arms. Space forbids an enumeration of even its most considerable successes. But it may be said that there is no finer instance of a pursuit than that of Lee's army by Sheridan in 1865; none of a screen impenetrable, even by a vigorous enemy, than that formed by Stuart in 1863–64; none of a well-contested cavalry battle than that near Brandy Station, 9th June 1863; none of cavalry on the defensive than the resistance of the Confederate horsemen before Spottsylvania on 8th May 1864, or of the Federals near Hawes' Shop, six weeks later; none of effective intervention on the field of battle than Sheridan's handling of his divisions, an incident most unaccountably overlooked by European tacticians, when Early's army was broken into fragments, principally by the vigour of the cavalry, in the valley of the Shenandoah.

Nor are these all. Continental writers have persistently decried the value of the so-called raids, in which whole divisions of cavalry rode boldly round the hostile army, crossing his communications, and spreading panic and embarrassment far and wide; and doubtless, in several instances, the results were hardly worth the risks involved. But many of these enterprises were much more than forays or reconnaissances. Large bodies of cavalry, accompanied by horse artillery, and stripped of everything which would impede their mobility, operated for weeks, and even months, as detached forces, with specific strategical missions, and the value of their work cannot be overrated. "The secret of war," said Napoleon, "lies in the communications." The profound wisdom of this remark has never been more forcibly illustrated than in the great American conflict. The lines of supply and of retreat were the first pre-occupation of every leader of an army; their importance is continually impressed on even the casual student of the several campaigns; and they appear to have played a far more prominent part than is usually the case. To a certain extent the character of the theatre of war was accountable; but the strategical use of a well-organized, well-trained, and well-led cavalry had even more to say to it. If the chief difficulty of the American generals was the maintenance of their communications, it was because these communications were attacked with a method and a persistence which had been hitherto unknown in warfare. The operations of Forrest, of Grainger, of Wilson, of Earl van Dorn, of Sheridan, and of Hampton are brilliant examples of the great strategical value of a cavalry which is perfectly independent of the foot soldier, and which at the same time is in the highest degree mobile. Those who have never had to deal with the communications of an army may be unable to realize the effect that may and has been produced by such a force; but no one with the least practical experience of the responsibilities which devolve upon a commander-in-chief will venture to abate one jot from the enormous strategical value assigned to it by American soldiers. It may, however, be unhesitatingly admitted that no cavalry of the 19th century, except the American, could have achieved the same results; and, as these results were far greater than those produced by any other cavalry since the advent of the breech-loader, it may be just as unhesitatingly declared that the horseman of the American war is the model of the efficient cavalryman.

The evolution of the American trooper is due, in the main, to new tactical conditions. In 1861 fire had already become the predominant factor in battle. In range and accuracy the rifle so far surpassed the musket that the infantry was more formidable than ever; and even small forces, unless taken at disadvantage, had very little to fear from a much larger number of cavalry armed with lance or sabre. In order, then, to avoid being brought to a standstill at every turn by a few riflemen, the cavalry leaders soon found it necessary that at least a portion of their command should be equipped with firearms. A trial was given to the carbine, but despite its handiness, it was soon discarded in favour of the long rifle; and it was not long before the whole of the cavalry, with the exception of those regiments which carried breech-loading carbines, were armed, in addition to the sabre, or to the sabre and the revolver, with the same weapon as the infantry. It may fairly be asked whether a European cavalry, in case of war, would not be compelled, and compelled with even greater force, to follow precisely the same course as the Americans of 1861–65, substituting the rifle for the carbine, and modifying its tactics to meet the conditions of modern battle?

Duties of cavalry.

Let us consider the duties which cavalry is called upon to perform. In the first place, it is required to cover the front and flanks of the army to which it is attached, securing it from surprises, and enabling it to carry out movements of concentration or other strategical manœuvres unobserved. In the second place, it is required to burst through the screen which covers the movements and manœuvres of the opposing army, and to obtain the information which is absolutely essential to the commander-in-chief. Its action is thus twofold, protecting and at the same time aggressive; but its immediate enemy being the same in both cases, the enemy's mounted troops, it is evident that a bold offensive, which succeeds in sweeping away the hostile squadrons, is the readiest means of accomplishing the double duty. Attack, therefore, would seem to be imposed upon the cavalry so long as the armies are manœuvring; and the collision of large masses of horsemen, both seeking the encounter, a necessary preliminary to the meeting of armies on a decisive field. Now, when two bodies of cavalry meet in conflict, shock-tactics and *l'arme blanche* are unquestionably the speediest, the traditional, and the most natural method of deciding the issue. Thus shock-tactics, until one or other of the opposing bodies has been reduced to impotency, have been generally assumed to be the usual method by which cavalry will seek to attain its object. This conclusion, however, will not stand the test of examination. In the first place, the action of the covering cavalry cannot be entirely aggressive. While the main body is moving to seek the enemy, there will be points, such as roads, bridges, fords, and the like, which, in the interests of the duty of protection, as well as to give the cavalry itself due freedom of manœuvre, will be economically and effectively held by riflemen. In the second place, fire, both before and during an encounter, has always been easily a most valuable auxiliary, as is proved by the existence of horse artillery. Thus in this phase also the presence of a body of riflemen, accompanied by machine-guns, will confer the greatest freedom of manœuvre on the force to which they belong, embarrassing the enemy, covering the line of retreat, and relieving the cavalry commander of all anxiety for the safety of his waggons and the security of his communication. In the third place, it is exceedingly improbable that in one quarter or other of the theatre of the cavalry operations the ground will not be of such a character as to favour dismounted tactics. It is evident therefore that cavalry, even when confronted only by mounted troops, cannot rely on shock-tactics only to achieve its object, and that the rifle is an absolutely indispensable auxiliary.

Arising out of these considerations two most important questions present themselves:—

(1) Are shock-tactics any longer possible against a force which is endowed with a high degree of fire-power?

(2) Should the fire-power which has been shown to be essential to the free and effective working of cavalry be supplied by the cavalry itself, or by highly mobile infantry?

A force endowed with a large degree of fire-power possesses the most formidable attribute of infantry, and not even the most vehement partisan of *l'arme blanche* denies that against infantry, unless surprised, shock-tactics have the very smallest chance of success. But troops who dismount to make use of their rifles have two great disadvantages to contend with. The led horses are a source of weakness, physical and moral. They form a most sensitive and most vulnerable point. It is not always easy to place them in security; and the fact that they constitute the sole means of retreat renders them a source of continual anxiety both to officer and man. The former is preoccupied with providing for the safe cover of a crowd of animals; the latter, fully realizing his helplessness and discomfort if deprived of his mount, is never quite happy when there is the slightest chance that they may become separated. In consequence there is always a tendency on the part of dismounted men to think more of getting safely into the saddle than of offering a protracted resistance; they are thus less stubborn in defence than infantry, and more inclined to give way when there is a danger of their being outflanked. Now, there can be no doubt, when led horses and a safe retreat are concerned, that shock-tactics, which are the essence of rapidity and surprise, are far more to be feared than the slower process of an attack on foot. It is beyond question, therefore, that in dealing with a dismounted force, whatever may be the degree of fire-power with which it is endowed, shock-tactics may play a most important part. The opportunities of effective outflanking or of surprise may possibly be few; but the very fact that the enemy has both the power and the will to seek out such opportunities and to charge home, is bound to hamper the movements and to affect the *moral* of any force of horsemen which depends on fire alone. Such a force, even if it could hold on to its position, would be unable, except under favourable conditions of ground, to make any forward progress, for directly it mounted it would be at the mercy of its antagonist, and it would thus be absolutely prevented from bursting through the hostile cavalry and of acquiring the information which it is its main object to obtain. In the valley of the Shenandoah, in 1864, the Confederate squadrons were armed only with rifles, while the Federals, under Sheridan, were trained both to fire and to charge. The result is significant. The Southerners, though admirable horsemen, were worsted at every turn, and their commander had at last to report that his mounted infantry were absolutely useless against the Union cavalry. At the same time, in consequence of the increased range, accuracy, and rapidity of both gun and rifle, the opportunities for charging will undoubtedly be fewer than before, and with every improvement of the firearm they must necessarily become more rare. A force while looking for an opportunity must keep at such a distance from its objective that when the moment comes a surprise will not be easy to effect; and it would seem that small bodies, of the size of a squadron or so, which can make good use of even insignificant cover and creep up where a heavier column would be at once detected, are far more likely to bring about success than large. What is required, therefore, for shock-tactics against cavalry endowed with fire-power—and, as we have seen, all cavalry comes under this designation—is great independence and skilled leading on the part of individual squadrons, and, on the part of the commander of the whole force, a judicious distribution and handling of his troops, part making use of their rifles to hold the enemy's attention, while the remainder, moving at the will of their immediate leaders, seek for openings to ride home with lance or sabre.

The second question that arises, viz., whether the necessary fire-power should be supplied by the cavalry itself, or by a body of mounted riflemen attached to the brigade or the division, is intimately connected with psychological considerations, and it is from the standpoint of the individual horseman that it must be discussed. Let us see what peculiar qualities are required from the trooper in the charge, that is, in the operation which differentiates him from his comrades of the other arms. In the first place, there is resolution; in the second, a certain eagerness for battle; and in the third, the quick decision which seizes an opportunity the instant it offers.[1] The sum of these three qualities is dash, and it is above all things important that dash, the most precious possession of the cavalry soldier, should never be tampered with, either in training or in war. A cavalry without the true cavalry spirit, lacking all spark of chivalry, and jibbing at the prospect of self-sacrifice, would be of small value in shock-tactics; yet if this spirit is not to disappear, it must be sedulously fostered. The cavalry soldier must be taught to consider himself as, first and foremost, the soldier of the charge and of the mêlée. It is this that he must be led to look upon, as the consummation of his training, the justification of his existence, as well as the finest, the most manful act of war. Now, if the cavalry soldier is called a mounted rifleman; if he is told that it is more useful to be a good shot than a good swordsman; if he is continually dismounted in preference to risking something by advancing; if he is not sometimes allowed to lose himself in the exhilaration of a charge, his dash invariably deteriorates. So, while it is absolutely essential that the trooper should be a good skirmisher and a good marksman, it is undoubtedly good policy to relieve him, so far as possible, of the necessity of fighting on foot.

Furthermore, from the psychological point of view, it is exceedingly desirable that for certain duties a force should be available which has a different training, different traditions, and a different ideal of the supreme incident of battle than the lancer or hussar. The mounted troops of an army, if they are handled as effectively as in the War of Secession, will often be called upon to capture and to hold localities and posts which are of strategic or tactical importance; and for the thorough fulfilment of their mission it is essential that they should be capable of carrying out, dismounted, an attack which culminates in an assault, as well as of defending a hastily occupied position against a hot counter-attack. Now, an attack on foot, culminating in an assault with the bayonet, demands in the troops who make it the same concentration of will and aspiration, the same exclusive training, and the same confidence in the weapon, which, as already shown, give shock-tactics their best chance of success. Dismounted cavalry, disposed as skirmishers, can render great assistance during the progress of an attack, holding the enemy to his ground, threatening him, and feinting; but the assault, that is, the actual storming of the position, will be most effectively carried out by a force which, while for purposes of mobility it has been trained to ride, for purposes of fighting has been trained as infantry. So, too, on the defensive. The cavalry trooper, regarding himself and his horse as inseparable, habituated to constant movement, and but little concerned with the occupation of positions, is not likely to offer so stout or so skilful a resistance as the soldier to whom the horse is but a secondary consideration, a stubborn defence the highest point of honour, and familiarity with the use of cover one of the chief ends of all instruction.

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[1] It is true that the quality of quick decision is more necessary to the leaders than to the men; but it is much to be doubted whether any body of cavalry could really be called efficient of which both leaders and men were not of the same temper.

The need, then, of attaching some sort of special force to the cavalry brigades and divisions, from the psychological point of view, is clearly demonstrated; and it has now to be decided whether this force should be a permanent organization, forming an integral part of the cavalry brigades and divisions, or whether the work can be done by a body of infantry organized on the spot, who have had sufficient practice in equitation to enable them to sit in their saddles and to groom their horses. Broadly speaking, and putting aside the question of expense, there can be little question but that the first suggestion is the better. A permanent force would be accustomed to work with the cavalry. The men would be better horsemasters, a most important consideration, both as regards mobility and the waste of horse-flesh. They could be trusted to act as scouts and take their share of reconnaissance work; and furthermore, it would be possible to give them sufficient instruction in the use of the sabre to enable them to have recourse to shock-tactics when these were the only means of defence, or in a pursuit or a mêlée when it was useless to fire. The fear that such a force might degenerate into indifferent cavalry cannot be accepted as a valid reason against its formation. Much, naturally, must depend upon the officers, more perhaps upon the system of inspection; but in a body of troops armed with the bayonet, and encouraged to prove themselves equal, if not superior, to the best infantry at purely infantry work, the cultivation of a healthy and distinctive *esprit de corps* should not be an insurmountable difficulty.

The formation, however, of a permanent force of mounted riflemen is a counsel of perfection; and, in default, a mobile infantry, mounted on cobs, cycles, or even in light carts, is the only alternative. Such infantry, if well trained and well officered, is capable of excellent work in conjunction with cavalry, and is a source of strength with which it would be simply pedantic to dispense.

Fundamental principles.

It has been shown in the preceding pages that when acting against mounted troops the following are the fundamental principles of cavalry tactics:—

(1) The combination, in the conflict, of shock and fire.

(2) The fire of the dismounted portion of the force, as well as of the guns, to be utilized as a pivot of manœuvres.[1]

(3) The line of retreat to be secured by dismounted riflemen.

(4) Independence of regimental and squadron leaders.

(5) An incessant watchfulness for opportunities of surprise.

(6) Skilful use of cover by regiments and squadrons, so as to take advantage of those opportunities by an unexpected charge.

(7) Protection of led horses is often only to be secured by shock.

So far as the details of shock action are concerned, such as formation in one, two, or three lines, the movement and position of the horse artillery batteries, it is quite useless to lay down hard and fast rules. Four principles are to be observed:—

(1) The enemy's line should always be outflanked.

(2) A reserve should always be retained in the hand of the commander.

(3) The guns should, if possible, accompany the cavalry when it advances with the view of charging, and by securing one of the flanks form a pivot of manœuvre.

(4) If the enemy is surprised, or attacked while he is manœuvring, success will be best assured. Beyond this it is unnecessary to go. Everything must depend on the readiness of the commander to adapt himself to the needs of the situation, to the quickness of his subordinates in apprehending and executing his instructions, and to the drill, training, and condition of both men and horses.

Combined action.

We now come to the employment of cavalry on the field of battle in conjunction with the other arms, and we have to note that with a certain school of tacticians the intervention of a vast mass of horsemen at the moment the defender is forced to evacuate his position is still as ever a pious expectation. The direction of the charge is presumably to be round the flank of the defeated army, and it appears to be anticipated that the cavalry, if led with sufficient boldness, and thundering forward in a close succession of steel-tipped lines, will have the supreme satisfaction of riding down a mob of panic-stricken fugitives, whose bandoliers are empty, or who are so paralysed by terror as to be incapable of using their rifles. To this picture two objections may be taken. First, it is only exceedingly bad troops that have ever been reduced to such a prostrate condition as, for the application of their theory, the advocates of the cavalry torrent are compelled to postulate; and even bad troops in the present firearm possess a power of resistance, derived as much from confidence in the magazine as from magazine-fire, against which the flood will break in vain. Even if some portion of the retreating troops be surprised, it is unlikely in the extreme that the panic will spread far. The great extent of the battlefield is against it; the troops not immediately attacked will have ample warning, and the artillery and machine-guns have time to occupy positions. Moreover, it is exceedingly improbable that any army whatsoever will not have made adequate arrangements for an organized and deliberate retreat. Again, it is quite a delusion to expect that when a position is carried the defending troops will dissolve into an uncontrollable and terrified mob. Men are not cattle; a few cool and intelligent riflemen, especially if favoured by the ground, can easily hold at bay a far larger number of mounted troopers; and it is not to be expected, even in an indifferent army, that such men will be lacking. So, even where the character of the country facilitates the deployment and the approach of a large force of cavalry, and makes surprise a possibility, the action of a mass of brigades or divisions will not penetrate beyond the fringe of battle; and it may be confidently expected that against guns and infantry, even if defeated and retreating, shock-tactics will be confined to regiments and squadrons acting independently and content with small captures. Whether such action will be worth while, whether it would not be better policy to concentrate the whole of the cavalry, and to occupy positions which will block, or at least flank, the lines of retreat, must be determined by the commander in accordance with the circumstances of the particular case.

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[1] A pivot of manœuvre is a force, a fortress, or natural obstacle, which secures a flank.

The second objection is that if the cavalry is armed with a rifle it will be simply a waste of fire-power to hold it in reserve for an opportunity which may never offer. The regiments must be dismounted and take part in the general attack, working, for preference, on the extreme flanks, or assailing posts and localities which cover the line of retreat. It is true that if it is to keep up a sustained pursuit when the enemy retreats, the cavalry must be nursed so long as he holds his position. But this applies rather to the horses than the men; and while the latter are fighting on foot, the former are getting quite as much rest as if the regiments were kept back in reserve. It may be urged, however, that in case of the failure of the attack, the cavalry, if it has been kept back, will be available to cover the retreat. The answer is simple. If the cavalry is employed in the attack, reinforcing the efforts of the infantry by an appreciable accession of fire-power, the possibilities of retreat will be much reduced; while the mobility of the arm, on the emergency arising, should enable it to withdraw from the line of battle in time to protect the guns against counter-attack, and to give the infantry the opportunity of rallying, re-forming, and occupying a defensive position.[1]

What cavalry will have to apprehend during a pitched battle is that it will be constantly engaged with the cavalry of the enemy. The mass of the horsemen on both sides will be found far out on the flanks, striving to put mobility to the best use, threatening whatever is in rear of the hostile front, and at the same time protecting whatever is in rear of their own. But it is not therefore to be anticipated that the charge and countercharge of all the available sabres on either side will be a feature of the great combats of cavalry that are bound to occur. It will very seldom be the case that the two sides will be so equally matched as to be equally prepared to risk the issue on the chances of a gigantic mêlée. One side must be the weaker, morally, numerically, or both, and it will certainly make the best use of the fire-power at its disposal, while at the same time it is in the highest degree unlikely that the stronger side will care to dispense with so valuable an auxiliary. These conflicts of cavalry will therefore take the form already indicated, even in the case when one army has been decisively defeated and its horsemen have the task of covering the retreat. Fire is a far better means of keeping the foe at a distance and of gaining time than shock; and a retreat from position to position, making full use of the rifle and the machine-gun, may be less glorious but much more effective than the supreme self-sacrifice of a desperate onslaught on the masses of a victorious enemy at the very moment of his triumph.

The principles of cavalry tactics in conjunction with the other arms may now be summarized:—

Summary.

(1) Action on the flanks, protecting and aggressive simultaneously.
(2) Posts and localities covering the lines of retreat and communication the proper objective.
(3) Action against infantry confined to surprises effected by bodies not larger than regiments or squadrons.
(4) The main object in pursuit to occupy position having or flanking the line of retreat.
(5) The main object in retreat to occupy a succession of positions, and so hold the pursuers at a distance, and gain time.

Armament.

The question of armament can hardly be excluded from a dissertation on cavalry tactics. We have seen that a rifle is indispensable. A sword, it is generally admitted, must be carried by every mounted man as the best means of protection against a sudden charge; and the rifleman is useless without his bayonet. Controversy is thus confined to the lance, and it may be said at once that the lance is undoubtedly a far more formidable weapon, even if it is not in reality more deadly, than the sabre or the revolver. Although there are many objections to it, such as its weight, its inconvenience in scouting and detached duties, the time taken up in mastering it, its uselessness in the mêlée or in the hands of a second or reinforcing rank, and the fact that its killing power depends altogether on the momentum of the horse, its moral effect is so great that a force carrying it is irresistible in the shock. So much is this the case, that it may be doubted whether a cavalry armed only with swords and revolvers, if opposed by one armed with lances, would not absolutely decline to cross weapons in the saddle. If, then, mounted troops are to meet lancers in the field, they must either be able to oppose them with the same arm, or they must be restricted to the tactics of mounted riflemen, and condemned to comparative immobility. But no army, except one whose only mission is the defence of a mountainous or forest country, dare make the smallest sacrifice of mobility; and there is no escaping the conclusion that a really good cavalry must be trained to use the lance as well as the sabre and the rifle.[2]

It may be said, in conclusion, that the trooper of the 20th century, if he is to fulfil the conditions of efficiency laid down in this article, must not only be a picked man, but that his facilities for training must be ample, his education a protracted process, and his instructors and leaders men of exceptional capacity. But when it is to be remembered that the cavalry is *par excellence* the strategical arm, that it depends on the cavalry, and on the cavalry alone, whether the commander of an army marches blindfold through the "fog of war," or whether it is the opposing general who is reduced to that disastrous plight, it will be admitted that to spare trouble or expense in the training and organization of the mounted branch is as unpardonable a mistake as to adhere to obsolete traditions.

There are still other points that deserve attention. Entrenchments play as great a part in modern campaigns as in those of 1861–65 or of 1877–78, and entrenchments are all in favour of the force that awaits attack. But, as suggested above, antidotes exist, such as surprise, the sudden seizure of tactical points which have been left unoccupied, outflanking manœuvres, and movements against the line of retreat. Now the effect of each of these operations depends, broadly speaking, on rapidity and secrecy; and, for reasons already alluded to, cavalry is the arm which best fulfils the required conditions. The principle of combination, however, demands that cavalry should always be supported in battle, directly or indirectly, by the other arms; or, to put it in another form, that the artillery and infantry should be so mobile as to be always within supporting distance when the cavalry comes into action. So far as the guns are concerned, there is no great difficulty; with the slow-moving foot-soldiers it is quite another matter. Much, however, may be done by constant training in combined manœuvres; much by sound administration, and by due regard for the physical condition of man and horse; more still—and here we touch the secret of all tactical as well as strategical success—by a thoroughly efficient staff. It is impossible to lay too much stress on this most powerful auxiliary.

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[1] This does not mean that a portion of the cavalry should not be attached to the general reserve.

[2] As has been suggested, however, the nature of the country in which the army is likely to be engaged has much to say to this question. There are theatres of war, such as the greater part of America, Great Britain, Switzerland, Sweden, all mountainous countries, where the lance would be an intolerable encumbrance.

Importance of the staff.

Take any army of the 19th century famous for the excellence of its grand tactics: Napoleon's army of 1805–06–07; Wellington's army of 1813–14; Lee's army of 1864–65; Grant's, Sherman's, and Johnston's armies of the same period; Moltke's army of 1870: the staff of each one of them had been welded by years of experience and the teaching of a great soldier into a magnificent instrument of war. They were not composed only of administrative officers, concerned with supply, organization, quartering, and discipline, but of tacticians and strategists of no mean order. Combinations in war too often "gang agley" from the neglect of some trifling precaution, some vagueness or omission in orders; and in the excitement of battle, or of approaching battle, when arrangements have to be made, possibly on the spur of the moment, for the co-operation of large bodies, unless he has been so trained that the measures necessary to ensure simultaneous and harmonious action occur to him instinctively, it is an exceedingly easy matter for even an able and experienced soldier to make the most deplorable mistakes. The practice of the staff in peace should not be less constant, to say the very least, than that of the units whose co-operation, as the only road to victory, it is the business of the staff to ensure. (G. F. R. H.)

III. Infantry.

The employment of infantry in action may be divided into two separate branches—attack and defence: in order to complete a satisfactory analysis of either, both must be studied, as the action of the one greatly influences the performance of the other. The principle is universally accepted that superiority in numbers, armament, position, or *moral*, are conditions indispensable, in a military sense, to justify attack. If the commander in the field commits himself to an attack, he delivers a frontal attack, a flank attack, or both in combination. A frontal attack, pure and simple, deprives the assailant of the opportunity of using his superiority by establishing a fighting line longer than that of the defending force; therefore it is undertaken only if natural obstacles preclude any overlapping extension to either flank. Still rarer are pure flank attacks, because the enemy, on seeing only his flank threatened, will naturally alter his front so as to face his opponent, whose contemplated flank attack thus becomes a frontal one. It follows that pure flank attacks must possess the character of surprise, and cannot be effected against a watchful enemy. Such attacks are occasionally initiated in order to compel the defender to quit a strong position, but in this case the enemy is merely out-manœuvred, and for his defeat an action is still required. By far the most usual form of attack is to combine the advance against the enemy's front with an assault against one, possibly both, of his flanks. In this case the task of the direct attack is to tie the enemy to his ground, so as to prevent him from changing his front. This very object makes it evident that a mere demonstration by a small number of troops is by no means sufficient, as it leaves the adversary free to assume the offensive against them, and then to conform to the assailant's flank attack. A further reason why the front attack should be made strong is the fact that the more vigorously it is executed the more troops the enemy needs for holding his own front, and the fewer he will have left for opposing the flank attack. It thus becomes evident that the success of the latter in a large measure depends on the energy with which the adversary's front is assailed, and also that the front attack must precede the advance against the enemy's flank. In order to ensure for the latter the character of a surprise, the assailant endeavours to conceal the movements of the troops detailed for it; the chances of attaining this object, however, are the slenderest when dealing with a watchful opponent, who, on detecting such movements, will take the counter-measure of facing it by deploying part of his main reserve. Obviously, then, the flank of the enemy can be gained, if at all, only at the end of a struggle. A flank attack usually resolves itself, therefore, into a fight which draws out the enemy's reserves and compels them to come into action on a line forming an angle with the original front, a procedure which confers the following advantages on the assailant—(1) the defender is compelled to expose himself to converging fire, the effect of which increases with the sharpness of the angle which his flank forms with his front; (2) the reserves moved out for opposing the flank attack have little or no time for throwing up entrenchments, and thus lose the chief advantage characteristic of the defensive; (3) if the defender is considerably inferior, he is compelled to oppose the flank attack by an attenuated line which obviously incurs the risk of being penetrated; (4) the doubled-back flank of the defender materially hampers his mobility.

Attack.

The firing line.

The battalion in European armies, being the organized body for disciplinary command, is also the fighting unit, and for the attack it is divided into firing line, supports, and reserve. The firing line invariably moves in extended order, while supports and reserves adopt this formation only if exposed to effective fire; otherwise they are kept in closer order, and furnish the means by which the firing line is fed and pushed closer to the enemy's position. It is impossible to lay down hard and fast rules as to how many companies should be retained in reserve, and how many should be used for the firing line and supports; that depends entirely upon the conditions, but for general guidance the following rules may be formulated:—A battalion must retain strong reserves, (1) if its flanks are unprotected; (2) if the fight is likely to last long; (3) if the enemy's dispositions are insufficiently known. A battalion may develop a strong fighting line (1) when its flanks are protected, (2) when its object is to gain an advantage over the enemy in a short time. The reinforcements which are sent forward from the supports and from the reserve give successive impulses for further advances; but this system will stand the test of war only if it is so thoroughly practised in peace time that it becomes a habit to the men, and if the conditions of real warfare are taken into consideration. The first check a firing line experiences is when it is fired at by an enemy who cannot be seen, an occurrence which will lose some of its novelty if imitated at manœuvres. The advance against a hostile position is admittedly a task that requires hours for its execution; this, too, should be imitated in peace time. The men should be taught to halt and to fire for long periods, making only short advances. During the latter it is not necessary to keep a strict alignment; on the contrary, if part of the firing line sees cover a short distance in front, it is justified in rushing to it, while the remainder seek to come gradually abreast of their comrades. During the halt it is the duty of subalterns to see that the privates have got the right range, and that they take careful and steady aim. Intelligent questions should compel the men to use their own judgment as to the enemy's disposition, so as to enable them to direct their fire upon targets which are of tactical importance, as, for instance, supports moving into the hostile firing line. These objects can be attained only if those who lead and direct a firing line have sufficient power of imagination, and a sufficiently serious conception of their responsibility, to put the stamp of reality even upon a sham fight. Experience has shown that if once a firing line is seriously engaged it is impossible to send orders to its leaders, who must rely upon their own resources; hence arises the difficulty of bringing their conceptions into line with the general plan of battle. The only means of attaining this end is to make junior officers acquainted with the principles underlying the leading of larger bodies of troops, so as to enable them to appreciate the intentions of their generals. This training would not, however, supply a sufficiently secure foundation upon which a commander could base his plans, were it not for the existence of another factor which is entirely of a psychical character. When the men get within effective rifle range they become convinced of the fact that retirement would mean annihilation; this knowledge causes anger, which is increased by the sight of the wounded and dead of their own, and awakens the spirit of retaliation. This desire is the chief motive which prompts the men to rush closer to the enemy's position whenever an opportunity offers, and on it are based two important tactical principles—namely, that troops which are within an effective zone of fire can neither be withdrawn nor moved towards a flank. It also explains the fact that the fighting capabilities of the average man are little influenced by the cause for which a war is waged, and lastly, it is the reason of the initiative for the final assault often coming from the firing line. The strength of the main reserve depends on the strength of the force engaged and on the knowledge of the enemy's dispositions. The bigger a force is, the longer the fight lasts; consequently the reserves retained are not only meant to carry out the final assault and to start the pursuit, but in addition to this they form the reservoirs from which such parts of the first line as have become absorbed or paralysed during the course of the action are replaced. Moreover, reserves furnish the means by which a general influences the course of an action; consequently, when the enemy's dispositions are insufficiently known, it is imperative to have a relatively weak first line and to retain strong reserves. The first line reconnoitres, so to speak, the enemy's position, and upon its experience the general must base his final decision in regard to the use of his reserves. The attempt to lay down on paper definite objects for reserves, and to formulate rules for their approximate strength, is of little assistance to a commander on the field of battle, where adaptation to varying conditions, which makes war an art, must dominate all theoretical considerations.

Defence.

In the defence the battalion also forms the fighting unit, and usually retains half its strength in reserve, while the other half furnishes the supports and the firing line. Supports and reserve keep the firing line at its most efficient strength, and should be posted as close as possible behind it, to avoid heavy losses during the process of reinforcement. The defence has profited more than the attack by the recent improvements of firearms. The absence of smoke compels the assailant to advance for at least 1000 yards, and possibly much more, under fire, before his opponent's position becomes disclosed to him; of this advantage the defender should make full use by placing his troops as far as possible behind cover that conceals them from view. Moreover, it has become easy for the defender to prolong the preliminary stages of the attack by occupying a series of advanced posts, which the enemy must make dispositions for attacking, and by quitting them as soon as such dispositions are completed. Naturally the troops occupying such posts must take care to retire in good time, lest they should be caught at a disadvantage by a rapidly advancing enemy. Strategical necessity limits the choice of defensive positions to narrowly confined areas; therefore, instead of simply choosing the best ground, it is generally necessary to make the most of the conditions as they exist. The choice of too strong a position is not always advantageous, since the assailant, instead of entering upon a hopeless task, may force the defender to quit his ground by turning his occupied position and threatening his lines of communication. Besides, the occupation of a position depends so much upon the direction of the enemy's advance, that in the majority of cases the defender has to adopt a waiting attitude till the adversary's intentions become known; and this uncertainty, with its concomitant danger of acting either too soon or too late, is the chief disadvantage of the defence. When the flanks of a defensive position do not rest on natural obstacles they must be protected by reserves, which eventually oppose the enemy's flank attack by meeting it with a newly-deployed front taken up in prolongation of the first line. Should, however, the ground not lend itself to that course, it is advisable to use weak bodies for opposing the hostile flank attack, to allow the latter to develop, and then to threaten counter-attack on the enemy's flank by a force of all arms previously echeloned for that purpose. This procedure is somewhat dangerous, as the force so detailed lays itself open to being cut off from the main body, as the adversary can hardly fail to discover its presence. Small bodies of infantry employed in this manner have chances of success, because not only is there a likelihood of their remaining concealed, but owing to the absence of smoke they can enfilade the adversary's lines for a considerable time before being discovered. At the end of the action, when all attempts of the assailant to carry the position have been foiled by the stubbornness of the defence, a vigorous counter-attack, which drives the enemy in disorder from the battlefield, alone entitles the defender to claim a victory; therefore, when a position is occupied with a view to inflict a decisive reverse upon the adversary, a reserve should always be retained for the purpose of assuming the final offensive.

Rearguard.

The method of defence adopted by a rearguard differs from that above described. Its principal object is to delay the enemy, and as this object is best attained by compelling the enemy to deploy as many of his troops as possible, thereby causing him a corresponding loss of time, it is evident that a rearguard must endeavour to show as broad a front as possible to the assailant. It is not necessary in this case to pay excessive attention to the security of the flanks, because a flank attack invariably requires time; therefore, should it be initiated by the pursuing force, the latter will play into the hands of the defence. Modern weapons have largely facilitated the work of a rearguard, because not only will the adversary's cavalry require much longer time for ascertaining the extent of front occupied, but the enemy will be compelled to deploy at ranges hitherto unknown. Yet, as a rearguard must avoid becoming seriously engaged, it must retire before the hostile infantry comes within a range that is likely to cause even slight losses.

Advance guard.

An advanced guard when coming in contact with the enemy acts on the same principles followed in the attack or defence, but must modify them when compelled to do so by its relations to the main body. For instance, an inferior enemy being met with, he should be driven in, to prevent the march of the main body from being interrupted; and as in this case quickness is the essence of the fight, the advanced guard must at once bring all its available forces into action. Similarly, when holding a superior hostile force in check to gain time for the main body to come up, no hesitation should be felt by the commander of an advance guard to use every man in the front line.

Patrols.

The use of smokeless powder favours the detachment of small bodies of troops to occupy folds of the ground, &c., whence they can enfilade the adversary's lines without disclosing their own position. This possibility necessitates, in the attack as well as in the defence, the employment of patrols, who reconnoitre to the right and left of the fighting force and carefully examine all ground affording concealment to the enemy. As the presence of small hostile bodies on the flank ceases to be a danger as soon as they are discovered, it is not advisable to make such patrols too strong, because the stronger a patrol the stronger is its inclination to fight. A few privates led by an intelligent man are well suited for this purpose. (J. BE.)

IV. ENGINEERS.

Principles.

The employment of engineers in the field is as ancient as history. The military operations of the Persians, Greeks, and Carthaginians would have been impossible without field engineers; and the engineers of Xerxes, Alexander, and Hannibal must have been remarkably proficient. From time immemorial the attacks on strongholds and fortresses of great strength depended upon the skill of the engineers to execute works in the field. History teaches us that, from the siege of Troy to modern times, the field army has, with few exceptions, eventually overcome the resistance of the strongest fortresses; in other words, the attacking engineer has almost invariably beaten the defending engineer. The primary objective of all military operations is to secure possession of certain positions which are of decisive importance, and victory in battle is the only means by which this end can be attained. A battle is an encounter between bodies of men armed, equipped, and organized for war; and the means by which a commander endeavours to attain his end—that is, victory —should be by a strict observance of the principle of being stronger than the enemy at a decisive point. This principle is not always observed, but where it is followed on one side and neglected on the other, the result is generally a decided victory for the former. The same principle should be observed on all occasions, whether the encounter is between large forces or is merely a small affair between detachments. A modern army is an exceedingly complicated organization, and a general requires much knowledge, skill, and experience, and many high moral and physical qualities, if he is to handle the troops with full command and power. He should never lose sight of the fact that the cavalry, artillery, and engineers exist mainly to support and assist the infantry—this arm being paramount in battle. The usefulness of the subsidiary arms is therefore proportionate to the extent to which they devote themselves to furthering the requirements of the infantry. But they are more than adjuncts to the infantry, being essentially part of the army, and quite indispensable if decisive results are to be expected.

In the field.

From the earliest times engineers have been employed at sieges, and on field defences to protect the besiegers against relieving armies. But sieges are outside the scope of this article, and we have now to consider how the engineers should be employed in the field so as to assist towards a victory on the field of battle. Napoleon knew the true value of engineers, but on some notable occasions he suffered from having neglected to apply his knowledge in practice; for example, at the Beresina, at Leipzig, and during the campaign of 1814 in France. He said that "those who proscribe the use of defensive lines, and the support that the art of the engineer can give, gratuitously deprive themselves of a power and an auxiliary that are never hurtful, nearly always useful, and often indispensable. However, the uses of field fortification require reconsideration; this important part of the art of war has made no progress since the time of the ancients—it is even behind what it was two thousand years ago. We must therefore encourage officers of the engineers to improve this part of their art and bring it up to a level with the rest." There is no evidence that the art of employing the engineers as an auxiliary force has been exercised to the fullest advantage in the great battles that have been fought since Napoleon summed up the situation. At Plevna the Turkish engineers were employed to the fullest advantage at first, but this was only as long as it was good strategy to hold Plevna. After the defensive works had fulfilled their object, they ought to have been abandoned; instead of this, the mistake was made of holding on to them, and they thus became a snare and delusion, and were entirely responsible for the loss of an army that might have been employed with advantage elsewhere in the theatre of war. The earliest instance of the systematic employment of field works was the Roman fortified camp, from which the troops sallied out and formed up in battle array—the Roman custom and tradition being to take the offensive —but the fortified camp was close at hand as a place of refuge in case of a reverse, and a safe place in which to leave the sick, non-combatants, and baggage. All the infantry were employed in making the defences of the camp. Many centuries later we find armies again making an extensive use of the spade, though instead of enclosed camps they made great lines of works adapted for defence by firearms. But, unlike the Romans, the troops on both sides placed more reliance on the cover from fire and the impediment to the assailants afforded by the parapets, ditches, and obstacles, than upon the skilful manœuvring of a mobile army operating outside the protection of the field defences. The brilliant generalship and strategy of Marlborough brought into discredit this misuse of field fortification. It was another of Napoleon's maxims that "field fortifications are useful, never harmful, *when they are well understood.*" The qualifying clause is at the root of the whole question of the employment of engineers. Frederick the Great was also sound in his views when he insisted that it was better to have too few than too many field works, because it is not the works that stop the enemy, but the troops that defend them. We may go back farther, to Lycurgus, who refused to enclose Sparta with walls because "that city is well fortified which has a wall of men instead of brick." It is one of the great errors made in the use of field works to imagine that fortifications can be made a substitute for men. In only a restricted sense is the statement true; if a position is fortified so that the defenders can inflict heavier losses than they suffer, it requires, of course, fewer men to defend than to attack. The error pointed out has led many to overlook the fact that decisive victory cannot be expected from mere defensive resistance, though the object in view may be best furthered, for the time being, by defensive action, as at Torres Vedras in 1811. Although it is dangerous to regard field fortifications as a substitute for men, they are a means by which the enemy may be delayed, and thereby time saved, pending the arrival of reinforcements or the decisive action of that part of the army which is making an offensive movement elsewhere. If time and opportunity offer, a rear guard may gain time by means of the protection afforded by field works; and siege works enable an investing army to hold its positions with far fewer men than would otherwise be possible.

Field works.

The use of field works is frequently wrong in principle, owing to the general not taking a sufficiently broad view of the situation, and making the troops subservient to the field works instead of the works being subordinated to the requirements of the troops. The only correct procedure is to choose the best position for the troops, with due regard to the weapons in use and to the tactical situation, and then to consider in what way the troops may be aided in their defence by the use of field works. This is the only way to ensure that the tactical relation between the troops and the ground is correctly observed. It is wrong in principle to select sites because they are the easiest to strengthen with works, and then to dispose the troops to defend these fortified localities. In other words, fortification should not govern the situation, but the military situation should indicate where fortifications may be of value. No doubt in many cases the best positions for the troops will also happen to be those easiest to strengthen with works; but to regard a position from a purely fortification point of view would often lead to error, because due consideration should first be given to the troops available, and the composition and quality of those troops, and the tactical conditions generally. The use of field works in the attack has never been fully developed, and there are many difficulties in the way, the most important being the absence of entrenching tools. That infantry on a large scale should be burdened with these implements has been advocated, but fortunately in vain, since the extra weight would militate much against mobility, and it would be only on exceptional occasions that the tools would be required. It is far better to have great mobility, and to rely upon the natural features of the ground. It is doubtful if many tools will ever be available for the attacking troops on the eve of a great battle, so as to enable them to make any very extensive use of field fortifications, except in so far as existing banks, walls, and hedges can be improved as cover for those troops that are to hold certain defensive positions as pivots of manœuvre for the remainder. The engineers, supplemented by the other troops, should make every effort to render defensive positions as strong as possible, working throughout the night if need be; but whether the most important work will be clearing the field of fire, preparing cover, or making obstacles, will depend upon circumstances. In any case, it must be carefully borne in mind that invisibility of the defences has become of the utmost importance since the introduction of accurate long-ranging and rapid-firing weapons and smokeless powder, since it is impossible to produce good results unless the targets and the effects of fire can be observed. In many cases the engineers can be most profitably employed in opening up communications for the free movements of the troops. After a position is taken it should not be retaken through the neglect of the engineers to strengthen its natural defences. From this captured position a further offensive movement may be contemplated.

Duties.

Engineers are employed in the field, especially on the lines of communication, in connexion with railways, roads, telegraphs, water-supply, balloons, mines, bridges, embarkations and disembarkations, demolitions, and the fortification of entrenched camps and positions. The frequent adoption of new and complicated inventions for war purposes demands an increase of skilled labour which can only be performed by trained specialists, and the conditions of modern warfare have given rise to fresh developments in the methods of attack and defence requiring the closest reflection if engineers are to be employed in the field so as to co-operate according to the changing conditions. For field works to be useful they must be in the right place, and, above all things, at the right time; in other words, there must be a close tactical connexion between the works and the troops.

Moral.

There is a moral side to the question of the use of field works, which is, that troops who seek shelter in works lose all mobility and fitness for offensive operations, and may be regarded as half beaten. The results of defensive action are generally merely local and rarely decisive; and the theoretical idea of vigorous offensive action, after an attack has failed, has rarely had any application in practice. If the defenders really contemplate a serious counter-attack, it must be deliberately prepared beforehand in the way Napoleon did at Austerlitz; he invited attack, and then met it half way. It may be that the troops are so wanting in training, *moral*, or organization as to be unfit for active operations, or that the general, having no confidence in his skill to handle troops, finds his task simplified by having a clearly defined line on which to dispose his army for defence. In any case, the very fact of acting on the defensive is an admission of weakness. With the greatly increased mobility of armies, due to improvements in communication, the advantages to be derived from an extensive use of field works in modern battles are not always commensurate with the disadvantages. But if the officer in command of the engineers has a sound knowledge of the art of war, and possesses initiative and self-reliance, he will be able, in all kinds of battles, to employ the engineers as a powerful auxiliary that is always useful, and often indispensable, if worked in co-operation with the other arms and in subservience to the general object in view. (R. C. H.)

V. Combined Arms.

Strategy is the art of bringing the enemy to battle. Combined, or, to use the phraseology of the Napoleonic era, "grand" tactics are the methods employed for his destruction by a force composed of all arms, that is, of infantry, artillery, and cavalry. Each of these possesses a power peculiar to itself, yet is dependent, for the full development of its power, to a greater or lesser degree upon the aid and co-operation of the rest. Infantry and artillery, unaccompanied by cavalry, if opposed by a force complete in all arms, are practically helpless, always liable to surprise, and whether attacking or defending, hampered by ignorance of the enemy's movements and bewildered by uncertainty. Cavalry trained to fight as infantry, and carrying a magazine rifle, is the ideal arm. But without artillery the most mobile cavalry cannot be expected, in ordinary circumstances, either to hold or to storm a position; and, when fighting dismounted, the necessity of protecting the horses so cramps its freedom of movement that it is less effective than infantry.

Proportion of the three arms.

It is essential, then, for decisive success that every force which takes the field against an organized enemy should be composed of the three arms. Their relative proportions in the armies of the great Powers stand as follows:—

5 to 6 guns per 1000 infantry soldiers;
1 cavalry trooper per 6 infantry soldiers.

These proportions have undergone a marked change during the past hundred years. The number of guns has been very largely increased, while that of the cavalry has been slightly diminished. It is probable, however, that the proportion of the latter will soon be restored to the old standard, and in small armies will very greatly exceed it. The reason for these disturbances is not far to seek. Before the introduction of the breechloader and the rifled cannon, the three arms of the service employed very different methods of combat. The infantry depended principally on the bayonet; the cavalry on the lance or sabre; the artillery on fire. Since the advent of the small-bore rifle and the quick-firing gun there is practically but one method, common to all arms. The bayonet and the sabre still have their part to play; but in almost every phase of the combat both infantry and cavalry, as well as the artillery, must rely on fire, and on fire alone, to compass the enemy's overthrow. All movements and all manœuvres have but one end in view, the development of fire in greater volume and more effectively directed than that of the opposing force; and it is "superiority of fire," to use the technical term, that decides the conflict.

Combination of the three arms.

For the attainment of this superiority no further rule can be laid down than that the three arms must combine. In war every situation differs. *Moral*, ground, numbers are never identical, and it is these considerations that form the basis of the problems with which a general has to deal. Of all errors in the conduct of war, none is more pernicious than the attempt to fight battles according to a sealed pattern. Even the formations in which troops approach the enemy, or occupy a position, must vary with the circumstances. In like manner, it is impossible to dictate a normal procedure for the combination of the three arms. Certain principles demand respect, for to infringe them generally spells disaster. But even this rule is not absolute. Great victories have been won not merely in spite of great principles being disregarded, but because they have been disregarded; and those are the greatest generals who have known when and where to discard the accepted maxims of war. Yet it would be very far from the truth to say that they did so because the principles embodied in those maxims had no weight with them. On the contrary, Napoleon, for instance, unfolded much of his practice of the art of war in a series of maxims, and the volume containing this series was Stonewall Jackson's constant companion in the field. We are not, however, to conclude that these great soldiers invariably shaped their conduct in accordance with the precepts they so diligently studied. They looked on them as warnings of the dangers that generally follow certain courses of action, rather than as finger-posts showing the path to be pursued. When they formed their plans for defeating the enemy they undoubtedly weighed these warnings, instinctively, perhaps, rather than deliberately; but whether they obeyed them or rejected them was a question of judgment. They were in no way bound by them. Far from it. They would have no fetters cramping their intelligence and common-sense, for it was on their intelligence and common-sense, and on no normal procedure and hard and fast rules, that they relied to solve the problems of war. And herein is the key to successful combinations on the battlefield: the habit of using the wits, of subordinating the rules of theory to the needs of the moment, and if necessary discarding them *in toto;* the habit of improvising stratagems, of inventing on the spot new methods of attack and defence. Habit is all-powerful in war, especially under the excitement generated by the near presence of the enemy; and it is undeniably the case that when conflict is imminent the average officer will act exactly as he has been accustomed to on the manœuvre-grounds of peace. If he has been accustomed to stereotyped proceedings; to a perfunctory reconnaissance of the enemy and of the ground; to beginning the fight with the whole of his guns massed in a central position; to handling his infantry in one invariable formation; to using his cavalry without regard for their horses, he will probably do the same in action. The danger is great. A slavish adherence to set form and inelastic regulations had much to do with the destruction of the Prussians at Jena and Auerstadt, of the Austrians in 1866, and of the French in 1870; and if ill-organized and half-trained levies have sometimes triumphed over highly-educated and well-disciplined soldiers, it is because the latter have come to look on war as a mechanical rather than an intellectual art, and have lacked all power of originality and resource in dealing with tactical difficulties.

Modern conditions of the battlefield.

As we have already implied, the first principle of grand tactics is co-operation, *i.e.*, the full development of the force inherent in each arm at the right place and the right time; and before discussing the methods of producing this development it will be well to describe the conditions which affect it. The flat trajectory of the magazine rifle, smokeless powder, and the quick-firing field gun, have wrought a greater change in tactics than did the substitution of the breechloader for the musket and of the rifled cannon for the smoothbore. With the older rifle, deadly as it was, the ground in front of a position was not thoroughly covered by bullets for more than 500 yards at most. Beyond that range, owing to the elevation of the trajectory, a great many bullets flew high over the heads of men even in an upright position. Nowadays, the ground for 900 yards in front of a strong line of infantry, provided that the rifles are held a few inches above the level, is so closely swept by the sheet of lead as to be practically impassable by men standing upright or even crouching. The long deadly zone of this horizontal fire, which every improvement in the firearm tends to increase, is the most potent factor in modern battle. Of little less importance is smokeless powder. The absolute invisibility of a skilful enemy renders reconnaissance tenfold more difficult than heretofore. Smoke betrayed not only the position but the strength of the troops who held it; the new powder tells nothing. Moreover, the rattle of rapid fire is most deceptive, for a few riflemen, or a few guns, firing at their utmost speed, give the idea of far larger numbers than are actually present. Again, at the crisis of the conflict the quick-firing field-piece is far more effective than the gun it superseded. On troops whose power of resistance is already strained to the utmost, on masses of men and horses, on crowds breaking to the rear, on a line suddenly assailed in flank, the constant hail of shells, even if less devastating than might be imagined, is terribly demoralizing. Nor is greater range and greater accuracy without influence on *morale.* Enfilade fire, the most telling of all, is more easily brought to bear, and more deadly; while the knowledge that, if once they are outflanked, they can no longer reckon, owing to the range of the enemy's projectiles, on a secure line of retreat, tends to shake the nerves of the most stubborn fighters.

The gain to the defence.

Such are the conditions of modern battle, and it is often urged that they are distinctly in favour of defensive tactics; in other words, that the force which awaits attack can develop the full force of each arm with more facility than that which delivers it. The contention may be true; but it is not always realized that anything which gives new strength to the defence at the same time adds something to the advantages of the army which attacks. The net outcome of the improvements in rifles, guns, and powder is that far fewer men are required to hold a position than of old. A direct (or frontal) attack against good troops well-posted, always a desperate undertaking, has now become suicidal. To a certain extent this favours the defence. A much larger number than formerly can be set free to act in reserve, and to deliver the counter-stroke; *i.e.*, a much larger number than formerly can be employed by the defenders *in attack.* This is to the good. But the assailant profits in an almost equal ratio. His strength has always lain in his power of manœuvring, of hiding his movements, and of massing suddenly against some weak point. To-day his power of manœuvring is greater than before. The increased strength of the defence renders it comparatively easy for him to form with a part of his force an impenetrable barrier behind which the remainder can move unobserved. He needs far fewer men and guns to cover his communications; and a general counter-attack, delivered, like those of Wellington, of the French in 1870, of Osman at Plevna, direct to the front, is very little to be dreaded. Moreover, the object of the assailant's manœuvres will be to place portions of his force on the flank or flanks of the position he is attacking. If he can accomplish this, the effect, moral and physical, of the enfilade fire he brings to bear upon the enemy's front will be far greater than that which attended a similar operation when fire was of less account. In short, the process of envelopment is easier than it used to be; and envelopment, which means that the enemy is under fire from several directions, is much more effective than in the past.

The gain to the attack.

It does not appear, then, that the new conditions are altogether in favour of the defender. To win a decisive victory and annihilate the enemy he must, at some time or another, leave his position and attack. But the time, if not the place, must depend on his adversary's movements, and will only be disclosed during the progress of the battle. What time will be given the defender for the long preliminaries which attack against even a shaken force demands, for the preparation by artillery, for the massing of the infantry, for their deployment in line of battle, for the issue of adequate orders? Tacticians have long been puzzled over the rarity and ineffectiveness of the counter-stroke in modern campaigns. The reason lies in the increased power of the local defensive, even with the needle-gun and the slow-firing cannon. With the newer weapons this power is trebled. The counter-stroke, therefore, is more difficult than ever; and this difficulty, combined with the greatly enhanced effect of envelopment fire, gives a marked advantage to the assailant. Resistance is more protracted than heretofore, but defence, as a method of giving battle, is no stronger.

The question will probably suggest itself, Why should envelopment be the monopoly of the advancing army? The reply is easy. Save in exceptional circumstances, the force that surrenders the initiative and stands still in position will be too weak for far-reaching manœuvres. Envelopment requires a numerical superiority or a vastly higher *moral;* and an army possessing these advantages must needs seek out its adversary and attack him, for the very simple reason that not otherwise can he be brought to battle. Yet it is not to be understood that the numerically inferior army is debarred from attacking; but it may be taken for granted that it will not do so until it sees the opportunity—the fruit, as a rule, of more skilful strategy—of falling on an isolated portion of the enemy's forces.

The concentric attack.

It would seem, however, that under the new conditions an army can split up into detachments with greater impunity than heretofore. Some of the most remarkable victories in history—Vittoria, Bautzen, Waterloo, the First and Second Manassas, Chancellorsville, Königgrätz—have been won by two distinct forces, operating from different bases, or approaching the field of battle from different directions, and crushing the enemy between them. This "sweep of the dragon's wings" is by no means an easy operation to put into successful practice. Von Moltke, indeed, has laid it down that the junction of two previously separated forces on the field of battle is the highest triumph of generalship; and Napoleon, although on more than one occasion he availed himself of the expedient, was never weary of pointing out the risk. It cannot, therefore, be questioned that separation has hitherto involved great dangers. Unless the separated forces acted in perfect unison, unless their leaders displayed the utmost activity and resolution, it was always to be apprehended that the one might be attacked and defeated before the other could intervene. At Waterloo, for instance, some of the Prussian generals, when they reached the neighbourhood of the field, and saw, as they believed, the British retreating, were for turning back immediately. Again, the timidity of Ney in finding himself separated from the main army made Bautzen a barren victory; and if there is one thing more conclusively proved by military history than another, it is that without determined, energetic, and skilful leaders, without superiority of *moral,* or great superiority of numbers, movements entailing separation were, under past conditions, very likely to end in disaster. To a certain extent this still holds good, for human nature, in war, recoils from nothing so much as from isolation. Nevertheless, the use of the field telegraph has done much to modify the risks that were formerly attendant on such manœuvres, and the increased strength of the local defensive has brought them within the scope of everyday tactics. It may be assumed, therefore, that the directors of future campaigns will have always in view the advantages to be derived from hurling a fresh force, whose approach, if possible, has been concealed until it opens fire, against the enemy's flank and rear; and the sudden onset of Blucher at Waterloo, of Lee at the Second Manassas, of Stonewall Jackson at Chancellorsville, of the Crown Prince of Prussia at Königgrätz, will be the ideal of the decisive act of battle.

It is to be observed, however, that successful concentric movements have been carried out more frequently by a force acting on the offensive than the defensive. In the first place, as has been said above, an army which adopts the offensive has usually the superior numbers or the superior *moral,* and it consequently incurs less risk from separation. In the second place, it is usually superior in cavalry, and is thus able to prevent all knowledge of the separation from reaching the enemy, as well as to conceal the march of the outflanking column. We may conclude, therefore, that it is only when the defender has the more powerful cavalry, and is at least equal to his adversary in numbers and in *moral,* that he will dare to deliver a concentric counter-stroke.

Importance of cavalry.

The army, then, which assumes the strategical offensive has, as a general rule, the best chance of employing this most effective manœuvre; but much depends on the quality and handling of the cavalry. If the cavalry is so armed and trained that it is capable of holding off the enemy's scouts and patrols, a tactical surprise may be effected, and surprise is far more than half the battle. And surprise is not only of the very greatest importance in offensive operations from different bases, but in every species of attack. An ordinary enveloping movement for which a portion of the main army is detached after it reaches the vicinity of the battlefield, is much more likely to be effective if the troops making it are protected from observation up to the last moment. Cavalry, then, sharing the enormous defensive power conferred by a low trajectory and rapidity of fire, play a rôle in grand tactics of which the importance can hardly be over-estimated. They make it possible for a general to adopt the most brilliant of all manœuvres, the concentric attack, and to make that attack, as indeed all other attacks, more or less of a surprise.

But to protect the troops in rear from observation is not the only duty of cavalry. Reconnaissance of the enemy's position is the foremost of its functions, and the occupation of points of tactical vantage, such as hills, woods, villages, &c., behind which the main army can deploy in security, or the outflanking columns march unobserved, is not far behind. The pursuit, too, falls upon the mounted arm, the destruction of the enemy's trains, the capture of his guns, the spreading of demoralization far and wide. But most important, perhaps, of all its functions are the manœuvres which so threaten the enemy's line of retreat that he is compelled to evacuate his position, and those which cut off his last avenue of escape. A cavalry skilfully handled, as at Appomattox or Paardeberg, may bring about the crowning triumph of grand tactics, viz., the hemming in of a force so closely that it has either to attack at a disadvantage or to surrender.

The cavalry attached to an army on the defensive acts on much the same lines, furnishing a large proportion of the outpost or advanced troops, and making use of its mobility to prolong the line of battle when a flank is threatened, and of its power of defence to hold back any force which may attempt to work round in rear. In a word, the cavalry of the defence endeavours to obstruct that process of envelopment which the cavalry of the attack endeavours to complete.

Co-operation of artillery and infantry.

It has long been understood that to attain the superiority of fire over a vigilant enemy in a strong position, a heavy artillery bombardment is as absolutely essential a preliminary as a thorough reconnaissance. It has not, however, been always realized that unless the infantry co-operate, the artillery is not likely to produce the slightest result. If the infantry is kept behind the guns, or at such a distance from the position that it cannot pass quickly to the assault, the enemy during the cannonade will keep his troops under cover, perhaps leaving his trenches unoccupied, and thus present no target to the guns. It is an important principle, therefore, of combined tactics that the infantry should co-operate with the artillery in the preliminary bombardment, for by this means only will the enemy be compelled to man his defences, to show himself above his parapets, and thus expose himself to the demoralizing effect of shrapnel.

Again, however thorough the artillery preparation may have been, it is not likely to have caused such losses that the defender's fire will be altogether innocuous when the attacking infantry advances. In fact, the assailant will probably suffer very heavily, for infantry advancing to the attack—that is, before it has established a strong firing line at decisive range (within 800 yards) from the enemy's position—can do nothing towards attaining the superiority of fire. Over 800 yards, if the enemy is well covered, its fire will be practically harmless, for the very good reason that the men will see no target at which to aim. But if the artillery co-operate by pouring a heavy and concentrated fire on the defender's lines, and, if necessary, by pushing forward batteries or guns to the most effective range, it will so disturb the aim of his riflemen as to secure the attacking troops from very heavy loss. We deduce, therefore, another principle: superiority of fire can only be gained by the close co-operation of the artillery and infantry at every stage of the attack.

Nor is it the guns alone that should cover the infantry advance. Where the ground permits, a portion of the infantry should be detailed for this purpose before the remainder move forward. At 2000 yards telescopes and strong glasses can be used to locate the exact position of the enemy's trenches; the range, by means of mechanical appliances, can be accurately measured; and the fire of the companies can be controlled with the same ease as that of the machine-guns. Such fire is little less effective than that of field or horse artillery. It may be less demoralizing; but, if the exact range can be ascertained, it will be more accurate, for infantry has not to contend with the technical difficulties, fuzes, the errors of the day, &c., of the sister arm. Especially will it be effective when it enfilades, or strikes at an oblique angle, the front of the defence. We are justified, therefore, in laying down the secondary principle that long-range rifle fire is an important auxiliary to the artillery in covering the advance of attacking infantry.

The use of ground.

It cannot escape notice that the application of these principles is intimately connected with the use of ground. If there are favourable positions for the artillery, or localities adapted to the development of long-range rifle fire; if the enemy's line is so exposed and well-marked that the guns can fire over the heads of the attacking infantry until the very moment of assault; or if it is open to enfilade, the co-operation of infantry and artillery should be comparatively easy. But it is no simple matter, without constant practice, to recognize at a glance the capabilities of the ground, and the manner in which the various physical features, hills, knolls, ridges, woods, should be employed in order to attain the superiority of fire.

If we look back on history, we cannot but be struck by the exceedingly important part that the appreciation or neglect of the capacities of the ground have played in every campaign. The most brilliant victories have been won by manœuvres which, if not suggested by the physical features of the battlefield, were at least deprived by the nature of the ground of half their risk. Rosbach, Leuthen, Austerlitz, Friedland, Dresden, Vittoria, Orthez, Chancellorsville, the Green Hills at Plevna, are examples. Nor can we fail to notice that the object of the great masters of tactics in carefully reconnoitring the enemy was to discover the key point or points of his position, and to judge for themselves how each separate locality, wood, village, farm, or hill, might be turned to account and fitted into the plan of battle. In short, we see in many most successful battles an almost methodical progression from point to point, each successive capture weakening the enemy's position, and paving the way for a further and more decisive advance; and the method pursued seems to have been in every case the same. "By threatening the village on the left, and seizing the wood in rear of it, I shall attract the enemy's attention, and perhaps his reserves. As soon as I have succeeded in doing this, I shall attack the hill on his right, and having captured this, bring every available gun to bear upon the central ridge, and attack, under cover of their fire, in full strength." This, or something very like it, appears to have been the ordinary mental process of such leaders as Frederick, Wellington, Napoleon, and Lee, and in many respects it is still eminently adapted to the field of battle. The difficulty of reconnaissance, the increased power of the defence against direct attack, the difficulty, owing to the wide front occupied by a defending force, of developing flank attacks, the general use of entrenchments, will make the fight for each locality long and exhausting; and it will consequently be necessary for a general to proceed with the utmost caution, and to make certain of securing one point of vantage before he attacks the next. The attack, moreover, of each point will consume far more troops in proportion to the strength of the army than heretofore. The whole army, indeed, may be employed in mastering one single point, part keeping the enemy employed elsewhere, the remainder combining for the decisive attack. The battle, more often than not, will thus resolve itself into a distinct series of engagements, each raging round a different locality and each protracted over many hours.

A systematic attack, wresting point after point, in the order of their importance, from the enemy's possession, is not, however, the only expedient by which the defensive may be overcome. Surprise may be called into play. Manœuvring, which has been described as the "antidote to entrenchments," is likely to be a conspicuous feature in all skilful tactical operations. Feints will seldom be neglected; and night marches, preparatory to an attack at dawn from an unexpected direction, will be constantly resorted to. With the exception of the first, each one of these is made easier by the increased power of the local defensive, and by the enhanced difficulty of reconnaissance. A screen, behind which troops moving to a flank or making a night march will be secure from observation or interference, can be established in any ordinary country without much difficulty and maintained by comparatively small numbers; while no better means of deceiving the enemy, or of making feints effective, could have been invented than the magazine rifle, the quick-firing gun, and smokeless powder.

The normal attack.

But while the latest productions of mechanical invention have done much to help the general offensive, they have by no means made combination easier, and the success of the attack, as a rule, has always depended on the combination between the units, be they battalions, brigades, or divisions, of which an army is composed. To secure such combination has therefore been the constant aim of all tacticians. The ideal of many has been a simultaneous attack against the front and flank, or front and flanks, made on a uniform system, with all the troops disposed in a uniform manner. They apparently assumed that everything must give way before the rush of superior numbers; that localities would be submerged beneath the flood;

that accidents of ground, even if utilized by the enemy, would never produce a serious check; in fact, that the effect of physical features might be ignored, and each separate attack from left, right, and centre might be expected to reach close quarters at approximately the same time. On the other hand, there are those who have taken into account both the ground and the flat trajectory, and who have taught that the normal, simultaneous system, described above, is far less practical than a system which gives to each unit its specific task, which allots that task in accordance with the ground, and which arranges for combination by instructions which differ for every unit. In this system there is no uniformity, and it is therefore less simple than the other; but it is founded on sound principles. It does not, indeed, ensure combination. But inasmuch as it takes each physical difficulty into consideration, and recognizes that battle is a succession of efforts, not one continuous rush, it is likely to come much nearer than the other. It is not a popular system. It is more complicated than the almost mechanical manœuvres of the first; it is less easy to practise in peace; owing to the lack of uniformity, it is much less picturesque; and it makes large demands on the intelligence of all ranks. An officer commanding several units, if he wishes to make such use of the ground that each unit may support the others, and if he determines to allot to each its specific task, must not only make a careful reconnaissance and think out a definite plan of action, but he must issue such clear and comprehensive orders that every subordinate commander will thoroughly understand the general design, the part he has himself to play, and the manner in which he is to co-operate with others. By this means only can he ensure intelligent combination and resolute action; but it is hardly necessary to say that to frame adequate orders to this end requires a sustained intellectual effort, plenty of previous practice, a cool brain, a mind which knows exactly what it wants to do and how it is to be done. Moreover, unless the commanders of units and those under them are well trained, even the clearest and most comprehensive orders will probably fail to produce the desired results.

There is one more point connected with the attack which demands notice. It should always be the aim of a general, even when in command of a much superior force, to destroy his enemy with as little loss as possible to himself. Napoleon prided himself on winning his great triumph at Ulm with "the legs of his soldiers," and Moltke's stupendous victory at Sedan, where 104,000 Frenchmen laid down their arms, with an additional loss in killed and wounded of 18,000, cost the Germans no more than 2800 lives. At first sight, then, it would appear that an attack on a strong position, especially if entrenched and prepared, should be consistently avoided, and the enemy manœuvred out of it. And no doubt this is an excellent rule. Nevertheless, strategical reasons often forbid delay; and therefore, when time presses, it may happen that the attack has to be delivered then and there, and the consequent sacrifice of life deliberately accepted. But it is worth noting that the necessity of taking time by the forelock is apt to produce undue haste, disregard of ordinary precautions, and the neglect of essential preliminaries, such as reconnaissance, the conception of a comprehensive plan of battle, and the issue of clear orders. Furthermore, a reluctance to incur losses often leads to a small portion only of the force being employed in the attack, and the remainder being either kept in reserve, or so timidly handled as to lend no assistance whatever to the assaulting troops. Such half-hearted tactics bring with them their own punishment. Even if the battle be won, the losses of the troops actually under fire are generally heavier than would have fallen on the whole army had it been resolutely engaged; while it is exceedingly unlikely that the victory will be decisive. To take a strong position without suffering enormous losses demands the very closest co-operation of every element of force which the commander has at his disposal. What should be the object of such co-operation is a question of much interest. Under the old conditions the general idea of offensive tactics was by feints and secondary attacks to draw off the defender's attention, and, if possible, his reserves, from the weakest point of the position, and then to attack that point with an overwhelming mass of men and guns. It would be too much to say that this principle is no longer applicable, for it will always be necessary that the full weight of the artillery, when once the battle has become general, should be directed against some particular portion of the defender's line; but envelopment, and the capture of good "fire-positions," especially of localities which favour enfilade or oblique fire, are a far surer and much less costly means, against good troops, of attaining that superiority of fire which decides the victory.

The defence.

The grand tactics of the defence, of which the soul is the counter-stroke, are in many respects similar to those of the attack. The assailant at the outset occupies certain localities, and so long as he holds out he covers his communications, and the greater part of the force is available for active operations. The defender acts in much the same fashion. He occupies a position which protects his communications, and if possible threatens the communications of his adversary, and, using this position as a pivot of manœuvre, he keeps a large force in hand for the counter-stroke. It is in the employment of the force in hand that the great difference arises between an active and a passive attitude. The defender can seldom decide, when he takes up his position, at what moment and at what place he will let this force slip; his adversary, on the other hand, can determine the exact rôle of every unit before a shot is fired. It is most important, therefore, that the force detailed for the counter-stroke should be kept absolutely distinct from the garrison of the pivot of manœuvre, that it should be in every respect mobile, and be used for no other purpose than delivering a vigorous attack at the place and at the time a good opportunity offers. Whether it should be tied down to one particular spot is a debateable question. Some part of the battlefield may be more favourable to counter-attack than another, and it is of course desirable, when the blow is struck, to aim at the enemy's line of communication and his strategic flank. But the opening for the counter-stroke is more often offered by the enemy's mistakes than by the ground, and it is impossible to predict where mistakes are likely to be made. We might say, then, that the force set aside for the counter-stroke, unless it come from a distance, like Blucher's army at Waterloo, should be posted where it can rapidly intervene on any part of the battlefield. Yet in conflicts fought over a very wide front this would manifestly be impossible; and, as a matter of fact, the whole question is so dependent on local circumstances that no rule can be laid down. It is clear, however, that the value of mounted troops in this respect is very great.

"False fronts" and "false flanks."

It has been suggested that the attack will draw more advantage from feigned attacks than heretofore; but it is not the attack alone that will derive benefit from the power of deception that lies in quick-firing weapons. By detaching small mobile forces to tactical points beyond the flanks, and by pushing them forward in advance of the main line of defence, the difficulties of reconnaissance on the part of the assailant will be largely increased; and it will be always on the cards that uncertainty and the loss of time may betray him into undue extension, dissipation of strength, and purely frontal attacks on the strongest points of the position. In ordinary country, where troops can manœuvre with facility, a few quick-firing guns, constantly changing their position, will add enormously to the effect of these "false fronts" and "false flanks," and it may here be stated that the mobility of field and horse artillery confers a great advantage on the defender. In ordinary circumstances, that is, when he is outnumbered in guns, it is questionable whether he is likely to gain anything by accepting a duel with the opposing batteries. His heavy artillery should be sufficient to protect the front and flanks of the central fortress—his pivot of manœuvre—leaving the remainder available to prevent the assailant from securing strong tactical points and to prepare the counter-stroke. Especially will it be important for the artillery to keep down enfilade and oblique fire, and cover should always be provided whence guns can sweep with shrapnel the hills or ridges which lie beyond the flanks, but within range. The artillery of the defence, in fact, should be handled on the same principles as the light artillery which forms part of the armament of a fortress, and it should only be concentrated when it is clear that the enemy is about to deliver a resolute attack against some one point of the position, or just previous to the counter-stroke. In both cases as many guns as possible should co-operate. The assailant will endeavour to cover the advance of his infantry by overwhelming the entrenchments with the fire of a mass of guns, and this the defender's artillery must do its best to render inaccurate and harmless, leaving the enemy's infantry alone until it is clear that the advance is progressing, and that the attack is gaining the upper hand. For the counter-stroke, concentration is even more important. As a rule, the time for preparation will be short, and yet preparation is as essential as in the attack; the more guns, therefore, that can be brought into action, the less likelihood of failure. It is true that the counter-stroke, as a rule, will only have to deal with troops shaken by long fighting or by repulse; but behind them will be the batteries, undemoralized, probably superior in numbers, and maintaining an iron grip on the ground already won. The combination, then, of infantry, cavalry, and artillery should be as carefully planned in the counter-stroke as in the attack. Superiority of fire must be attained by a skilful use of the ground, by enveloping and enfilading the point of attack. (G. F. R. H.)

Tafalla, a town of Spain, in the province of Navarra, south of Pamplona, on the river Cidacos, with a station on the railway from Saragossa to Alsasua. Population (1887), 6496; (1897), 5758. The surrounding country is hilly and well cultivated, producing much wheat, good wine, olives, fruit, and vegetables. There are in the town saw-mills, manufactures of alcohol and brandies. The old walls with a few towers and a citadel on a hill outside are still standing. In the parish church of Santa Maria and San Pedro there are some fine bas-reliefs and a Greco-Roman altar front. There is a modern town hall on a large square. There is an old palace of Carlos el Noble now in ruins, and some convents are worthy of notice. Tafalla is an ancient city, first mentioned in the historical documents of Navarre in 1040. It played a conspicuous part in mediæval wars between Navarre, Aragon, and France even. It was often besieged and taken by the kings of Navarre and their rebel vassals. In 1512 it passed into the hands of the kings of Castille with the rest of Spanish Navarre.

Tafîlált (*i.e.*, "The Country of the Fîlâli," as its inhabitants are called because descended from the Arabian tribe of Hîlál, settled here in the 11th century), formerly known as Sajilmása, the most important oasis of the Moroccan Sahara, ten days' journey south of Fez, across the Atlas. It is celebrated for its large and luscious dates, to the successful cultivation of which, soon after the arrival of an ancestor of the reigning dynasty of Morocco (hence called the Fîlâli Shareefs, *i.e.*, descendants of Mohammed), *circ.* A.D. 1250, this dynasty owes its rise to power. Instead of living in towns, its bellicose inhabitants occupy fortified buildings and are constantly at war.

Tahiti.—The French establishments in Oceania constitute a colonial government embracing the Society Archipelago, with Tahiti, the most important of the Windward Islands, the Leeward Islands, the Marquesas, the Tuamotu Islands, the Gambier group, the Tubuai Islands, Ravavae, and Rapa. These groups are widely scattered, the Marquesas being 720 miles north-east of Tahiti; the nearest of the Leeward Islands, 60 miles north-west, and the Gambier Islands 850 miles south-east. The Tuamotu Islands are spread over an area of 700 miles from north-west to south-east. The island of Tahiti was transferred to the Government of France by Pomare on 29th June 1880; the Marquesas were annexed in 1842; the Gambier Islands in 1894; Rapa in 1867; the Leeward Islands in March 1888, in accordance with an arrangement made two years earlier by the cabinets of Great Britain and France; the Tubuai Islands in 1889. The establishments have altogether an area of 1520 square miles, with a population of about 29,000. They are administered by a governor who resides at Papeete in Tahiti, and is assisted by a director of the interior, a judicial head, and a privy council. In 1885 an elective general council was created, consisting of 18 members, 10 for Tahiti, 2 for the Marquesas, 4 for Tuamotu, 1 for the Gambier Islands, 1 for Tubuai and Rapa. The tribunals (superior, first instance, and justices of peace) are now all French, the native courts having been suppressed under a convention of 1887. Schools are in general in the hands of religious orders, in particular that of St Joseph of Cluny for girls' schools. The local budget balanced in 1900 at 1,237,456 francs; the expenditure of France amounts to about 800,000 francs yearly.

Tahiti has an area of 600 square miles, with magnificent vegetation and picturesque scenery. The fertile lands have an area of about 25 square miles, but only 2 or 3 square miles are under cultivation, the crops being cocoanuts, oranges, sugar, and vanilla. Cotton, coffee, and tobacco growing have been abandoned. From the cocoanut copra and flour are made, and from the sugar-cane both sugar and rum. For some years the orange crop has steadily increased. Cattle are scarce; the industries comprise sugar works, brick works, and printing-offices, and the Tahitians prepare flour and make straw hats. The natives, however, are not fond of work, and this fact accounts for the backward condition of agriculture. In 1900 Tahiti had a population of 10,750, of whom 4282 were at Papeete, the capital; of these 2490 were French or the descendants of French. The trade of this port amounts to about £240,000 a year, of which about half is for exports. The staple exports are copra, 40 per cent.; mother-of-pearl, 30 per cent.; vanilla, 17 per cent.; cocoanuts, oranges; while the imports are tissues, 27 per cent.; farinaceous foods, 12 per cent.; wines, 6 per cent. The United States send to the port goods to the value of £52,000 per annum; France, £28,000; New Zealand, £20,000; Great Britain, £3200. The shipping, exceeding 80,000 tons, derives its importance from the situation of Papeete in the Pacific. The port has a slip for repairing and a coal dépôt. Tahiti is connected by a weekly service with Mooréa, and by other services with other French establishments. It has communication also with San Francisco, Nouméa, and Auckland. *Mooréa* has an area of 50 square miles, of which 13 are cultivable. The coffee and cotton area descends low. The island contains 1596 inhabitants grouped around Papetoai, the capital. The chief produce of the Windward Islands is copra. Raiatea and Tahaa have 2300 inhabitants; Huahine, 1300; Bora Bora, which arose in 1890, 800.

The *Tubuai* or *Austral Islands* are all very small, their total area being under 100 square miles, but they bristle with mountains, reaching at Rouroutore a height of 1300 feet. They contain 2300 inhabitants, and are rich in cocoanut trees and ironwood. The seat of administration is Rotoava.

Rapa (15 square miles) is an old crater, 2000 feet high. It has 192 inhabitants, and possesses a coal mine.

The *Tuamotu Islands* or *Low Archipelago* produce cocoanuts, mother-of-pearl, and pearls. The population exceeds 7000.

The *Gambier* Islands, with an area of 6 square miles and a population of 460, yield annually about £16,000 worth of mother-of-pearl.

The *Marquesas* have 5246 inhabitants, and produce oranges, cocoanuts, and yams. Cattle are comparatively numerous, over 2000; and the natives are skilful in the construction of whaleboats. The commerce exceeds £20,000. The capital, Taiohae, has 493 inhabitants.

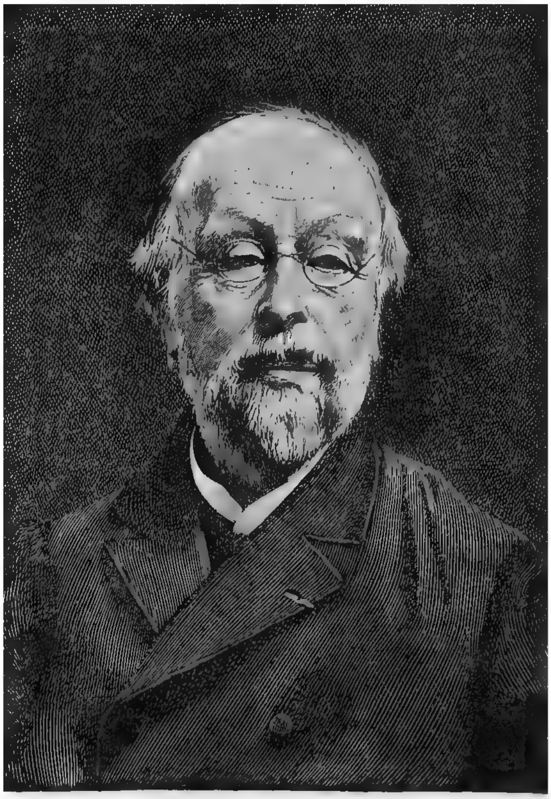
See HAURIGOT. *Établissements Français en Océanie.* Paris, 1887.—LE CHARTIER. *Tahiti.* Paris, 1887. *L'Année Coloniale, 1900.*

Tain, a royal and parliamentary burgh of Ross and Cromarty, Scotland, near the Dornoch Firth, 44 miles N.N.E. of Inverness by rail. The shrine of St Duthus is a roofless ruin, and the collegiate church of St Duthus dates from about 1360. The public buildings are of considerable architectural merit, notably a court house, a public hall, and the endowed academy. The industries include distilling and the manufacture of aerated waters. The town has a valuable "common good" in the shape of lands and fishings. The rainfall is one of the lowest in the kingdom. Population (1881), 2221; (1901), 1645.

Taine, Hippolyte Adolphe (1828–1893), French critic and historian, the son of Jean Baptiste Taine, an attorney, was born at Vouziers on the 21st of April 1828. He remained with his father until his eleventh year, receiving instruction from him, and attending at the same time a small school which was under the direction of M. Pierson. In 1839, owing to the serious illness of his father, he was sent to an ecclesiastical pension at Rethel, where he remained eighteen months. J. B. Taine died on the 8th of September 1840, leaving a moderate competence to his widow, his two daughters, and his son. In the spring of 1841 Taine was sent to Paris, and entered as a boarder at the Institution Mathé, where the pupils attended the classes of the Collège Bourbon. Madame Taine followed her son to Paris. Taine was not slow to distinguish himself at school. When he was but fourteen years old he had already drawn up a systematic scheme of study, from which he never deviated. He allowed himself twenty minutes' playtime in the afternoon and an hour's music after dinner; the rest of the day was spent in work. His efforts met with brilliant success and prompt reward. In 1847, as *vétéran de rhétorique*, he carried off six first prizes in the general competition, the prize of honour, and three accessits; he won all the first school prizes, the three science prizes, as well as two prizes for dissertation. It was at the Collège Bourbon that he formed lifelong friendships with several of his schoolfellows who afterwards were to exercise a lasting influence upon him: among these were Prévost-Paradol, for many years his most intimate friend; Planat, the future "Marcelin" of the *Vie Parisienne;* and Cornélis de Witt, who introduced him to Guizot when the latter returned from England in 1846.

Public education was the career which seemed to lie open to Taine after his remarkable school successes. In 1848 he accordingly took both his *baccalauréat* degrees, in science and letters, and passed first into the École Normale; among his rivals, who passed in at the same time, were About, Sarcey, Libert, and Suckau. This was a brilliant epoch in the annals of the École Normale; among those of Taine's fellow-students who afterwards made a name in teaching, letters, journalism, the theatre and politics, &c., were Challemel-Lacour, Chassang, Aubé, Perraud, Ferry, Weiss, Yung, Gaucher, Gréard, Prévost-Paradol, and Levasseur. Taine made his influence felt among them at once; he amazed everybody not only by his erudition, but by his indefatigable energy; and not only by his prodigious industry, but by his facility both in French and Latin, in verse as well as in prose. Taine enjoyed this period of his life to the full; he revelled in the stimulating pleasure of feeling himself surrounded by young, keen, and audacious minds. His reading was immense. He devoured Plato, Aristotle, the Fathers of the Church, and he analysed and classified all that he read. He already knew English, and set himself to master German in order to read Hegel in the original. The brief leisure he allowed himself was devoted to music. The rare quality of Taine's intellect and his extraordinary industry placed him beyond the range of rivalry. The teachers of his second and third years, Deschanel, Géruzez, Berger, Havet, Filon, Saisset, and Simon, were unanimous in praising the nobility of his character, the vigour and the fertility of his intellect, the distinction of style with which his work was always stamped; they were equally unanimous in finding fault with his unmeasured taste for classification, abstraction, and formula. The director of studies, M. Vacherot, gauged his capacity at the end of his second year with prophetic insight. He prophesied that Taine would be a great savant, adding that he was not of this world, and that Spinoza's motto, "Vivre pour penser," would also be his. In the month of August 1851 he came forward as a candidate for the fellowship in philosophy (*agrégation de philosophie*) in company with his friends Suckau and Cambier. The jury was presided over by M. Portalis, and consisted of MM. Bénard, Franck, Garnier, Gibon, and l'Abbé Noirot. Taine was declared to be admissible, together with five other candidates; but in the end only two candidates were admitted, his friend Suckau and Aubé. This decision created almost a scandal. Taine's reputation had already spread beyond the college. Everybody had taken for granted that he would be admitted first. The fact was that his examiners sincerely considered his ideas to be absurd, his style and method of handling a subject dry and tiresome; they declared that he was incapable of teaching philosophy, and an unlikely candidate ever to succeed in a competition for a fellowship. Four years later this fellowship was abolished.

The Minister of Public Instruction, however, judged Taine less severely, and appointed him provisionally to the chair of philosophy at the college of Toulon on 6th October 1851; but he never entered upon his duties, as he did not wish to be so far from his mother, and on 13th October he was transferred to Nevers as a substitute. Two months later, on the 27th December, occurred the *coup d'état*, after which every university professor was regarded with suspicion; many were suspended, others resigned. In Taine's opinion it was the duty of every man, after the plébiscite of the 10th December, to accept the new state of affairs in silence; but the universities were not only asked for their submission, but also for their approbation. At Nevers they were requested to sign a declaration expressing their gratitude towards the President of the Republic for the measures he had taken. Taine was the only one to refuse his endorsement. He was at once marked down as a revolutionary, and in spite of his success as a teacher and of his popularity among his pupils, he was transferred on 29th March 1852 to the lycée of Poitiers as professor of rhetoric, with a sharp warning to be careful for the future. Here, in spite of an abject compliance with the stringent rules imposed upon him, he remained in disfavour, and on 25th September 1852 he was appointed assistant professor of the sixth class at the lycée of Besançon. This time he could bear it no longer, and he applied for leave, which was readily granted him on 9th October 1852, and renewed every year till his decennial appointment came to an end. It was in this painful year, during which Taine worked harder than ever, that the fellowship of philosophy was abolished. As soon as Taine heard of this he at once began to prepare himself for the fellowship in letters, and to work hard at Latin and Greek themes. On 10th April 1852 a decree was published by which three years of preliminary study were necessary before a candidate could compete for the fellowship, but by which a doctor's degree in letters counted as two years. Taine immediately set to work at his dissertations for the doctor's degree; on the 8th June (1852) they were finished and 150 pages of French prose on the Sensations and a Latin essay were sent to Paris. On the 15th July he was informed that the tendency of his Essay on the Sensations made it impossible for the Sorbonne to accept it, so for the moment he laid this work aside, and on 1st August he began an essay on La Fontaine. He then started for Paris, where an appointment which was equivalent to a suspension awaited him. His university career was over, and he was obliged to devote himself to letters as a profession. In a few months his two dissertations, *De personis Platonicis* and the essay on La Fontaine's fables were finished, and on 30th May 1853 he took his doctor's degree. This was the last act of his university career; his life as a man of letters was now to begin.



Hippolyte Adolphe Taine.

(*From a photograph by Braun, Clément et Cie., Paris.*)

No sooner had he deposited his dissertations at the Sorbonne than he began to write an essay on Livy for one of the competitions set by the Academy; in this work he displayed a new side of his extensive erudition. Here again the moral tendency of his work excited lively opposition, and after much discussion the competition was postponed till 1855; Taine toned down some of the censured passages, and the work was crowned by the Academy in 1855. The essay on Livy was published in 1856 with the addition of a preface setting forth determinist doctrines, much to the disgust of the Academy. In the beginning of 1854 Taine, after six years of uninterrupted efforts, broke down and was obliged to rest; but he found a way of utilizing his enforced leisure: he let himself be read to, and for the first time his attention was attracted to the French Revolution; he acquired also a knowledge of physiology in following a course of medicine. In 1854 he was ordered for his health to the Pyrenees, and Hachette, the publisher, asked him to write a guide-book of the Pyrenees. Taine's book bore little resemblance to a guide-book. It was a collection of vivid descriptions of nature, historical anecdotes, graphic sketches, satirical notes on the society which frequents watering-places, and underlying the whole book was a vein of stern philosophy; it was published in 1855.

The year 1854 was an important one in the life of Taine. His enforced leisure, the necessity of mixing with his fellow-men, and of travelling, tore him from his cloistered existence and brought him into more direct contact with reality. His method of expounding philosophy underwent a change. Instead of employing the method of deduction, of starting with the most abstract idea and following it step by step to its concrete realization, henceforward he starts from the concrete reality and proceeds through a succession of facts until he arrives at the central idea. His style also became vivid and full of colour; he shows that he is acutely sensible to the outward manifestations of things and depicts them in all their relief. Simultaneously with this change in his works his life became less self-centred and solitary. He lived with his mother in the Isle Saint-Louis, and now he once more associated with his old friends, Planat, Prévost-Paradol, and About. He made the acquaintance of Renan, and through Renan that of Sainte-Beuve, and he renewed friendly relations with M. Havet, who for three months had been his teacher at the École Normale. These years (1855–56) were Taine's periods of greatest activity and happiness in production. On 1st February 1855 he published an article on La Bruyère in the *Revue de l'Instruction Publique*. In the same year he published seventeen articles in this review and twenty in 1856 on the most diverse subjects, ranging from Menander to Macaulay. On 1st August 1855 he published a short article in the *Revue des Deux Mondes* on Jean Reynaud. On 3rd July 1856 appeared his first article in the *Débats* on Saint-Simon, and from 1857 onwards he was a constant contributor to that journal. But he was seeking for a larger field, which would afford scope for the development of his theory on race, period, environment, and the dominating faculty. On 17th January 1856 his history of English literature was announced, and from 14th January 1855 to 9th October 1856 he published in the *Revue de l'Instruction Publique* a series of articles on the French philosophers of the 19th century, which appeared in a volume at the beginning of 1857. In this volume he energetically attacked the principles which underlie the philosophy of Victor Cousin and his school with an irony which amounts at times to irreverence.

The book closes with the sketch of a system in which the methods of the exact sciences are applied to psychological and metaphysical research. The work itself met with instantaneous success, and Taine became famous. Up till that moment the only important articles on his work were an article by About on the *Voyage aux Pyrénées*,[1] and two articles by Guizot on his *Livy*.[2] After the publication of *Les Philosophes Français*, the articles of Sainte-Beuve in the *Moniteur* (9th and 16th March 1856), of Sherer[3] in the *Bibliothèque Universelle* (1858), and of Planche in the *Revue des Deux Mondes* (1st April 1857) show that from this moment he had taken a place in the front rank of the new generation of men of letters. Caro published an attack on Taine and Renan, called "L'Idée de Dieu dans une Jeune École," in the *Revue Contemporaine* of 15th June 1857. Taine answered all attacks by publishing new books. In 1858 appeared a volume of *Essais de Critique et d'Histoire ;* in 1860 *La Fontaine et ses Fables*, and a second edition of his *Philosophes Français*. During all this time he was persevering at his history of English literature up to the time of Byron. It was from that moment that Taine's influence began to be felt; he was in constant intercourse with Renan, Sainte-Beuve, Sherer, Gautier, Flaubert, Saint-Victor, and the Goncourts, and gave up a little of his time to his friends and to the calls of society. A more liberal atmosphere was abroad, and in 1862 Taine came forward as a candidate for the chair of literature at the Polytechnic School, but M. de Loménie was elected in his place.

The following year, however, in March, Marshal Randon, Minister of War, appointed him examiner in history and German to the military academy of Saint Cyr, and on 26th October 1864 he succeeded Viollet-le-Duc as professor of the history of art and æsthetics at the École des Beaux Arts. He was to meet, nevertheless, with renewed opposition. Renan's appointment at the Collège de France and Taine's candidature for the Polytechnic School had alarmed Mgr. Dupanloup, who in 1863 issued an *Avertissement à la Jeunesse et aux Pères de Famille*, which consisted of a violent attack upon Taine, Renan, and Littré: Renan was suspended, and Taine's appointment to Saint Cyr would have been cancelled but for the intervention of the Princess Mathilde. In December 1863 his *Histoire de la Littérature Anglaise* was published, prefaced by an introduction in which Taine's determinist views were developed in the most uncompromising fashion. In 1864 Taine sent this work to the Academy to compete for the Prix Bordin. M. de Falloux and Mgr. Dupanloup attacked Taine with violence; he was warmly defended by Guizot: finally, after three days of discussion, it was decided that as the prize could not be awarded to Taine, it should not be awarded at all. This was the last time Taine sought the suffrages of the Academy save as a candidate, in which quality he appeared once in 1874 and failed to be elected, Mézières, Caro, and Dumas being the rival candidates; and twice in 1878, when, after having failed in May, H. Martin being chosen, he was at last elected in November in place of M. Loménie. In 1866 he received the Legion of Honour, and five years later (October 1871), on the conclusion of his lectures in Oxford on Corneille and Racine, the University conferred upon him its degree of D.C.L.

The period from 1864 to 1870 was perhaps the happiest of Taine's life. He derived pleasure from his employment at the Beaux Arts and Saint Cyr, which occupied but a limited portion of his time and left ample leisure for travel and research. In 1864 he spent three months (February to May) in Italy, which furnished him with several articles for the *Revue des Deux Mondes* from December 1864 to May 1866. In 1865 appeared *La Philosophie de l'Art*, in 1867 *L'Idéal dans l'Art*, followed by essays on the philosophy of art in the Netherlands (1868), in Greece (1869), all of which short works were republished later (in 1880) as a work on the philosophy of art. In 1865 he published his *Nouveaux Essais de Critique et d'Histoire ;* from 1863 to 1865 appeared in *La Vie Parisienne* the notes he had taken for the past two years on Paris and on French society under the sub-title of "Vie et Opinions de Thomas Frédéric Graindorge," published in a volume in 1867, the most personal of his books, and an epitome of his ideas. In 1867 appeared a supplementary volume to his history of English literature, and in January 1870 his *Théorie de l'Intelligence*. During these last years his life had undergone another change; in 1868 he married Mademoiselle Denuelle, the daughter of a distinguished architect, and from that time his life was lightened of half its cares.

He had made a long stay in England in 1858, and had brought back copious notes, which, after a second journey in 1871, he published in 1872 under the title of *Notes sur l'Angleterre*. On 28th June 1870 he started to visit Germany, but his journey was abruptly interrupted by the outbreak of the war; his project had to be abandoned, and Taine, deeply shaken by the events of 1870, felt that it was the duty of every Frenchman to work solely in the interests of France. On 9th October 1870 he published an article on "L'Opinion en Allemagne et les Conditions de la Paix," and in 1871 a pamphlet on *Le Suffrage Universel ;* and it was about this time also that the more or less vague ideas which he had entertained of writing on the French Revolution returned in a new and definite shape. He determined to trace in the Revolution of 1789 the reason of the political instability from which modern France was suffering. From the autumn of 1871 to the end of his life his great work, *Les Origines de la France Contemporaine*, occupied all his time, and in 1884 he gave up his professorship in order to devote himself wholly to his task; but he succumbed before it was finished, dying in Paris on 5th March 1893. In the portion of the work which remained to be finished Taine had intended to draw a picture of French society and of the French family, and to trace the development of science and the scientific spirit in the 19th century. He had also planned a complementary volume to his *Théorie de l'Intelligence*, to be entitled *Un Traité de la Volonté*.

The *Origines de la France Contemporaine*, Taine's monumental achievement, stands apart from the rest of his work. His object was to explain the existing constitution of France by studying the more immediate causes of the present state of affairs—the last years of what is called the *Ancien Régime*, the Revolution and the beginning of the 19th century, to each of which several volumes were assigned. He also had another object, although he was perhaps hardly conscious of it, which was to study man in one of his pathological crises; for Taine makes an investigation into human nature, and the historian checks and endorses the pessimism and misanthropy of Graindorge. The problem which Taine set himself was, to inquire why the centralization of modern France is so great that all individual initiative is practically non-existent, and why the central power, whether it be in the hands of a man or of an assembly, is the sole and only power; also to expose the error underlying two prevalent ideas:—(1) That the Revolution destroyed absolutism and set up liberty; the Revolution, he points out, merely caused absolutism to change hands. (2) That the Revolution destroyed liberty instead of establishing it; that

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[1] *Revue de l'Instruction Publique*, 29th May 1856.
[2] *Débats*, 26th and 27th January 1857.
[3] Reprinted in *Mélanges de Critique Religieuse*.

France was less centralized before 1789 than after 1800. This also he shows to be untrue. The centralization was as great before 1789 as after 1800. France was already a centralized country before 1789, and grew rapidly more and more so from the time of Louis XIV. onwards. The Revolution was the last step, completing what had already been done. The Revolution neither destroyed nor created despotism; it merely gave it a new form.

The *Origines* differ from the rest of Taine's work in that, although he applies to a period of history the method which he had already applied to literature and the arts, he is unable to approach his subject in the same spirit: he loses his philosophic calm; he cannot help writing as a man and a Frenchman, and he lets his feelings have play; but what the work loses thus in impartiality it gains in life. The most important part of this great work is the deductive part, in which Taine traces step by step by what succession of facts and ideas, converted into facts later, ancient France developed into modern France. According to Taine, the chief causes of the French Revolution were the crying abuses of the *Ancien Régime*, the stupendous waste of the State revenue, and the conversion of the French *esprit classique* into abstract idealism.

Taine was the philosopher of the epoch which succeeded the era of romanticism in France. The romantic era had lasted from 1820 to 1850. It had been the result of a reaction against the classical school, or rather against the conventionality and lifeless rules of this school in its decadence. The romantic school introduced the principle of individual liberty both as regards matter and style; it was a brilliant epoch, rich in men of genius and fruitful of beautiful work, but towards 1850 it had reached its decline, and a young generation, tired in turn of its conventions, its hollow rhetoric, its pose of melancholy, arose, armed with new principles and fresh ideals. Their ideal was truth; their watchword liberty; to get as near as possible to scientific truth became their object. We can trace their efforts in all the branches of art, in the pictures of Meissonier, Millet, and Bastien-Lepage; in the poetry of Leconte de Lisle and of Sully-Prudhomme; in the historical works of Renan; in the fiction of Flaubert, Zola, and Maupassant. Taine was the mouthpiece of this period, or rather one of its most authoritative spokesmen.

Many attempts have been made to apply one of Taine's favourite theories to himself, and to define his predominant and preponderant faculty. Some critics have held that it was the power of logic, a power which was at the same time the source of his weakness and of his strength. He had a passion for abstraction. "Every man and every book," he said, "can be summed up in three pages, and those three pages can be summed up in three lines." He considers everything as a mathematical problem, whether it be the universe or a work of art: "C'est beau comme un syllogisme," he said of a sonata of Beethoven's. Taine's theory of the universe, his doctrine, his method of writing criticism and history, his philosophical system, are all the result of this logical gift, this passion for reasoning, classification, and abstraction. But Taine's imaginative quality was as remarkable as his power of logic; hence the most satisfactory definition of Taine's predominating faculty would be one which comprehended the two gifts. M. Lemaître gave us this definition when he called Taine a *poëte-logicien;* M. Bourget likewise when he spoke of Taine's *imagination philosophique,* and M. Barrès when he said that Taine had the power of dramatizing abstractions. For Taine was a poet as well as a logician; and it is possible that the portion of his work which is due to his poetic and imaginative gift may prove the most lasting.

Taine's doctrine consisted in an inexorable determinism, a negation of metaphysics; as a philosopher he was a positivist. Enamoured as he was of the precise and the definite, the spiritualist philosophy in vogue in 1845 positively maddened him. He returned to the philosophy of the 18th century, especially to Condillac and to the theory of transformed sensation. Man knows nothing save through sensations, which are transformed in him into ideas by means of the faculty of abstraction. Sensations grouping themselves represent phenomena, and abstract ideas are significative of the constant relations between phenomena, or *laws;* and since to abstract and to generalize is all that man can do, his whole knowledge is limited to phenomena and the laws of phenomena. He can never arrive at the knowledge of a cause—the domain of metaphysics; but he can get to know more and more about, although he can never attain to, the knowledge of the *how*—the domain of science. Metaphysics does not exist; but science exists; therefore, philosophy to be a science must stop short on the threshold of metaphysics. Taine presented this philosophy in a vivid, vigorous, and polemical form, and in concrete and coloured language which made his works more easily accessible, and consequently more influential, than those of Auguste Comte. Hence to the men of 1860 Taine was the true representative of positivism.

Taine's critical work is considerable; but all his works of criticism are works of history. Hitherto history had been to criticism as the frame is to the picture; Taine reversed the process, and studied literary personages merely as specimens and productions of a certain epoch. He started with the axiom that the complete expression of a society is to be found in its literature, and that the way to obtain an idea of a society is to study its literature. The great writer is not an isolated being; he is the result of a thousand causes; firstly, of his race; secondly, of his environment; thirdly, of the circumstances in which he was placed while his talents were developing. Hence Race, Environment, Time—these are the three things to be studied before the man is taken into consideration. Taine completed this theory by another, that of *predominating faculty,* the *faculté maîtresse.* This consists in believing that every man, and especially every great man, is dominated by one faculty so strong as to subordinate all others to it, which is the centre of the man's activity and leads him into one particular channel. It is this theory, obviously the result of his love of abstraction, which is the secret of Taine's power and of his deficiencies. He always looked for this salient quality, this particular channel, and when he had once made up his mind what it was, he massed up all the evidence which went to corroborate and to illustrate this one quality, and necessarily omitted all conflicting evidences. The result was an inclination to lay stress on one side of a character or a question to the exclusion of all others. Consequently, in his study of man and history he did what he blamed the classical authors of the 18th century in France for doing. These authors saw and portrayed the type exclusively, and entirely neglected the individual. Taine generalized in the same manner. Hence the one-sided character of his work.

Taine served science unfalteringly, without looking forward to any possible fruits or result. In his work we find neither enthusiasm nor bitterness, neither hope nor yet despair; merely a hopeless resignation. The study of mankind was Taine's incessant preoccupation, and he followed the method already described. He made a searching investigation into humanity, and his verdict was one of unqualified condemnation. In *Thomas Graindorge* we see him aghast at the spectacle of man's brutality and woman's folly. In man he sees the primeval savage, the gorilla, the carnivorous and lascivious animal, or else the maniac with diseased body and disordered mind, to whom health, either of mind or body, is but an accident. Taine is appalled by the *bête humaine;* and in all his works we are conscious, as in the case of Voltaire, of the terror with which the possibilities of human folly inspire him. It may be doubted whether Taine's system, to which he attached so much importance, is really the most lasting part of his work, just as it may be doubted whether a sonata of Beethoven's bears any resemblance to a syllogism. For Taine was an artist as well as a logician, an artist who saw and depicted what he saw in vital and glowing language. From the artist we get his essay on La Fontaine, his articles on Balzac and Racine, and the passages on Voltaire and Rousseau in the *Ancien Régime.* Moreover, not only was Taine an artist who had not escaped from the influence of the romantic tradition, but he was by his very method and style a romanticist. His emotions were deep if not violent, his vision at times almost lurid. He sees everything in startling relief and sometimes in exaggerated outline, as did Balzac and Victor Hugo. Hence his predilection for exuberance, strength, and splendour; his love of Shakespeare, Titian, and Rubens; his delight in bold, highly-coloured themes. Thus we have the curious spectacle of a man who combats and attacks the classical spirit with all his might, and yet passes his life in generalizing; of a man who comes to supplant romanticism, and yet affords us one of the most striking examples of the romantic style and method.

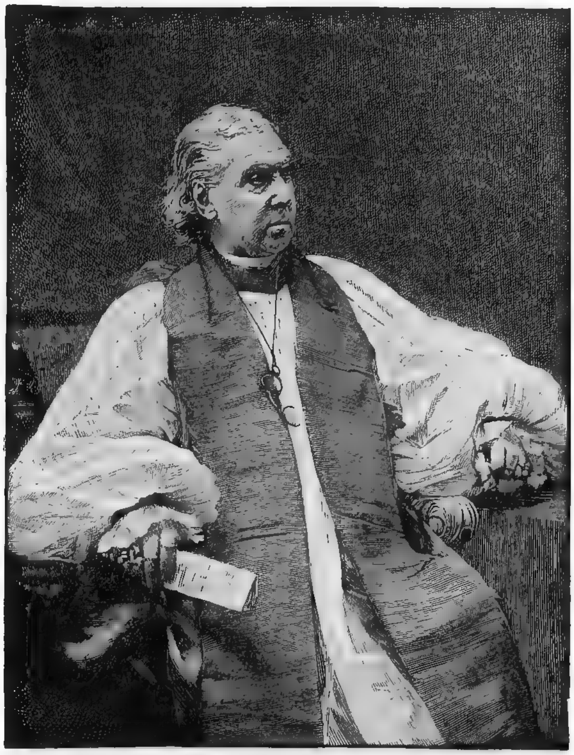
Taine's influence was great, and twofold. On his own generation it was considerable; during the epoch in which he lived, while a wave of pessimism was sweeping over French literature, he was the high priest of the cult of misanthropy, in which even science was held to be but an idol, worthy of respect and devotional service, but not of faith. In its turn came the reaction against positivism and pessimism, and an attempt at spiritual renascence. Around a man so remarkable as Taine a school is certain to form itself; Taine's school, which was one of positivist doctrines, rigid systems, and resigned hopelessness, was equally certain to produce at some time or another a school of determined opponents to its doctrines and system. If, therefore, the tone which pervades the works of Zola, Bourget, and Maupassant can be immediately attributed to the influence we call Taine's, it is also the influence of Taine which is one of the ultimate causes of the protest embodied in the subsequent reaction.

(M. BA.)

Tait, Archibald Campbell (1811–1882), Archbishop of Canterbury, the son of Craufurd Tait and his wife Susan, daughter of Sir Ilay Campbell, was born at Edinburgh on 21st December 1811. His parents being Presbyterians, he was baptized (10th February 1812) by Dr Thomas MacKnight of St Giles's, Edinburgh; but he early turned towards the Scottish Episcopal Church, and was confirmed in his first year at Oxford, having entered Balliol College in October 1830 as a Snell exhibitioner from the University of Glasgow. He won an open scholarship, took his degree with a first-class *in literis humanioribus* (1833), and became fellow and tutor of Balliol; he was also ordained deacon (1836) and priest (1838), and served the curacy of Baldon. Rapid changes amongst the fellows found him at the age of twenty-six "the senior and most responsible of the four Balliol tutors." The experience gained during this period stood him in good stead afterwards as a member of the first Oxford University Commission (1850–52), in which he took a prominent part. But he cannot be said to have left any permanent effect on the university. He never sympathized with the principles of the Tractarian movement, and on the appearance of Tract XC. in 1841 he drafted the famous protest of the "Four Tutors" against it; but this was his only important contribution to the controversy. On the other hand, although his sympathies were on the whole with the liberal movement in the university, he never took a lead in the matter. In 1842 he became an undistinguished but useful successor to Arnold as headmaster of Rugby; and a serious illness in 1848, the first of many from which he suffered, led him to welcome the comparative leisure which followed upon his appointment to the deanery of Carlisle in 1849. His life there, however, was one of no little activity; he served on the University Commission already mentioned, he restored his cathedral, and did much excellent pastoral work. There too he suffered the great sorrow of his life. He had married Catharine Spooner at Rugby in 1843; in the spring of 1856, within five weeks, five of their children were carried off by virulent scarlet fever. Not long afterwards he entered upon his real life-work, being consecrated bishop of London on 22nd November 1856, as successor to C. J. Blomfield. He at once took a leading part in all ecclesiastical affairs, and never ceased to do so. His translation to Canterbury in 1868 (he had refused the archbishopric of York in 1862) constituted indeed a recognition of his work, but made no break in it. His latter days were interrupted by illness and saddened by the death in 1878 of his only son Craufurd (whom he had ordained priest three years before) and of his wife; but although his activity was thus lessened, his influence grew steadily down to his death.

If Blomfield had almost remodelled the idea of a bishop's work, his successor surpassed him. Tait had all Blomfield's earnestness and his powers of work, with far wider interests. Blomfield had given himself zealously to the work of church-building; Tait followed in his steps by inaugurating (1863) the Bishop of London's Fund. He realized too that the obtaining of funds was not enough, and that the real problem was the far larger one of getting hold of the people. He spent a large part of his time at London in actual evangelistic work; and to the end his interest in the pastoral side of the work of the clergy was greater than anything else. With his wife, he was instrumental in organizing women's work upon a sound basis, and he did not a little for the healthful regulation of Anglican sisterhoods during the formative period in which this was particularly necessary. Nor was he less successful in the larger matters of administration and organization, which brought into play his sound practical judgment and strong common-sense. He was constant in his attendance in Parliament, and spared no pains in pressing on measures of practical utility. The modification of the terms of clerical subscription (1865), the new lectionary (1871), the Burials Act (1880) were largely owing to him; for all of them, and especially the last, he incurred much obloquy at the time, but it would be generally agreed at the present day that he was right. The Royal Commissions on Ritual (1867) and on the Ecclesiastical Courts (1881) were due to him, and he took a large part in the deliberations of both. Probably his successor (see BENSON, E. W.) was brought into closer relations with the colonial churches than Tait was; but the healthy development of the Lambeth Conferences on the lines of mutual counsel rather than of a hasty quasi-synodic action was largely due to him; and many pitfalls which might have endangered the orderly growth of the Anglican Communion, especially as regards South Africa and India, were avoided owing to his practical clear-sightedness.

On the other hand, Tait was greatly at fault in dealing with matters which called for the higher gifts of a ruler, and especially in his relations with (*a*) the liberal trend in modern thought, and (*b*) the Catholic revival. (*a*) As regards the former, he was himself not a little in sympathy with it. But although a very well-read man, he was no scholar in the true sense of the word, and had neither the knowledge to feel sure of his ground nor the theological insight to perceive the real point at issue. His object in dealing with questions of faith, as in dealing with the ritual question, was primarily a practical one: he wished to secure peace, and obedience to the law as he saw it. Consequently, after his sympathies had led him to express himself favourably towards some movement, he frequently found himself compelled to draw back. He expressed a qualified sympathy with some of the writers of *Essays and Reviews*, and then joined in the censure of it by the bishops (1861). The same kind of apparent vacillation was found in his action in other cases; *e.g.*, in the Colenso case (1863), and in the controversy as to the use or disuse of the Athanasian symbol (1872). It was naturally and widely misunderstood. Some who did not know him thought, or pretended to think, that he was a Socinian or a freethinker. The world at large knew better; but even Dr Temple warned him, in the case of *Essays and Reviews*, "You will not keep friends if you compel them to feel that in every crisis of life they must be on their guard against trusting you." (*b*) As regards the second point, Tait was concerned with it during the whole of his episcopate, and above all on the side of ritual, on which it naturally came into most direct conflict with the recognized ecclesiastical practice of the day. He had to deal with the St George's-in-the-East riots in 1859, and the troubles at St Alban's, Holborn, in their earlier stages (1867); he took part as assessor in the Privy Council judgment in the Ridsdale case (1877); he was more closely concerned than any other bishop with the agitation against confession in 1858, and again in 1877. His method throughout was the same: he endeavoured to obtain a compliance to the law as declared by the courts; failing this, he made the most earnest efforts to secure obedience to the ruling of the Ordinary for the sake of the peace of the Church; after this, he could do nothing. He did not perceive how much of reason the "ritualists" had on their side; that they were fighting in some cases for practices (such as confession) which had been widely used in England since the Reformation; in other cases for what, as they contended, and not altogether unreasonably, were covered by the letter of the rubric; and that at any rate, where rubrics were notoriously disregarded on all hands, it was not fair to proceed against one class of delinquent only. In fact, it is not too much to say that, if others were inclined to ignore it altogether, Tait could hardly realize anything but the connexion between the English Church and the State. From such a position there seemed to be no escape but in legislation for the deprivation of the recalcitrant clergy; and the Public Worship Regulation Act (1874) was the result. For this Tait was by no means responsible as a whole: some of the provisions which proved most irksome were the result of amendments by Lord Shaftesbury which the bishops were unable to resist; and it must be borne in mind that the most disastrous results of the measure were not contemplated by those who were instrumental in passing it. The results followed inevitably: clergy were cited before a new tribunal, and not only deprived but imprisoned. A widespread feeling of indignation spread not only among High Churchmen, but among many who cared little or nothing for the ritual practices involved; and it seemed impossible to foretell what the outcome would be. But the aged archbishop was moved as much as anybody, and tried hard to mitigate such a state of things. At length, when the Rev. A. H. Mackonochie was on the point of being deprived of his benefice of St Alban's, Holborn, for contumacy, the archbishop, then on his deathbed at Addington, took steps which resulted in the carrying out of an exchange of benefices (which had already been projected), which removed him from the jurisdiction of the court. This proved to be the turning-point; and although the ritual difficulty by no means ceased, it was afterwards dealt with from a different point of view, and the Public Worship Regulation Act became practically obsolete. The archbishop died on Advent Sunday 1882, leaving a legacy of peace to the Church.



Archbishop Tait.
(*From a photograph by Bassano, London.*)

Tait was a Churchman by conviction; but although the work of his life was all done in England, he remained a Scotsman to the end. It was the opinion of some that he never really understood the historical position of the English Church and took no pains to learn. Tillotson was a favourite hero of his, and in some ways the two men resembled one another. But Tait had none of Tillotson's gentleness, and he rode roughshod over the obstacles in his way. To say that he was a great ecclesiastical statesman is misleading, for he could not discern the signs of the times; and, well though he administered his office, his work was in many ways a failure. On the other hand, he was undoubtedly one of the foremost public men of his day. But he was more: he was a man of great devotion and beauty of character; and his face grew steadily in power and nobility to the day of his death.

Authorities.—Bishop R. T. Davidson and W. Benham. *Life of Archbishop Tait*, 2 vols. London, 1891.—A. C. Tait. *Catharine and Craufurd Tait.* London, 1880.—*Dictionary of National Biography*, article "A. C. Tait," by W. H. Fremantle. (W. E. Co.)

Tait, Peter Guthrie (1831–1901), Scottish physicist, was born at Dalkeith on 28th April 1831. After attending the Academy at Edinburgh and spending a session at the University, he went up to Cambridge as a member of Peterhouse, and graduated as senior wrangler and first Smith's prizeman in 1852. As a fellow and lecturer of his college he remained in Cambridge for two years longer, and then left to take up the professorship of mathematics at Queen's College, Belfast. There he made the acquaintance of Andrews, whom he joined in researches on the density of ozone and on the electrolytic condensation of mixed oxygen and hydrogen, and by whom he was introduced to Hamilton and quaternions. In 1860 he was chosen to succeed his old master, Forbes, as professor of natural philosophy at Edinburgh, and this chair he occupied till within a few months of his death, which occurred on 4th July 1901, at Edinburgh. The first scientific paper that appears under Tait's name only was published in 1860. His earliest work dealt mainly with mathematical subjects, and especially with quaternions, of which he may be regarded as the leading exponent after their originator, Hamilton. He was the author of two text-books on them—one an *Elementary Treatise on Quaternions* (1867), written with the advice of Hamilton, though not published till after his death, and the other an *Introduction to Quaternions* (1873), in which he was aided by Professor Kelland, who had been one of his teachers at Edinburgh. In addition, quaternions was one of the themes of his address as president of the mathematical section of the British Association in 1871. But he did not long confine himself to pure mathematics, and soon began to produce original work in mathematical and experimental physics. In 1864 he published a short paper on thermodynamics, and from that time his contributions to that and kindred departments of science became frequent and important. In 1871 he emphasized the significance and promise of the principle of the dissipation of energy. In 1873 he took thermoelectricity for the subject of his discourse as Rede lecturer at Cambridge, and in the same year he presented the first sketch of his well-known thermoelectric diagram before the Royal Society of Edinburgh. Two years later researches on "Charcoal Vacua" with Dewar led him to see the true dynamical explanation of the Crookes radiometer in the largeness of the free path of the molecule of the highly rarefied air. From 1879 to 1888 he was engaged on a long and difficult series of experimental investigations, which began with an inquiry into the corrections required, owing to the great pressures to which the instruments had been subjected, in the readings of the thermometers employed by the *Challenger* expedition for observing deep-sea temperatures, and which were extended to include the compressibility of water, glass, and mercury. Between 1886 and 1892 he published a series of papers on the foundations of the kinetic theory of gases, the fourth of which contained what is, according to Lord Kelvin, the first proof ever given of the Waterston-Maxwell theorem of the average equal partition of energy in a mixture of two different gases; and about the same time he carried out investigations into impact and its duration. Many other inquiries conducted by him might be mentioned, and some idea may be gained of his scientific activity from the fact that a selection only from his papers, published by the Cambridge University Press, fills three large volumes. This mass of work, it must be remembered, was done in the time he could spare from his professorial teaching in the university, which he always regarded as his primary duty. In addition, he was the author of a number of books and articles. Of the former, the first, published in 1896, was on the dynamics of a particle; and afterwards there followed a number of concise treatises on thermodynamics, heat, light, properties of matter, and dynamics, together with an admirably lucid volume of popular lectures on *Recent Advances in Physical Science.* With Lord Kelvin he collaborated in writing the well-known *Treatise on Natural Philosophy.* "Thomson and Tait," as it is familiarly called ("T and T′" was the authors' own formula), was planned soon after Lord Kelvin became acquainted with Tait, on the latter's appointment to his professorship in Edinburgh, and it was intended to be an all-comprehensive treatise on physical science, the foundations being laid in kinematics and dynamics, and the structure completed with the properties of matter, heat, light, electricity, and magnetism. But the literary partnership ceased in about eighteen years, when only the first portion of the plan had been completed, because each of the members felt he could work to better advantage separately than jointly. The friendship, however, endured for the twenty-three years which yet remained of Tait's life. Tait also collaborated with Balfour Stewart in the *Unseen Universe*, which was followed by *Paradoxical Philosophy.* Among his articles may be mentioned those which he wrote for the ninth edition of this Encyclopædia on Light, Mechanics, Quaternions, Radiation, and Thermodynamics, besides the biographical notices of Hamilton and Clerk-Maxwell. The article on Halos in the tenth edition (vol. xxix.) is also from his pen.

(H. M. R.)

Takazzè. See Abyssinia.

Takhtsingjee (1858–1896), Mahraja of Bhavnagar, was a rajput chief of the Gohel clan, and the ruler of a considerable territory in western India. He was born in 1858, and succeeded to the throne of Bhavnagar at the age of twelve, on the death of his father, Jaswantsingjee, in 1870. During his minority, which ended in 1878, the education of the chief was directed and controlled by the joint administration of Mr E. H. Percival, a member of the British Civil Service, and Azam Gavrishankar Oodeyshankar, C.S.I., one of the foremost native statesmen of India, who had served the state in various capacities and finally as minister since 1822. This system of joint administration under the direction of the paramount Power, in cases where the succession to the *gadee* of large native states on the death of the ruling chiefs devolved upon minors, was the evolution of much experience and serious consideration on the part of the local government. It was tried for the first time in the case of the Bhavnagar state, and resulted in such conspicuous success that it is now the recognized mode of administration during periods of minority. The training of the youthful chief and the conduct of the state's affairs under his guardians prospered, and at the age of twenty Takhtsingjee found himself the independent ruler of a territory nearly 3000 square miles in extent, of a highly productive character, and with a population of over 400,000, embracing large mercantile and agricultural communities. His early education, the administrative training he had undergone during the latter years of his minority, and above all his suavity of manner and sympathy with his people, soon won for him the recognition both of the British Government and his own subjects as "a model ruler of a model state." His first public act was the sanctioning of the line of railway connecting his territory with one of the main trunk lines. It was the first enterprise of its kind on the part of a native raja in western, if not in all, India, and many were the misgivings expressed by the old school of Indian politicians; but the enterprise was so fully justified by results that before long other native chiefs followed his example. The commerce and trade, and the economic and even social development of the state, which came in the wake of this railway, confirmed Takhtsingjee in a policy of progressive administration under which educational establishments, hospitals and dispensaries, trunk roads, bridges, and handsome edifices and other public works grew apace. In 1886 he inaugurated a system of constitutional rule, by placing several departments of his government in the hands of four indepenent members of a Council of State under his own presidency. This innovation, which had the warm support of the then governor of Bombay, Lord Reay, provoked a most virulent attack upon the chief, who brought his defamers to trial in the High Court of Bombay. The punishment of the ringleaders broke up a system of blackmailing to which the native rajas used to be regularly exposed, and the public spirit of Takhtsingjee in freeing his brother chiefs from this evil was widely acknowledged throughout India, as well as by the British authorities. The most conspicuous traits in the Mahraja's character were unstinted benignity and an unflinching attachment to British rule. In 1893 he took the occasion of the opening of the Imperial Institute by Queen Victoria to visit England in order to pay personal homage to the sovereign of the British Empire. His cordial reception on that occasion was a matter of the highest pride to him to the day of his death, which occurred in 1896. His eventful career was several times recognized by the British Government, which, for the first time in the history of Kathiawar, elevated the chiefs of that province in the person of Takhtsingjee to a status of equality with the highest class of native princes by enrolling him in the first rank of the Order of the Star of India, and augmenting his title of "Thakore" to that of "Mahraja." During his visit to England in 1893, the University of Cambridge conferred on him the degree of LL.D. in recognition of his encouragement of learning in his own state and of his munificent gifts to educational bodies out of it.

The Mahraja Takhtsingjee could trace his descent from a long line of progenitors, whose origin, according to the chronicles of Hindu mythology, was derived from the sun. Many of his actual ancestors were distinguished for their prowess in the battlefield against their foreign invaders, and in holding their own in internecine conflicts. The most remarkable of these was Sejukji, who was the virtual founder of the state, while of those who consolidated the kingdom and laid the foundation of its future commercial development was Bhavsingjee, who ruled long and wisely from 1723 to 1764. Takhtsingjee's own father, Jaswantsingjee, was one of the staunchest allies that Great Britain had throughout the troublous days of the Mutiny. (M. M. Bh.)

Talavera de la Reina, a town of Spain, province of Toledo, on the Tagus, 40 miles W. by N. of Toledo. It stands in the midst of a fertile, well-irrigated country, producing abundantly wheat, pod fruit, wine, olives, and vegetables. It has fine squares and streets, well lighted by electricity. Population (1897), 10,544.

Talca, a town of Chile, capital of a province and department of the same name, 156 miles south of Santiago by rail. Population (1890), 33,232; (1900), 40,987. It is an important commercial centre, and carries on a large business through the port of Constitucion (distant 5 miles) by the Rio Maule, and with the countries north and south of it by the Central railway.

Talcahuano, or Talcaguano, a town of Chile, in the province of Concepcion. Population (1895), 10,431; (1900), 15,376. It is the terminus of a railway communicating with Concepcion, Santiago, and Valparaiso. It is the most important port in southern Chile, so far as foreign trade is concerned, and is steadily increasing in importance. The value of its imports increased from £477,784 in 1890 to £954,770 in 1898. In 1900 the imports were valued at £1,242,757, the exports at £156,428. The movement of foreign shipping was in 1897—entries (from abroad), 126 ships of 284,973 tons; clearances, 42 ships of 95,743 tons; coastwise, 415 entries with 497,683 tons; clearances, 498 with 716,270 tons. In 1900 the entries from abroad and coastwise were 525 ships of 832,843 tons, and clearances the same. The Chilian Government opened a dry dock at this port in 1895. It is the finest on the west coast of South America, over 650 feet long by 70 broad. It is principally used in docking the Chilian men-of-war, and is also the principal naval depôt of the republic.

Talienwan, an open bay or roadstead on the east side of the Liaotung peninsula, in the province of Manchuria, China. It was leased to Russia by the Chinese Government in 1898 along with the naval fortress of Port Arthur, from which it is distant 40 miles. A portion of the bay, namely, that on the west side known as Port Victoria, was intended to be opened to foreign trade as soon as the railway was finished. Being ice-free all the year round, it has an advantage over the treaty port of Newchwang, which is frozen up for four months in the year. On the other hand, Newchwang lies much nearer to the great producing and consuming districts of Manchuria, and it remains to be seen how far trade will be attracted to the newer port. The railway from Port Arthur to the Russian main line in north Manchuria touches at Talienwan. The eastern part of the bay is to be retained as a Russian naval depôt, where already a number of buildings have been erected for barracks, store-houses, &c. Talienwan was the rendezvous of the British fleet during the Anglo-China war of 1860, whence the names Port Arthur and Port Victoria.

Talmage, Thomas De Witt (1832-1902), American Presbyterian preacher, was born at Bound Brook, New Jersey, 7th January 1832. He was educated at the University of the City of New York, and at the theological seminary at New Brunswick, N.J. In 1856 he became pastor of a church at Belleville, N.J. In 1859 he removed to Syracuse, N.Y., in 1862 to Philadelphia, and in 1869 to the Central Presbyterian Church in Brooklyn, later known as the Tabernacle. In 1872 the church was burned down. A larger one, holding 5000 persons, was built for him, but even this could not contain the crowds attracted by his eloquence. In 1889 this church also was burned to the ground, only to be succeeded by another and larger church, which again in its turn was burned. Shortly afterwards (1894) he moved to Washington. During the last years of his life Dr Talmage ceased to preach, and devoted himself to editing. At different periods he was editor of the *Christian at Work*, the *Advance*, *Frank Leslie's Sunday Magazine*, and the *Christian Herald*. For years his sermons were published regularly in about 3000 journals, reaching it is said, 25,000,000 readers. His books also have had large circulations. His eloquence, while sensational, was real and striking; and his fluency and the picturesqueness of his language and imagery were remarkable. He died at Washington, 13th April 1902.

Tamaqua, a borough of Schuylkill county, Pennsylvania, U.S.A., on the Schuylkill river, in a gap in Nesquehoning Mountain, on the Central of New Jersey, and the Philadelphia and Reading railways, in the eastern part of the state, at an altitude of 787 feet. Its site is uneven and its plan irregular. It is divided into east, north, south, and middle wards, and has a water-supply by gravity. It is surrounded by anthracite coal mines, and its chief industries consist in mining, handling, and shipping coal. Population (1890), 6054; (1900), 7267, of whom 625 were foreign-born.

Tamatave, the chief seaport of Madagascar, situated nearly on the centre of the eastern coast in 18° 10′ S., 39° 5′ E. It owes its importance to the existence of a coral reef, which forms a spacious and fairly commodious harbour, entered by two openings. The town is built on a sandy peninsula which projects at right angles from the general coast-line. On this are crowded together a considerable number of houses, with good shops and merchants' offices in the main thoroughfares. Tamatave is the seat of several foreign consuls, as well as of numerous French officials, and is the chief port for the capital and the interior. In 1901 the imports, consisting principally of piece-goods, farinaceous foods, and iron and steel goods, amounted to £663,925; and the exports, chiefly gold dust (£122,150), but embracing also raffia, hides, caoutchouc, and live animals, amounted to £182,400. Regular communication with Europe is maintained by steamers of the Messageries Maritimes and two other French companies, as well as by the English Castle line. Of the whole foreign trade of Madagascar, 46 per cent. is through Tamatave. Small wharves and jetties have been constructed, and other works for the improvement of the port are in progress. A short line of railway connects with Hùròndrona, a village 5 miles to the south, and will ultimately run to Antanànarìvo. There are Anglican, Congregational, and Roman Catholic churches. Owing to the character of the soil and the formerly crowded native population, the town is not healthy, and has often been attacked by epidemic disease: the plague broke out in 1898, and again in 1900. Since 1895 the native population has been removed from the town and settled in a new village to the north-west. An electric telegraph, 180 miles in length, connects Tamatave with the capital. Population about 8000. (J. SI*.)

Tamaulipas, a state of Mexico, bounded on the N. by Texas, on the N.W. by Coahuila, on the W. by Nuevo Leon, on the S. by San Luis Potosi, on the S.E. by Vera Cruz, and on the E. by the Gulf of Mexico. Area, 32,585 square miles. Population (1879), 140,137; (1895), 206,502. The commercial future of the state is assured by reason of its excellent ports (Matamoros, Tampico), its proximity to the United States, its railways, and its mineral and agricultural wealth. Three railways traverse the state—the Mexican National, the Monterey and Gulf, and the Mexican Central. The capital, Ciudad Victoria (14,774 inhabitants), is 475 miles from Mexico by rail. It has fine public buildings, tramways, and other modern improvements. Amongst other towns may be mentioned Tula, handsomely laid out (19,421), Matamoros (17,564), Tampico (11,912), Jaumave (9220), Santa Barbara (9079), Villagran (7400), Mier (7114), Loreto (7022), San Carlos (6871), Camargo (6815), Reynosa (6137), Guerrero (5664), San Fernando (5383), Bustamante (5260).

Tamayo y Baus, Manuel (1829–1898), was born at Madrid in 1829. He came of a family connected with the theatre, his mother being the eminent actress Joaquina Baus. It is interesting to note that she appeared as Geneviève de Brabant in an arrangement from the French made by Tamayo when he was in his tenth year. Through the influence of his uncle, Antonio Gil y Zárate, minister of education, Tamayo's independence was secured by his nomination to a post in a Government office. The earliest of his printed pieces, *Juana de Arco* (1847), is an arrangement from Schiller, and *Una Aventura de Richelieu*, which the author has not cared to preserve, is said to be an imitation of Alexandre Dumas. The general idea of his *Angela* (1852) was derived from Schiller's *Kabale und Liebe*, but the atmosphere is Spanish, the situations are original, and the phrasing is Tamayo's own. His first great success was *Virginia* (1853), a dramatic essay in Alfieri's manner, remarkable for its ingenuity and noble diction. In 1854 Tamayo was expelled from his post by the new Liberal Government, but was fortunately restored before long by Cándido Nocedal, a minister who had been struck by the young man's talent. Next year he joined with Aureliano Fernández-Guerra y Orbe in writing *La Ricahembra*, a historical drama which recalls the vigour of Lope de Vega. *La Locura de Amor* (1855), in which Juana *la loca*, the passionate, love-sick daughter of Isabel the Catholic, figures as the chief personage, established Tamayo's reputation as Spain's leading playwright. *La Hija y Madre* (1855) is a failure, and *Bola de Nieve* (1856) is notable solely for its excellent workmanship. It is unfortunate that Tamayo's straitened means forced him to put original work aside and to adapt pieces from the French. Examples of this sort are fairly numerous. *Lo Positivo* (1862), imitated from Adrien-Augustin-Léon Laya's *Duc Job*, is well-nigh forgotten, though the Spanish version is a dexterous piece of stagecraft and contains some elements of original value. *Del dicho al hecho* (1864) is from *La Pierre de touche* of Jules Sandeau and Émile Augier, and a pleasing proverb, *Más vale Maña que Fuerza* (1866) is a great improvement upon Mme Caroline Berton's *Diplomatie du Ménage*. The revolution of 1868, which cost Tamayo his post at the San Isidro Library, is indirectly responsible for *No hay mal que por bien no venga* (1868), a clever arrangement of *Le Feu au Couvent*, by Henri Murger's friend, Théodore Barrière. During these seven years Tamayo produced only one original piece, *Lances de Honor* (1863), which turned upon the immorality of duelling, and led to a warm discussion among the public. Written in prose, the piece is inspired by a breath of mediæval piety which had not been felt in the Spanish theatre since the 17th century. This renascence of an old-world motive has induced many critics to consider *Lances de Honor* as Tamayo's best work, but that distinction should be accorded rather to *Un Drama nuevo* (1867), a play in which the author has ventured to place Shakespeare and Yorick upon the scene. *Los Hombres de bien* (1870) was Tamayo's final contribution to the Spanish stage. His last years were spent in recasting his *Virginia*, and the result of his efforts may be read in the posthumous edition of his *Obras* (Madrid, 1898–99). In 1859 Tamayo was elected a member of the Spanish Academy, to which he afterwards became permanent secretary; and in 1874 the Conservative minister, Alejandro Pidal y Mon, appointed him director of the National Library. He died in 1898. At his best Tamayo is the most accomplished and most rational dramatist that Spain has produced since 1850. He was not, however, altogether happy in his period. The rage for romanticism was over; the taste for the old classic—that is to say, for the ancient romantic—drama had not yet reached the Madrid public; and the audacities of a later time would not have been endured. Yet Tamayo's qualities are of a very high order. His ambition was great, his scrupulousness was admirable; his origin and early training gave him an intimate knowledge of theatrical possibilities; and, though he was a born poet, his prose is not inferior to his verse. Some of his characters, such as Juana *la loca*, are drawn with exceptional skill; and, as he is rich in the eloquent declamation which characterizes the national theatre, his dramas will constantly be read though they may not be played. (J. F.-K.)

Tamboff, a government of central Russia, lying to the south-east of Tula and Ryazan, with an area of 25,710 square miles. Population (1883), 2,519,660; (1897) 2,715,453 (domiciled only), of whom 1,385,100 were women; average density 105 per square mile, and urban population 224,697. The government is divided into twelve districts, the chief towns of which are Tamboff (48,134 inhabitants), Borisoglyebsk (22,370), Elatma (4533), Kirsanoff (10,677), Kozloff (40,347), Lebedyañ (13,352), Lipetsk (20,323), Morshansk (27,756), Shatsk (13,928), Spassk (6024), Temnikoff (5737), and Usmañ (9843). In 1897 there were 1944 schools, attended by 85,500 boys and 22,400 girls. Agriculture, the chief industry, has greatly developed, machinery being largely used on the wide prairies. Of forests there remained in 1900 only 1,224,900 acres, while 5,760,200 acres were under cereal crops. The average yield of cereals in 1895–1899 was: rye, 20,194,000 cwt.; wheat, 494,000 cwt.; oats, 9,401,000 cwt.; and barley, 12,250 cwt.; all cereals, 32,346,000 cwt.; also potatoes, 13,445,000 cwt. Good breeds of horses and horned cattle are raised, and there were in 1897 494,100 horses, 321,800 horned cattle, 1,121,710 sheep, and 128,770 pigs. Manufactures are still backward, the chief factories being flour-mills, distilleries, sugar works, and tallow works, whose aggregate returns in 1897 amounted to only about 16,000,000 roubles.

Tamboff, the capital of the above government, on the Tsna river, 300 miles south-east of Moscow by rail. It is a prairie town, the merchants of which carry on a considerable trade in grain and cattle. Population (1897), 48,134.

Tamise, a town of Belgium, in the province of East Flanders, 25 miles east of Ghent, on the Scheldt, with a station on the line from Malines to Saint Nicolas. Its manufactures include lace, cotton and woollen fabrics, and soap. Jute yarns and tissues are also produced. Population (communal, 1880), 9943; (1890), 11,039; (1900), 12,348.

Tammany Hall, a political organization in the city of New York, U.S.A., claiming to be the regular representative of the Democratic party in that city. It takes its name from a sachem or chief of the Delaware Indians, Tamanend or Tammany, the name itself meaning "the Affable." In May 1789 the "Tammany Society or Columbian Order" was founded in New York City as a patriotic, benevolent, and non-political organization, and with the intent to counteract the influence of what was believed to be the aristocratic Order of the Cincinnati. In 1805 it was incorporated, in 1811 it built its first hall in Frankfort Street near the City Hall, and in 1867 it moved to its present hall in Fourteenth Street. The society was a secret organization, divided into tribes, with sachems (the most important being the Grand Sachem) as the chief officials, and with a ritual of supposedly Indian character. This "Tammany Society" is not itself the well-known political organization, but rents its hall to the Tammany Hall General Committee, the "Tammany Hall" of political notoriety: the leading members, however, of the "Society" and of the "Hall" are identical, so that the difference between the two is little more than nominal. Almost from the beginning Tammany has been actively engaged in politics, being part of, and during the greater period of its existence actually representing in New York City, the Democratic party. It has had local rivals at different times, but these, though successful for a while, have not lived long; on the other hand, the Hall has not generally been regarded with favour by the Democratic party throughout the country at large. In 1800 it worked for the election of Jefferson as President, and by 1812 had become an important force in New York City politics. Its power grew steadily with the growth of the city, with the increase of the ignorant immigrant vote, and with the introduction of the spoils system. It reached its height of power under the leadership of William M. Tweed about 1870. In the mayoralty and the other administrative offices and in the common council of the city, in the chair of the governor of the state, and even in some of the judges' seats, Tweed had placed or had secured the election of accomplices or tools. A system of official plunder then began that has had few parallels in modern times. How much was actually stolen can never be known; but the bonded debt of the city, which was $36,000,000 at the beginning of 1869, was $97,000,000 in September 1871, an increase of $61,000,000 in two years and eight months: nor was this all, for within the same period a floating debt of $20,000,000 was incurred, making a total of $81,000,000, or over £16,000,000. For this vast sum the city had something to show, but very far from what it should have had. The method of plunder was the presentation of excessive bills for work done, especially in connexion with the new court house then being erected. The bills were ostensibly paid in full, but in reality only in part, the rest being retained by Tweed, and divided amongst his followers in proportion to their importance. The total cost of the court house to the city was about $13,000,000—many times the actual cost of construction. Later investigations showed that $404,347 was paid for safes, and $7500 for thermometers to be used in this building. The amount paid in these two years for the city printing and stationery was nearly $3,000,000. The end came through a petty quarrel over the division of the spoils. One of the plunderers, dissatisfied with the office he had received, gave to the *New York Times* a copy of certain swollen accounts which showed conclusively the stealing that had been going on. The better classes were now thoroughly aroused, and with Mr Samuel J. Tilden, afterwards governor of the state, at their head, completely overthrew the ring and rescued the city. Tweed was tried and convicted, but afterwards released on a technicality of law; he was re-arrested, but managed to escape and fled to Spain; was identified and brought back to gaol, where he died in 1876. The rest of the gang fared little better. Tammany itself, however, was not killed, but scotched. Within a few years and under a new leader, "Boss" Kelly, it was again in control of the city. Kelly was succeeded after his death in 1886 by Richard Croker, a former saloon-keeper, who became absolute master of Tammany. During the years 1881 to 1902 Tammany was in virtual control of the city government about half the time, a Tammany and a reform mayor often alternating. The two most conspicuous overthrows of Tammany since the days of Tweed were in 1894 and in 1901, the latter being the more important, in that practically the whole reform ticket from mayor to alderman was elected. The grosser forms of corrupting that prevailed under Tweed did not as a rule prevail in later years. Instead, the money raised by and for the Hall and its leaders has come from the blackmailing of corporations, which find it easier to buy peace than to fight for their rights; from corporations which desire concessions from the city, or which do not wish to be interfered with in encroachments on public rights; from contributions of the liquor-dealers, whose licences are more or less at the mercy of an unscrupulous party in power; from contributions of other dealers, especially in the poorer parts of the city, whose business can be hampered by the police; from contributions of office-holders and candidates for office;

and, lastly, from contributions, obtained indirectly through corrupt police officials, of the criminal classes and gambling establishments in return for non-intervention on the part of the police. The power of Tammany Hall is the natural result of the well-regulated machine which it has built up throughout the city, directed by an omnipotent "boss." Each of the "assembly districts" into which the city is divided sends a certain number of representatives to the General Committee of Tammany Hall. Each district also has a "boss" or leader and a committee, and these leaders form the Executive Committee of the Hall. There is also a "captain" for each of the voting precincts, over 1000 in number, into which the city is divided. The patronage of the city filters down from the real "boss" of the Hall to the local precinct leader, the latter often having one or more small municipal offices at his disposal; he also handles the election money spent in his precinct. The party headquarters in the different assembly districts are largely in the nature of social clubs, and it is in considerable degree through social means that the control of the Hall over the poorer classes is maintained. The headquarters are generally over or near a saloon, and the saloon-keepers through the city belong as a rule to the Hall—in fact, are its most effective allies or members. It should be remembered too that the Hall is not subject to divided counsels, but is ruled by one man, a "boss" who has risen to his position by sheer force of ability, and in whose hands rest the finances of the Hall, for which he is accountable to no one. The incorporation of Brooklyn in the city of New York had not up to 1902 led to the extension of Tammany into the former city. (See New York City.) (F. H. H.)

Tammerfors, a town in the grand duchy of Finland, capital of the government of Tavastehus, on the rapids connecting Lakes Näsi-järvi and Pyhä-järvi, 125 miles by rail N.W. of Helsingfors. Tavastehus being the chief industrial province of Finland, 14,000 workers are employed in factories, the yearly returns of which amount to 43,100,000 marks, including textiles, 20,540,000 marks; paper, 7,460,000 marks; timber and wood, 6,226,000 marks. Tammerfors is an important centre for the manufacture of and trade in cotton, linen, and woollen goods, leather, and paper. Population (1875), 8443; (1898), 28,725.

Tampa, a city and seaport of Florida, U.S.A., capital of Hillsboro county, on Tampa Bay, on the west side of the peninsula, on the Plant and the Florida Central and Peninsula railways. It is a favourite winter resort, with magnificent hotels, good water-supply, and sewerage system. The harbour is excellent, with ample depth of water, and the city has regular steamer communication with the principal ports of the Atlantic and Gulf coasts. It has a large commerce in lumber, phosphates, and cigars. The chief industry is the manufacture of cigars from Cuban tobacco, an industry which for some time increased rapidly, as indicated by the following figures of population: (1880), 720; (1890), 5532; (1900), 15,839, of whom 5085 were foreign-born and 4382 negroes.

Tanega-shima, an island 36½ miles long and 7¼ broad at its widest part, lying to the south of Kiushiu, Japan, in 30° 50′ N. and 131° E. It is a long low stretch of land, carefully cultivated, and celebrated as the place where Mendez Pinto landed when he found his way to Japan in 1543. Until modern times firearms were colloquially known in Japan as "Tanega-shima," in allusion to the fact that they were introduced by Pinto. The distance from Misaki, the most northerly point of Tanega-shima, to Satonomisaki, the most southerly point of Kiushiu, is 23 miles.

Tanganyika, a vast lake in East Central Africa, the longest freshwater lake in the world, measuring just over 400 miles, with a general breadth varying from 30 to 45 miles, and an area of about 12,700 square miles. It occupies the southern end of the great central rift valley, which terminates suddenly at its southern point, the line of depression being represented farther south by the more easterly trough of Lakes Nyasa and Rukwa, from which Tanganyika is separated by the Fipa plateau, composed of old granitoid rocks; though even here traces of old valley-walls are said by Dr Kohlschütter to exist. North of Tanganyika the valley is suddenly interrupted by a line of ancient eruptive ridges, which dam back the waters of Lake Kivu (*q.v.*), but have been recently cut through by the outlet of that lake, the Rusizi, which enters Tanganyika by several mouths at its northern end. The flat plain traversed by the lower Rusizi was evidently once a portion of the lake floor. Tanganyika has been formed by the subsidence of a long narrow tract of country relatively to the surrounding plateaux, which fall to the lake in abrupt cliffs, some thousands of feet high in places. The geological formations thus exposed show that the plateaux are composed of a base of eruptive material, overlaid by enormous deposits of reddish sandstones, conglomerates, and quartzites, exposed in parts to a depth of 2000 feet. Besides the plain to the north, a considerable area to the west, near the Lukuga outlet (see below), shows signs of having been once covered by the lake, and it is the opinion of Mr J. E. Moore that the sandstone ridges which here bound the trough have been recently elevated, and have been cut through by the Lukuga during the process. The past history of the lake is still a disputed question, Mr Moore's view that it represents an old Jurassic arm of the sea being contested by Dr Stromer. The mapping of Tanganyika, which long rested on the surveys of Mr E. C. Hore, published in 1882, has received considerable modification from the work of Fergusson, Lemaire, Kohlschütter, and Gibbons, who have shown that while the general outline of the coasts has been drawn fairly correctly, the whole central portion, and to a lesser degree the northern, must be shifted a considerable distance to the west. At Mtowa, in 5° 43′ S., the amount of shifting of the west coast is about 30 miles. At Ujiji, on the east coast, the longitude is given by Fergusson and Kohlschütter respectively as 29° 42′ 0″ E. and 29° 42′ 38″ E.,[1] as compared with 30° 4′ 30″ E. of Cameron, a difference of some 25 miles.

Recent investigations have shown that the Mlagarazi, perhaps the largest river that enters the lake, derives most of its water from the rainy districts east of the strip of high ground which shuts in the lake on the north-east. The main stream, in fact, has a nearly circular course, rising in 4° 40′ S., only some 10 miles from the lake shore and less than 40 miles from its mouth, though its length is at least 220 miles. The other branches of the Mlagarazi, which traverse the somewhat arid granite plateaux between the lake and 33° E., bring comparatively little water to the main stream. In its lower course the river is a rapid stream flowing between steep jungle-clad hills, with one fall of 50 feet, and is of little use for navigation. The various channels of its delta are also obstructed with sand-banks in the dry season. The Rusizi, the next (or perhaps equal) in importance among the feeders of the lake, has already been spoken of. It receives many tributaries from the sides of the rift valley, and is navigable for canoes. The outlet of the lake to the Congo (*q.v.*), after running strongly for some years, has shown signs of ceasing to flow. This is due to the gradual fall of the lake level, which was in progress from about 1880 to 1890 or later, and which was estimated by Wissmann at 2 feet annually. In 1896 Captain Ramsay found that a wide level plain, which had before been covered by water, intervened between Ujiji and the lake, but stated that no farther sinking had taken place during the two previous years. Near Tembwe head Mr L. A. Wallace found recent beaches 16 feet above the present level. Further fluctuations have since taken place, for whereas the Lukuga was reported blocked by a bar about 1897, a certain amount of water was found flowing down by Mr Moore in 1899; while in 1901 Mr Codrington found the level 4 or 5 feet higher than in 1900, the outlet having again silted up. In any case, the alterations in level appear to be merely periodic, and due to fluctuations in rainfall, and do not point, as some have supposed, to a secular drying up of the lake.

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[1] So given in a letter to Mr Fergusson; the final result, published in 1902, is 29° 40·2′, but it is not clear whether the figures refer to the same point of observation.

In the partition of Africa among the European Powers, the shores of Tanganyika have been shared by the Congo State, Great Britain, and Germany, Great Britain holding the southern extremity, Germany the east, and the Congo State the west. Stations have been established on the lake by all three Powers, the principal being—German: Bismarckburg in the south and Ujiji[1] in the north; British: Sumbu and Kasakalawe, on Cameron Bay; Belgian: Mtowa or Albertville in 6° S. Missionaries, especially the Catholic "White Fathers," are also active on its shores. A small steamer, the *Good News*, was placed on the lake by the London Missionary Society in 1884, but is now owned by the African Lakes Corporation; a larger steamer, the *Hedwig von Wissmann*, carrying a quick-firing Krupp gun, was launched in 1900 by a German expedition under Lieutenant Schloifer; and two others are owned by the "Tanganyika Concessions" and Katanga companies. The greater part of the trade with Tanganyika is done by the African Lakes Corporation by the Shire–Nyasa route, but the Germans have been active in opening up overland routes from Dar-es-Salaam.

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Tangermünde, a town of Prussia, province of Saxony, on the Elbe, 43 miles north-north-east from Magdeburg by rail *viâ* Stendal. It has numerous buildings of the 14th and 15th centuries, including the turreted walls, the church of St Stephen (1376), and the town hall. The castle, built in the 14th century, was the chief residence of the Margraves of Brandenburg. There is a school of navigation; and the manufactures include sugar, oil, shot, and brewing, and there is a trade in corn. Population (1885), 5852; (1895), 9059; (1900), 11,524.

Tangier (improperly *Tangiers*, locally *Tanjah*), a seaport of Morocco, situated on the Strait of Gibraltar. It is the only town in the empire in which the effects of progress are marked. As the seaport nearest to Europe it has been for over a century the diplomatic headquarters, since the Court divides its time between the three metropolitan cities—Fez, Marrákesh, and Mequinez—and campaigns for the chastisement of unruly tribes. The nucleus of a cosmopolitan society thus formed has expanded into a most powerful community, enjoying privileges and immunities unknown to natives who do not receive its protection. Not only has the steadily increasing number of visitors induced the opening of first-class hotels, but extensive building operations have been necessitated, resulting in the immigration of some thousands of artisans, chiefly Spanish. Several printing-presses have been established, and newspapers appear in Spanish, French, and English. Among the more apparent signs of development are the European shops, which are replacing the picturesque native cupboards; the drinking dens, which have sprung up at every corner; telephone wires, and electric light; while for corn-mills, &c., European machinery has been introduced. Elsewhere these details might seem trivial, but in so conservative a land as Morocco they are signs of the times which did not fail to arouse the alarm and disgust of the late sultan on his only visit to the city "devoted to dogs." The Europeans number perhaps 6000 in an estimated population of 25,000, the Jewish element forming a somewhat larger proportion. Tangier is the headquarters of the Franciscans, the North Africa Mission, and the Gospel Union of Kansas. Of the annual imports, which average about £300,000 in value, but were £427,750 in 1899 and £488,670 in 1900, about two-fifths come from or through Great Britain and Gibraltar, and nearly one-fourth from France. About one-half of the total value represents cottons. But for increased facilities for reaching Fez and Mequinez by way of Laraiche and Rabat, the imports by way of Tangier would be much greater. The exports average only about £260,000 in value, though in 1900 they rose to £386,270, so that there is a constant drain of specie, made up for, however, at some of the other ports. The principal items under this head are: Oxen, £75,700 in 1900 (chiefly to Spain); slippers, £62,000; wax, £46,200; woollens (to the East), £41,200; eggs, £78,000 (chiefly to Spain); and goatskins, £40,500, the agricultural produce finding but a slight outlet at this port. Shipping entered (1896), 324,183 tons; (1898), 391,517 tons; (1900), 423,900 tons. (B. M*.)

Tanjore, a city and district of British India, in the Madras Presidency. The city is situated on the right bank of the Cauvery; an important junction on the South Indian railway, 218 miles south of Madras. Population (1881), 54,745; (1891), 54,390; (1901), 57,605. Municipal income (1897–98), Rs.94,920. Tanjore is a great centre of Brahmans and of Sanskrit literature. There are Roman Catholic and S.P.G. missions. St Peter's College had 126 students in 1896–97, the three high schools 541 pupils, and the Prince of Wales medical school 25 students and an endowment of Rs.1,00,000. There are five printing-presses, issuing one vernacular newspaper. Though the city makes specialities of jewellery, carpets, modelling in pith, &c., it has no large industries.

The district of TANJORE has an area of 3709 square miles; population (1881), 2,131,019; (1891), 2,228,114, showing an increase of nearly 5 per cent.; average density, 601 persons per square mile, compared with 252 for the province generally. In 1901 the population was 2,245,361, showing an increase of less than 1 per cent. The land revenue and rates in 1897–98 were Rs.67,26,484, the incidence of assessment being Rs.5 per acre, compared with R.1.2.0 for the province generally; cultivated area, 1,273,606 acres, of which 957,814 were irrigated, including 827,994 from Government canals; number of police, 1238; boys at school (1896–97), 52,965, being 33 per cent. of the male population of school-going age; girls at school, 7116, being 4 per cent.; registered death-rate (1897), 27·4 per 1000. The one staple crop is rice, which is grown on 85 per cent. of the total cultivated area. The chief irrigation work is the Cauvery delta system, upon which the capital outlay has been Rs.19,94,978. In 1897–98 the irrigated area was 989,808 acres, and the net profit was 41 per cent. The district is traversed by several branches of the South Indian railway, running to Mayaveram, Karikal, Negapatam, and Muttupet. The district board has undertaken to extend the last-named branch to Avadaiyarkovil. There are no large industries, except one rice-cleaning mill. The chief seaport is Negapatam. In 1897–98 the total sea-borne trade was valued at Rs.1,94,29,666, chiefly exports of rice to Ceylon.

Tank Ships. See PETROLEUM and SHIPBUILDING.

Tann-Rathsamhausen, Ludwig Samson, BARON VON UND ZU DER (1815–1881), Bavarian general, was born at Darmstadt on the 18th of June 1815, the scion of an old Alsatian family. Entering the army as ensign of artillery in 1833, he soon afterwards, in quest of adventure, joined a French military expedition operating in Algiers against the Tunisian frontier. In 1849 von der Tann took part in the Danish war, and especially distinguished himself at the lines of Düppel. Becoming lieutenant-general in 1850, he was placed in command of a division. In the war of 1866 he was chief of the staff to Prince Charles of Bavaria, who commanded the South German contingents. Although vehemently attacked in the Ultramontane press for the unsuccessful issue of this campaign, he continued to enjoy the favour of the king, and received promotion, being appointed in 1869 commandant of Munich. In the Franco-German war he commanded the 1st Bavarian corps, and fought with great gallantry at Wörth and Sedan, being in the latter battle prominently concerned in the attack upon Bazeilles. Transferred in the autumn to an independent command on the Loire, he conducted the operations against Aurelle de Paladines, at first with marked success, and forced the surrender of Orleans. He had, however, at Coulmiers to give way before a numerically larger French force; but reinforced, he fought several successful engagements under the Grand Duke of Mecklenburg near Orleans. On the termination of the war he was appointed commander-in-chief of the 1st Bavarian corps, a post which he held until his death at Meran on the 26th of April 1881.

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[1] The transference of the German station from Ujiji, 7 miles north-west, to Kajoma Bay—a better harbour—is meditated.

Tantah, a town of Lower Egypt, in a central position nearly midway between the two main branches of the Delta, and converging-point of several railways traversing the Delta in all directions. It is the capital of the rich province of Gharbieh, and is noted for the fairs and Moslem festivals, which are held three times a year in honour of the renowned saint, Seyyid el-Bedáwi, and are sometimes attended by 200,000 pilgrims and traders. There are a large railway station, a very fine mosque (restored), and a palace of the Khedive. Population (1900), 35,000.

Tapajos. See AMAZON.

Tapestry. See TEXTILES.

Tara, a district town of Russia, western Siberia, in the government of Tobolsk, 201 miles N.N.E. of the Trans-Siberian railway at Omsk, on the left bank of the Irtysh river, 35 miles below its junction with the river Tara. It has a distillery and several tanneries, and the surrounding country is beginning to be thickly populated with Russian immigrants. Population (1897), 7226.

Tarai, or TERAI (=moist land), the name of the submontane strip of marshy jungle stretching along beneath the lower ranges of the Himalaya in northern India. This strip extends roughly from the Jumna river on the west to the Brahmaputra on the east. Everywhere it is most unhealthy, and inhabited only by tribes who seem to be proof against malaria. A large portion lies within Nepal. The part below the Kumaun hills used to form a district of the North-Western Provinces, called Tarai, now combined with Naini Tal. Area, 963 square miles; population (1891), 210,568, showing a density of 219 persons per square mile.

Tarancon, a town of Spain, province of Cuenca, with a station on the railway from Aranjuez to Cuenca. Population (1887), 5066; (1897), 5316. It is situated in a plain watered by the river Rianzares, and the principal products of the district are wheat, wine, oil, and fruit. The town has some manufactories of linen goods, distilleries of alcohol, and saw-mills. The streets are regular, and contain many good modern houses, including the palace of the Duke of Rianzares, who became the morganatic husband of the Queen Regent Christina of Bourbon, widow of Ferdinand VII. and mother of Isabella II. He built this palace and gardens, and restored the convent of our Lady of Rianzares. Tarancon has a few old churches and convents.

Taranto, a seaport of southern Italy, on the gulf of the same name on the Ionian Sea. In 1861 the military importance of Taranto, which Napoleon I. had foretold, was recognized by the Italian Government, and in 1864 a Naval Commission designated it as third maritime arsenal, after Spezia and Venice. In 1882 it was declared the seat of the second maritime department in place of Naples, but the declaration was afterwards withdrawn out of regard for Neapolitan susceptibilities. Nevertheless, the arsenal must in time take precedence over that of Naples, which will then be given over to private industry. Work was begun on the arsenal in 1883, and continued as the finances of the State permitted, and already it is capable of turning out new war-vessels and of executing repairs of all kinds for the Mediterranean Squadron. The arsenal extends for a mile and a half on the southern coast of the Mare Piccolo, which constitutes its chief basin. The receiving dock and the anchorage for torpedo-boats, with a wide landing-stage, form dependencies. The arsenal proper faces north-east, and has an area of 2,564,000 square metres. Its dock is 220 metres long, 38 metres wide, and 11·50 metres deep. The dock is divisible into two compartments, each capable of containing a full-sized battleship. It holds 70,000 metres of water, which can be drawn off in eight hours by two 600-h.p. steam pumps. The equipment of the arsenal comprises cranes up to 100 tons' lifting power, eight workshops, supply magazines, a coalyard of 85,000 tons' capacity, three-quarters of a mile of wharves, two moles 100 and 180 metres long, complete railway communication between all points of the workshops and yards, and an aqueduct supplying 1000 cubic metres of water a day to two reservoirs of the capacity of 200 and 2000 cubic metres. In addition there are other naval dependencies, barracks for marines, and an ammunition depot. The Mare Grande is connected with the Mare Piccolo by a channel 800 metres long, constructed at a cost of £120,000, and sufficiently capacious to permit the passage of the largest battleships. In its present form it provides well-sheltered anchorage, 11 metres deep and 6325 acres in extent. Taranto as a port is therefore superior to Spezia, Toulon, Marseilles, and Cherbourg. The channel was bridged in 1887 by an iron swivel-bridge, which when open leaves a passage-way 60 metres broad. In consequence of the establishment of the arsenal the importance of Taranto is steadily increasing. The citadel built in 1404 has been demolished. Large new buildings and wide streets have been constructed. The city is the seat of an archbishopric and a sub-prefecture, and also includes 23 associations, several of which are mutual benefit societies, four charitable institutions, and well-kept municipal and Government schools. The chief industry is the cultivation of oysters, the *Ostrea Tarantina* being a variety of the *Ostrea edulis*. The oyster parks are four in number, and yield an annual total of 27,000,000 oysters, worth £10,000. Besides oysters, Taranto carries on a large trade in *cozze*, a species of large black mussel of pleasant flavour, which is packed in barrels with a special sauce. The other chief trades are barrel-making, oil-making, soap-making, and a mother-of-pearl button factory. Corn, honey, and fruit are largely exported from the district. Population (1881), 26,000; (1901), 53,000.

Tarapaca, a province in the north of Chile, situated between 18° 30′ and 21° 40′ S. and 68° 20′ and 70° 15′ W. It is bounded on the N. by the province of Tacna, on the E. by Bolivia, on the S. by Antofagasta, and on the W. by the Pacific. Area 19,300 square miles, divided into two departments. It was ceded to Chile by Peru, and organized as a province in 1884. In 1898 the marriages were 426; births, 2665; deaths, 2712. The capital is Iquique. Population of province (1900), 98,769.

Tarascha, a district town of Russia, in the government of Kieff, 12 miles from Olshanitsa station of the South-Western railway. There are large flour-mills and sugar works in the district, and a brisk trade in flour, spirits, and sugar (exported) is carried on. Population (1897), 11,452.

Tarazona, a town of Spain, province of Saragossa, on the river Queiles, to the north-west of Borja, with a station on the railway to Tudela. The surrounding country is mountainous, but many of the hills are cultivated nearly to the summit. It produces wine, oils, hemp, and wheat in abundance. The town is situated in a pleasant, well-wooded vale, on rising ground, crowned by the episcopal palace and tower of Magdalena. The part of the town on the right bank of the Queiles has narrow, steep streets with old houses; the suburb on the left bank is modern. The parish church of La Magdalena is a more ancient cathedral, with a Gothic tower, arabesques, remains of a Byzantine crypt, and fine chapels. The Church of St Michael, too, is a fine Gothic structure, and Tarazona has several well preserved convents, a bull-ring, a town hall, and good schools for both sexes. Population (1897), 8470.

Tarentum, a borough of Allegheny county, Pennsylvania, U.S.A., on the Allegheny river, and the Allegheny Valley and Pennsylvania railways, in the western part of the state. Population (1890) 4627; (1900), 5472, of whom 1173 were foreign-born.

Targul Ocna, a small town of Moldavia, Rumania, on the left bank of the river Trotus, 80 miles south-west of Jassy. It lies on a series of bare hills formed of enormous deposits of rock-salt, which are worked for the benefit of the state. It was only in 1870, however, that the state undertook the working of the mines, where prisoners condemned to penal servitude are employed. The depth of the layer of salt is unknown, boring for 600 feet having been made without the bottom being reached. The annual production from the mines is from 10,000 to 12,000 tons. Between the salt mines and the town is the prison, consisting of large buildings surrounded by high walls. This is the largest penal establishment in Rumania. There are three churches, the most important being that of Raducanu, built in 1762. Population (1900), 8033.

Tarifa, a seaport of Spain, province of Cadiz, on the strait, and 21 miles W.S.W. of Gibraltar. Population (1877), 12,134; (1897), 11,699. A new lighthouse has been constructed on the southern part of the island in front of the town. The trade is not very important, except in fresh and salted fish and live stock.

Tariffs.—Resort is made to tariffs, or duties on imports, partly to secure revenue, partly to affect the course of industry within a country. Strictly speaking, these two objects are inconsistent with each other; since a customs duty, in so far as it causes a domestic industry rather than a foreign to supply the market, ceases to be a source of revenue. But in a great number of cases the imposition of a duty causes only a partial displacement of the foreign supply, and hence brings some revenue from that which remains. This circumstance strengthens the hold of the protective system, especially in countries where customs duties are an important source of revenue, the combination of fiscal convenience and of protection to home industry being a highly attractive one. Where tariff duties are imposed solely for revenue, an equivalent excise tax is imposed within the country, so as to put the domestic producer precisely on the footing of his foreign competitor; and tariffs so maintained are in complete conformity with the principle of free trade.

Great Britain.—Between the close of the Napoleonic wars of 1815 and the year 1860, the tariff system of Great Britain was changed from elaborate protection to practically complete free trade. An attempt had indeed been made in 1786 to modify the rigidly protective legislation of the 18th century. In that year Pitt concluded a commercial treaty with France, providing for large reductions of duties in both countries. But the treaty was swept away with the outbreak of the wars with France, and accordingly the old system was still in force in 1815. The first important step, and in some respects the decisive step, towards modifying it was taken in 1824, under the policy of Huskisson. In that year, and again in 1825, great reductions were made in the duties on raw materials, especially on wool, raw silk, flax, and iron, while considerable reductions were also made in the duties on manufactured goods. The most sharply contested of the changes was in regard to silks, which had been completely prohibited, and were now admitted at a duty of 30 per cent. A considerable breach was thus made in the protective system; and some further changes in the same direction were made in the next decade, especially under Lord Althorp in 1833. But in the decade from 1830 to 1840 the Corn Laws were the chief subject of contention. The great increase in population since the middle of the 18th century had made England a corn-importing country, especially with the rapid growth of manufactures in the early years of the 19th century. The first systematic Corn Laws imposing duties on grain had been passed in 1773. From 1816 onwards a series of measures were passed, all designed to maintain the high price of grain. The Act of 1816 prohibited the importation of wheat when the price was less than 80s. a quarter (=$2.50 a bushel). In 1822 the prohibitive point was lowered to 70s. In 1828 the sliding scale was introduced, under which the duty went up and down as the price of grain went down and up; and it was against this form of the Corn Law that the great agitation led by Cobden and Bright was directed after 1830. For a long time the anti-Corn Law agitation seemed to have no effect, although conducted with extraordinary skill and enthusiasm. In 1842, however, Sir Robert Peel made the first important concession, by modifying the sliding scale, his opponent, Lord John Russell, having proposed in the previous year a fixed duty of 8s. a quarter. In view of the bad harvest of 1845–46, and the famine in Ireland in 1846, Peel surrendered, and proposed in 1846 the admission of grain with only a fixed duty of 1s. a quarter as a registration fee. This change was carried, but Peel, being able to carry only a fraction of his party with him, was compelled shortly afterwards to resign. The Corn Laws had great political strength, serving as they did the interests of the landowners, whose hold on Parliament was still very strong; but the general economic situation in Great Britain, from the rapid growth of the manufacturing population and the imperative need of more food, made their abolition inevitable. After having been maintained till the middle of the century, apparently with irresistible support, they suddenly collapsed under the strain of a season of exceptionally short crops. Both their continued maintenance and their final sudden abolition are in some respects divergent from the general course of British tariff history.

Corn Laws repealed, 1846.

The remodelling of the tariff system in the direction of free trade went on, little retarded by the maintenance of the Corn Laws and not much accelerated by their abolition. In 1842 great reductions of duty were made on a large number of articles; in 1846 still further reductions of duty were made; another series of changes came in 1853; and finally, in 1860, the last remnant of protective duties disappeared. The four Acts of 1842, 1846, 1853, 1860—the first two under Peel's leadership, the second two under Gladstone's guidance—thus carried out gradually the policy of free trade in regard to other articles than grain. The first of them, in 1842, was signalized by the introduction of the Income Tax as a means of raising revenue to replace that lost by the diminished import duties. The last of them, in 1860, was largely influenced by the great commercial treaty with France. In that treaty the concessions made to France were the reduction by Great Britain of duties on wines and spirits, and the admission, free of duty, of some important French products, notably silk manufactures, gloves, and other products in which the French had superiority. Great Britain, instead of limiting the concessions to France, in 1860 made them applicable to all the world. The silk manufacture, as to which the first great changes had been made in 1824, and on whose products the duties had been kept higher in previous Acts than on other manufactures, was thus compelled, notwithstanding violent opposition, to face unfettered foreign competition.

General changes in 1842–60.

Two general features should be noted in regard to the tariff history of Great Britain. In the first place, most of the reductions of duty on manufactured articles were of little practical significance. The great mass of manufactured commodities were produced in the United Kingdom more cheaply than in foreign countries, and would not have been imported, with duty or without, except in sporadic amounts for some special qualities. The changes hence involved little real readjustment of industry. There is thus some ground for the assertion that the policy of free trade was not adopted by the United Kingdom until its industries had reached the stage of being independent of protection. But this does not hold good of some manufactures; especially not of the silk industry, and some parts of the woollen and linen trades. Still less does it hold good of raw materials, many of which have been really affected by the duties, and were largely imported after their abolition. Such was the case not only with some metals, such as lead, zinc, copper, but still more strikingly with textile materials such as wool, flax, and the like, and most of all with agricultural products such as grain, meat and meat products, timber. In regard to all these, the abolition of protection meant a real sacrifice to domestic industries. The second feature to be noted is the simplification which resulted in the administrative features of the English tariff. A great number of articles had been enumerated in the earlier tariff Acts, each of which was imported in very small quantity and yielded an insignificant revenue. The nature of the changes made between 1842 and 1860 is indicated by the following tabular statement:—

	Duties reduced.	Duties abolished.
1842–46	503	390
1846	112	54
1853	...	123
1860	...	371

After 1860 only forty-eight articles remained subject to duty, a number which has been still further reduced, the most notable change having been free admission of sugar in 1872. Since that date the English customs tariff has been simplicity itself. A very few articles (spirits, beer, wine, tobacco, tea, coffee, cocoa) yield practically all of the customs revenue, and so far as these articles are produced within the country, they are subject to an excise duty, an internal tax precisely equal to the import duty. In 1901, to aid in meeting the expenses of the South African war, a moderate revenue duty was again imposed on sugar.

France.—The tariff history of France in the 19th century divides itself into three periods: one of complete prohibition, lasting till 1860; second, of liberal legislation, from 1860 to 1881; third, of reversion to protection after 1881.

(1) During the first period the prohibitive legislation of the 18th century was retained, largely in consequence of the Napoleonic wars. The commercial treaty of 1786 between Great Britain and France has already been referred to as making a breach in the restrictive system of the 18th century; and in the early years of the French Revolution a similar wave of liberal policy is to be seen. But the great wars led to the complete prohibition of the importation of manufactures, reaching its climax in Napoleon's Continental system. The system of prohibition thus instituted, while aimed at Great Britain, was made general in its terms. Hence the importation into France of virtually all manufactured articles from foreign countries was completely interdicted; and such was the legislation in force when peace came in 1815. This system doubtless was not expected to last after the wars had ceased, but, as it happened, it did last until 1860. Successive Governments in France made endeavours to break with the prohibitive system, but naturally met with strong opposition from the manufacturing interests, not prepared to meet the competition of Great Britain, whose industries had made, and were continually making, rapid strides. The political position of the Governments of the Restoration and of Louis Philippe was such that they were unwilling to forfeit support by pushing measures in which, after all, they were not themselves deeply interested.

Treaty of 1860.

(2) It was not until Napoleon III. believed it to be to his political advantage to strengthen friendly relations with Great Britain by the moderation of the import duties that the change was finally made; while the despotic character of his government enabled him, when once the new policy was entered on, to bring about a radical change. After some secret negotiations, in which the English Corn Law agitator, Cobden, and the French economist, Cherbuliez, took an active part, Napoleon was persuaded to enter on the famous commercial treaty of 1860, and virtually to force its acceptance by the French legislature. In the treaty as finally framed duties on most manufactured commodities were reduced to a range of 10 or 15 per cent., some iron manufactures, however, being left at slightly higher rates. Before the treaty, all woollen and cotton manufactures, all manufactures of leather, of hardware, pottery, all glass ware, had been prohibited, while raw materials and such manufactures as were not prohibited had been subjected to heavy duties. The treaty thus made a radical change, revolutionizing the tariff system of France. It did so with relation not only to the United Kingdom, but, in its after effects, to the world at large. The French Government at once set to work to enter into similar arrangements with other countries, and treaties were successively concluded in 1860–66 with Belgium, with the Zollverein (Germany), Italy, Switzerland, Sweden and Norway, Holland, Spain, Austria. All these countries made reductions of duty on French products, while France admitted other products at the rates of the British treaty tariff. Thus a network of treaties was spread over Europe, leading to much greater freedom of trade and opening an era of freer international exchange.

Reaction since 1880.

Tariff of 1892.

(3) This more liberal policy, however, probably never had deep root in French public opinion. It received a check from the Franco-German War of 1870–1871. The treaty of Frankfort in 1871 contained, in place of the previous detailed commercial treaty with Germany, the simple "most favoured nation" proviso. The guarantee which each country thus gave to the other of treatment as favourable as that given elsewhere became irksome to France, sore after her defeat in the war. More important, however, in undermining the liberal system, was the change in agricultural conditions which began to set in in the decade of 1878–88. Then the great improvements in transpôrtation caused competition in agricultural products to be felt, especially from the United States. Agricultural prices declined; agricultural depression set in. The agricultural interest in France, hitherto indifferent about duties, now began to demand protection against competition from beyond the sea. To this factor was added the revival of national feeling and prejudice, with growing political complications and jealousies. Hence, by gradual steps, the customs policy of France has become more and more strongly restrictive. The first important step was taken in 1881, when a new general tariff was established, in which specific duties replaced the *ad valorem* duties chiefly applied in the treaty tariffs of 1860–66. The new rates were supposed to be no more than equivalent to those replaced by them, but in fact were in some cases higher. New treaty tariffs, less liberal than the earlier ones, were concluded with Belgium, Switzerland, and Spain; while with other countries (*e.g.*, Great Britain) a "most favoured nation" arrangement was substituted for the previous treaty régime. These new treaty arrangements expired in 1892: even before that date, duties had been raised on grain and meats; and finally, in 1892, a new and more highly protective general tariff was established on the recommendation of M. Méline, with high duties on agricultural products and raw materials as well as on manufactures, and with provisions for limited domestic bounties on silk, hemp, and flax. Nevertheless, some provision was made for negotiations with foreign countries by establishing a minimum tariff, with rates lower than those of the general or maximum tariff, the rates of this minimum tariff being applicable to countries which might make concessions to France. As a rule the minimum tariff has been applied, after negotiation, and thus is the tariff in practical effect; yet its rates are still high, and, most significant of all, agricultural products are granted no reductions whatever as compared with the maximum tariff, there being heavy and unrelaxed duties upon grain, animals, meats, and the like.

The Zollverein, 1834.

French treaty and low tariff, 1865.

Protection reinstated, 1879.

Germany.—The tariff history of Germany, up to the foundation of the German Empire, is the history of the Zollverein or German customs union; and this in turn is closely connected with the tariff history of Prussia. In 1818 Prussia adopted a tariff with much reduced duties, under the influence of the Liberal statesmen then still powerful in the Prussian Government. The excitement and opposition in Germany to the Prussian tariff led to customs legislation by the other German states, some smaller states joining Prussia, while the southern states endeavoured to form independent customs unions. Finally, by gradual steps between 1831 and 1834, the complete Zollverein was formed, notwithstanding popular opposition. All the German states formed a customs union, with free trade between them, except so far as differing internal taxes in the several states made some modifications necessary. The customs revenue was divided among the several states in proportion to population. The tariff of the Zollverein was, in essentials, the Prussian tariff of 1818, and was moderate as compared with most of the separate tariffs previously existing. Within the Zollverein, after 1834, there was an almost unceasing struggle between the Protectionist and Free Trade parties, Prussia supporting in the main a Liberal policy, while the South German states supported a Protectionist policy. The trend of the tariff policy of the Zollverein for some time after 1834 was towards protection; partly because the specific duties of 1818 became proportionately heavier as manufactured commodities fell in price, partly because some actual changes in rates were made in response to the demands of the Protectionist states. In 1853 a treaty between the Zollverein and Austria brought about reciprocal reductions of duty between these two parties. After 1860 a change towards a more liberal policy was brought about by the efforts of Prussia, which concluded independently a commercial treaty with France, forcing on the other members of the Zollverein the alternative of either parting company with Prussia or of joining her in her relations with France. The second alternative was accepted, largely because Austria did not vigorously support the South German states, and in 1865 the Zollverein as a whole concluded a commercial treaty with France, bringing about important reductions of duty. The régime of comparatively free trade thus established lasted for about fifteen years. After the foundation of the German Empire, the duties of the Zollverein became those of Germany, and for a time the liberal régime was maintained and extended, with respect to the tariff as with respect to other matters. But in Germany, as in France, a combination of political and of economic forces led before long to a reaction towards protection. Bismarck broke with the National Liberals, who were the champions of free trade; at the same time the agricultural depression set in, and the agricultural interest demanded protection against American and other foreign competition. The manufacturers, especially of iron, also manœuvred for protection. The reaction came in 1879, when duties were increased on manufactured articles as well as on agricultural articles. Other advances of duty were made in later years, especially on grain; and thus the policy of Germany has become distinctly Protectionist, though not to the same degree as in France. In 1892, however, the precise year in which France gave up her system of commercial treaties, some moderation was brought about in Germany's protective system by commercial treaties with Austria, Italy, Belgium, Switzerland, and shortly afterwards with Russia. These treaties provided for reductions of duties in all directions, the most important concessions being on certain agricultural products. Thus the duty on wheat, which had been gradually raised as high as 5 marks per hundred kilogrammes (roughly 1s. 3d., or about 30 c. a bushel) was reduced to 3·50 marks by the treaties. The rates of these treaties were extended to a number of other countries having "most favoured nation" relations with Germany. The tariff system of Germany, however, at the close of the 19th century, remained Protectionist, and the controversy on protection and free trade has not reached an end.

In other important countries changes in policy have taken place similar to those noted in Germany and in France. The era of moderated tariffs, which began with the great treaty of 1860, lasted for about twenty years, and has been followed in Italy, Austria, Belgium, Switzerland, and Spain by a reversion to protection, although usually to a less high system of protection than had prevailed before 1860. The United Kingdom and Holland alone have held consistently and unfalteringly to the principle of free trade. The factors which have brought about this reaction have been, as was already noted, partly economic, partly political: on the one hand, the pressure of competition from distant countries in agricultural products, a consequence chiefly of improved transportation; on the other hand, the revival of national sentiment and prejudice.

The United States.—The tariff history of the United States, like that of European countries, divides itself into two great periods, before and after the year 1860. But it is no more than an accident that this year constitutes the dividing line in both cases, the change in the United States being due to the Civil War, which so profoundly influenced the fiscal, economic, and political history of the country in all directions. The period before 1860 may again be divided into three sub-periods, the first extending from 1789 to 1816, the second from 1816 to about 1846, the third from 1846 to 1860.

1789-1816.

(1) The Tariff Act of 1789 was the first legislative measure passed by the United States. The Protectionists have pointed to it as showing the disposition of the first Congress to adopt at once a policy of protection; the Free Traders have pointed to it similarly as showing a predilection for their policy. Each had some ground for the claim. The duties of the Act of 1789 were very moderate, and, as compared with those which the United States has had under any subsequent legislation, may be described as free trade duties. On the other hand, the spirit of the Act of 1789 was protective. It had been the design of Madison, and of other firm supporters of the new constitution, to adopt in 1789 a very simple measure, designed solely to secure revenue. But the pressure from the representatives of some of the states, notably Pennsylvania and Massachusetts, compelled him to incorporate in the Tariff Act certain specific duties borrowed from the Tariff Acts then in force in these states, which had a distinctly protective aim. Thus the Act of 1789, although the duties levied by it were moderate, yet had a protective intent. Such in the main remained the situation until 1816, duties being indeed raised from time to time in order to secure more revenue, but the arrangement and the general rate of the duties not being sensibly modified. There was not at this time any considerable public feeling on the subject of protection, chiefly because during most of the years of this period the Eastern states, and especially New England, where manufactures might be expected to develop first, were profitably engaged in an extensive export and carrying trade.

1816-46.

(2) After the close of the war of 1812, however, a new spirit and a new policy developed. With the end of the Napoleonic wars, the opportunities for American commerce became less, while at the same time the expanding population necessarily led to diversified interests at home. A demand arose for two closely connected measures: protection to domestic manufactures, and internal improvements. Protection was demanded as a means both of aiding young industries and of fostering a home market for agricultural products. The chief spokesman of the new movement was Henry Clay, who remained throughout his life the consistent advocate of this so-called "American system." Some disposition in this direction showed itself as early as 1816, when tariff duties were raised. Still greater changes were made in 1824, 1828, and 1832. In 1824 duties were considerably raised; and thereafter the New England states, which so far had been lukewarm in supporting the movement, joined in it unreservedly. The tariff of 1828 was affected by some political manipulation, which caused it to contain objectionable provisions, and to be dubbed "the tariff of abominations." But the so-called abominations were removed in 1832, when the protective system was deliberately and carefully rearranged. By this time, however, the opposition to it in the South had reached a pitch so intense that concessions had to be made. As a planting and slave-owning region, the South inevitably had no manufactures: it felt that its cotton was sure to find a foreign market, and would gain little from the establishment of a domestic cotton manufacture within the country; and it judged, rightly, that the protective system brought it only burden and no benefit. The extent of the burden was greatly exaggerated by the leaders of the South, especially in the heat of partisan controversy; and the subject was closely connected with the controversy as to the rights of the states, and the endeavour of South Carolina, under the influence of Calhoun, to nullify the Tariff Act of 1832. The nullification movement led in 1833 to the well-known compromise, by which the rates of duty as established by the Act of 1832 were to be gradually reduced, reaching in 1842 a general level of 20 per cent. The compromise served its term in allaying political bitterness and staving off a direct conflict between the United States and South Carolina. But the reductions of duty made under it were never effectively carried out. In 1842, when the final 20 per cent. rate was to have gone into effect, the Protectionists again had control of Congress, and after a brief period of two months, during which this 20 per cent. rate was in force, passed the Tariff Act of 1842, which once more restored the protective system in a form not much less extreme than that of 1832.

1846-60.

(3) Four years later, however, in 1846, a very considerable change was secured by the South, and a new era was entered on. The Democratic party now was in control of legislation, and in the Tariff Act of 1846 established a system of moderate and purely *ad valorem* duties, in which the protected articles were subjected, as a rule, to a rate of 30 per cent., in some cases to rates of 25 and 20 per cent. The system then established has often been spoken of as a free trade system, but was in reality only a system of moderated protection. In 1857 duties were still further reduced, the rate on most protected commodities going down to 24 per cent., and remaining at this comparatively low level until the outbreak of the Civil War.

The War tariff, 1862-64.

The second great period in the tariff history of the United States opens with the Civil War. It is true that the first steps towards a policy of higher protection were taken just before the war began. In the session of 1860–1861, immediately preceding the outbreak of the conflict, the Morrill Tariff Act was passed by the Republican party, then in control because the defection of Southern members of Congress had already begun. It substituted specific duties for the *ad valorem* duties of 1846 and 1857, and made some other changes of significance, as in the higher duties upon iron and steel. Nevertheless, the advances then made were of little importance as compared with the far-reaching increases of duty during the Civil War. These formed part of the general resort to every possible fiscal device. The great struggle compelled every resource to be strained to the utmost: the issue of long-time bonds, continual borrowing in very large amounts on short-time inconvertible paper money, an elaborate and all-pervading system of internal taxes, and, finally, heavy import duties. The internal taxes of the war were applied not only in the form of income taxes, stamp taxes, licence and gross receipts taxes, but also as direct excise taxes on many commodities. The import duties were correspondingly raised, partly by way of off-set to the internal taxes, partly as a means of getting additional revenue, and finally in some degree because of a disposition to protect domestic industries. The most important Acts were the great revenue Acts of 1862 and 1864. Some further changes were made in 1865, and the close of the war thus left the United States with a complicated system of very high taxes both on imported duties and on domestic products.

Gradual consolidation of war duties.

Revision of 1883.

The main features of the tariff history of the United States since the Civil War have been that the internal taxes have been almost entirely swept away, the import duties on purely revenue articles similarly abolished, while those import duties that operated to protect domestic industries have been maintained, and indeed in many cases increased. The situation has had some analogy to that of France from 1815 to 1860, when similarly a highly restrictive system established during a period of war was unexpectedly retained long after peace had been established. This result in the United States came about by gradual steps and without premeditation. After the close of the war efforts were first directed to clearing the financial situation by funding the floating debt, and taking steps (never fully consummated) towards contracting the currency. Next the internal taxes were gradually done away with, until nothing was left except the excise on beer, spirits, and tobacco. No further resort was made to internal taxes until the revenue Act of 1898 was passed, at the outbreak of the Spanish War. Efforts were made also to reduce the tariff duties, but these naturally came last: they met with strong opposition, and in the end they were almost completely frustrated, thus leaving as the basis of the tariff the rates which had been levied in the course of the war. In 1870 some rearrangements were made, the duties on iron and on some other articles being reduced. In 1872 a more general reduction was carried out, strongly resisted by the Protectionists, and finally ending in a uniform cutting off of 10 per cent. from all the import protective duties. In 1875, however, when the revenue had become deficient after the crisis of 1873, the 10 per cent. reduction was repealed, and duties restored to their previous amounts. It deserves to be noted that in 1872 an important step was also taken towards removing entirely the duties on purely revenue articles, tea and coffee being then admitted free of duty. On the other hand, the maintenance of the protective duties, and the gradual consolidation of feeling in favour of a permanent policy of strong protection, led to other revisions and rearrangements in the direction of protection. In 1867 an important Act on wool and woollens was passed, largely increasing the duties on both. In 1869 the duty on copper was raised. In 1870, while some duties were lowered, others were raised, as, for instance, those on steel rails and on marble. Thus the ten years immediately following the close of the war brought about the gradual transformation of the high duties levied on all commodities for revenue purposes into a system of high duties almost wholly on protective commodities. This transformation met with much opposition, not less in the Republican party than in the Democratic party. While the feeling in the Republican party had been from the outset in favour of protection, so high a range of duties met with much opposition. This opposition led to an important general revision in 1883, largely influenced by the recommendations of a special Tariff Commission which Congress created in 1882. The Act of 1883 was passed in the main as a party measure by the Republicans, and on the whole served rather to put in order the protective system as it stood than to make any change of policy. Certain duties were reduced (though in no case greatly reduced) such as those upon wool, some woollens, cheaper grades of cotton cloths, iron, steel rails, copper. On the other hand, on many articles duties already high, but believed to be insufficient for the effective protection of the domestic producer, were raised; *e.g.*, on finer woollens and cottons, on some iron and steel manufactures.

McKinley tariff of 1890.

Wilson tariff of 1894.

The tariff system as revised and codified in 1883 would probably have remained unchanged for many years had it not been for the turn taken by political and financial history. The decade from 1880 to 1890 was one of great prosperity, consequently of rising imports, consequently of swelling customs revenue. In the second half of the decade a continuous large surplus in the Treasury necessarily directed attention to the state of the revenue, and gave strength to the protests against excessive taxation. In addition, the Democratic party, which had long been committed, though in a half-hearted way, against the policy of high protection, was brought to a vigorous and uncompromising attack on it through the leadership of President Cleveland. In his Presidential Message of December 1887 he attacked the protective system in unqualified terms; and in the session of 1887–88 the Democratic majority in the House of Representatives prepared a Bill providing for great reductions. The control of the Senate by the Republicans prevented any legislation. But the Republicans, as is almost inevitable under a party system, championed the policy opposed by the other side, and declared themselves not only in favour of the maintenance of existing duties, but of the consistent and unqualified further application of protection. The protection question thus became the main issue in the Presidential election of 1888, which resulted in the defeat of the Democrats. In the next ensuing session of Congress, in 1889–90, the Republicans passed a new tariff Act, known as the McKinley Tariff Act, because Mr McKinley was then chairman of the House Committee in charge of the Bill. It advanced duties materially on a considerable number of commodities, both raw materials and manufactured articles. The duties on wool were raised, corresponding changes made on woollen goods, the duties on cottons, linens, some silks, and velvets considerably raised. A further step towards consolidating the protective system was taken by abolishing the duty on sugar, mainly a revenue duty. The necessity for reducing the revenue and cutting down the continued surplus was met in this way rather than by lowering the protective duties. For consistency in maintaining the protective principle a direct bounty was given to the domestic producers of sugar in Louisiana. A turn in the political wheel brought an abrupt change four years later, in 1894. The tariff question was again the issue in 1892: President Cleveland, defeated four years before, was now again elected, and the Democratic party came into power, pledged to change the tariff system. Accordingly in the first ensuing session of the Congress elected in 1892 the tariff Act of 1894 was passed, known as the Wilson Tariff, bringing about considerable reductions of duty. The measure, however, was less incisive than its chief sponsors had planned, because of the narrow majority commanded by the Democrats in the Senate. Some of the Democratic senators were lukewarm in their support of the party policy of tariff reduction, and joined with the Republicans in mitigating the changes. Nevertheless some crucial changes were made. The duty on wool, typical among the duties on raw materials, was completely abolished, and with this change came a great reduction in the duties upon woollen goods. Changes, but of less importance, were made on other textile goods. The House had proposed to remove also the duties, on coal and on iron ore, but the Senate permitted only a reduction in these. A duty was reimposed on sugar, chiefly as a means of securing needed revenue, but at a less rate than had existed before 1890. At the same time the differential duty on refined sugar, which operated as protection to the sugar trust, was not abolished, as the ardent tariff reformers had proposed, but kept in substance not greatly changed. This circumstance, as well as the failure to make other desired reductions, caused the ardent tariff reformers to be greatly disappointed with the Act of 1894 as finally passed, and led President Cleveland to permit it to become law without its endorsement by his signature. The next election in 1896 brought still another turn in the political wheel, the Republicans being once more brought into power under the leadership of President McKinley. The currency issue had been foremost in the campaign, but the Republicans had also proclaimed themselves in favour of a return to the unqualified protective system. At the extra session which President McKinley called in 1897, almost the sole measure considered was the tariff Act, known (again from the name of the chairman of the House Committee) as the Dingley Act. This reimposed the duties upon wool, on most qualities at the precise rates of 1890, on some qualities at even higher rates. Necessarily the duties on woollens were correspondingly raised, and here again made even higher than they had been in 1890. On other textiles, particularly on silks and linens, similar advances were made. As a rule, the duties of 1890 were either retained or somewhat advanced. To this policy, however, there was a significant exception in the iron and steel schedule, where the reduced duties of 1894 were left mainly unchanged. The iron industry in the United States had made extraordinary advances, and confessedly was not in need of greater protection than had been given in 1894. Some provisions for reciprocity arrangements with other countries, opening the way for possible reductions of duty by treaty arrangement, were also incorporated in the Act of 1897, though with limitations which made it improbable that any considerable changes would ensue from this policy. Some such provisions had also been contained in the Act of 1890, but here also without important results. The tariff system of the United States at the close of the 19th century thus remained rigidly and unqualifiedly protective, with rates higher than those of even the most restrictive tariffs of the countries of the European continent.

Dingley tariff of 1897.

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Tarija, a city of Bolivia, capital of the department of the same name. It was founded in 1577 by Luis de Fuertes. Population (1898) about 24,000, mostly of Spanish descent. The most important building in the city is the convent founded in 1574 by the Jesuits, but belonging since their expulsion in 1769 to the Franciscans.

Tarn, a department of the south of France, traversed by the Cevennes (Montagne Noir), and watered by the Tarn, the Agout, and the Aveyron.

Area, 2232 square miles. The population, 358,757 in 1886, declined to 326,396 in 1901. The births in 1899 were 6462, of which 208 were illegitimate; deaths, 7201; marriages, 2484. There were in 1896, 959 schools, with 45,000 pupils, 4 per cent. of the population being illiterate. Out of 1,217,710 acres of land cultivated in 1896, 807,690 acres were plough-land and 37,050 acres in vines. The wheat raised in 1899 was valued at £1,064,000; rye, £157,000; oats, £182,000; maize, £149,000; potatoes, £133,500; chestnuts, £9400; vines, £393,000. The live stock includes (1899) 16,320 horses, 1820 mules, 4100 asses, 173,200 cattle, 368,500 sheep, and 100,900 pigs. Mining in 1898 turned out 552,000 metric tons of coal, valued at £297,000, at Carmaux; 8443 tons of iron, and 279 tons of other metals. The industry in metals in 1898 produced 6753 tons of cast-iron, 3540 tons of iron, and 2927 tons of steel, of the total value of £126,000. Albi, the capital (22,571), and Castres (24,120) do much work in glass-making, leather-dressing, and the manufacture of coverlets. Mazamet (13,700) is the centre for the weaving of woollen stuffs.

Tarn-et-Garonne, a department of the south-west of France, watered by the two rivers naming it.

Area, 1440 square miles. The population decreased from 214,046 in 1886 to 194,458 in 1901. The births in 1899 were 3204, of which 111 were illegitimate; deaths, 4751; marriages, 1326. The primary schools in 1896 numbered 551, with 22,000 pupils, 5 per cent. of the population being illiterate. The area under cultivation in 1898 comprised 832,390 acres; 590,330 acres in plough-land and 56,810 acres in vines. In 1899 the department raised wheat valued at £723,000; rye, £120,000; oats, £124,000; maize, £192,000; potatoes, £86,200; plums, £26,800; vines, £411,000. In 1899 horses numbered 16,660; asses, 1710; cattle, 84,200; sheep, 126,320; pigs, 33,900. In the absence of minerals, metallurgy has made little progress. The industries are tanning, weaving of coarse cloths, and silk manufacture. Montauban, the capital, had in 1901, 24,979 inhabitants.

Tarnopol, market-town and seat of a government district in Galicia, Austria, 75 miles E.S.E. of Lemberg. Population (1890), 27,405; (1900), 30,368, including garrison of 1724 men (estimated at 73 per cent. Poles, 19 per cent. Ruthenians, and 8 per cent. Germans; 51 per cent. Jewish, 24 per cent. Roman Catholic, and 25 per cent. Greek Catholic). There is a Jesuit college and two Polish gymnasia. Industry consists chiefly in corn-milling and the preparation of wax and honey. The principal trade is in horses, corn and other agricultural produce, and spirits.

Tarnow, the chief town of a government district in Galicia, Austria, and seat of a Catholic bishop, 46 miles east of Lemberg. It is situated on the river Biala, at its junction with the Dunajec, and is a station on the railway between Cracow and Lemberg. Population (1890), 27,574; (1900), 31,548, including garrison of 2426 men, almost exclusively Polish (57 per cent. Catholic, and 43 per cent. Jewish). The industry consists in the manufacture of agricultural implements, glass, and chicory; steam corn and saw mills. It has a trade in corn, leather, rape-seed, timber, and linen.

Tárom, a district of Persia, situated on the borders of Gílán, north-west of Kazvín. It is divided into upper and lower Tárom; the former, on the right bank of the Kizil Uzain river, is held in fief by the minister of Crown domains; the latter, on the left bank, forms part of the province of Kazvín. It produces much cotton and fruit, and derives a considerable revenue from its alum mines at Zájkanín. Most of the alum is exported to Russia. It also has a few olive groves.

Tarragona, a maritime province of Spain, on the Mediterranean. Area, 2451 square miles. Population (1887), 348,579; (1897), 336,579. The birth-rate is 3·38 per cent.; the death-rate, 2·74 per cent.; the proportion of illegitimate births 1·37 per cent. It is divided into 8 districts and 185 parishes. There are 250 miles of railway. It is one of the most industrious provinces in Spain, and its manufacturing interests have grown apace with its vineyards and agriculture. Its industries include silk, cotton, linen, woollen, velvet, felt, leather, alcohol, pottery, and paper, and vie with those of Barcelona. Its fisheries produce more than £20,000 yearly. Its exports exceed £560,000 a year. The climate is temperate on the coast and in the centre, cold in the highlands, very warm and damp in the valleys and in the lowlands on the banks of the rivers as they near the sea. It is an important vine-growing district. In 1898 36,000 acres were covered with fruit; 29,410 acres were devoted to wheat crops; 110,150 acres to rye, oats, barley, maize, and other cereals; 10,000 acres to pod fruit; 273,375 acres to vines; and 146,760 to olives. There were 1878 horses, 14,161 mules, 14,914 asses, 628 cattle, 47,398 sheep, 15,681 goats, 9659 pigs.

Tarragona, capital of the above province, a seaport on the Mediterranean coast, with a station on the railway from Valencia to Barcelona. Population (1887), 27,225; (1897), 25,358. It is the seat of an active trade in the agricultural products of the surrounding districts. The local industries include alcohols, liqueurs, chocolate, soap, flour, iron, paper, pipes, and salted fish. The town contains many modern public buildings, like its institute, normal training schools for teachers and primary schools for both sexes, archæological museum, seminary, tribunals, and several hospitals. Though it is still styled a fortified city, most of its fortifications, old and new, are ruinous. The port has been improved since 1892. In 1898, 843 vessels of 514,377 tons, mostly Spanish and French, entered and cleared the port. Total value of imports in 1898, £190,161, of which £32,954 was British; exports, £1,320,959 in 1898, of which £248,910 went to Great Britain, £719,449 to France, £201,663 to Italy.

Tarrasa, a town of Spain, province of Barcelona, W.N.W. of Sabadell, on the railway from Barcelona to Saragossa, in a plain surrounded with mountains. The principal agricultural products of the district are wine, oil, cereals, and fruit. Tarrasa has a model establishment founded in 1885 for experiments in the cultivation of vines. It was a Roman municipality, a bishopric from the 5th century to the invasion of the Arabs, and was razed by them and rebuilt later by the Christians. The three principal churches date from the Christian restoration. It is now mostly a modern city, with fine public buildings, including the royal college, built in 1864 for 450 students besides day scholars, the school of arts and handicrafts, the industrial institute, chamber of commerce, hospitals, town hall, several clubs and two theatres. It is above all an industrial town, with splendid factories employing several thousands of men and women. Some of the establishments are quite monumental structures. Population (1887), 13,182; (1897), 15,423.

Tarsus.—The ruins of ancient Tarsus are covered with silt brought down by the Cydnus. The modern town is connected by road and railway with Adana and Mersina, and is surrounded by gardens in which oranges, lemons, and citron are grown. The remarkable monument, Dunuk Tash, called the "Tomb of Sardanapalus," is supposed to be the substructure of a Roman or Græco-Roman temple. The population, about 25,000, includes Moslems, Armenians, Greeks, Persians, Afghans, Ansaríyeh, and Hindus.

Tashilunpo. See Tibet.

Tashkend, or Tashkent, the capital of the general-governorship of Russian Turkestan, situated in 41° 20′ N. and 69° 18′ E., at an altitude of 1480 feet, connected by rail with the Caspian Sea at Krasnovodsk, and with Khojent and Andijan, whilst in 1901 a railway was begun to connect it with Orenburg. Since the lines joining it with these places have been laid down it has begun to regain its former commercial importance, carrying on a considerable trade with Bokhara, Kashgaria, Persia, Kashmir, and Russia. In 1897 the total population was 156,414. The Russian town is rapidly growing, and its population is now over 15,000.

TASMANIA.

History.

Tasmania, or, as it was originally called, Van Diemen's Land, was discovered on 16th August 1642 by the Dutch navigator Tasman, who landed at Frederick Hendrik Bay near Hobart, and named the territory, which he believed to form portion of the Great South Land, after his patron, Van Diemen, the governor of the Netherland East Indies. The island was subsequently visited in 1772 by a French naval officer, Captain Marion du Fresne; in 1773 by Captain Furneaux, of the British man-of-war *Adventurer;* in 1777 by the great circumnavigator Captain Cook; by Bligh in 1788, and again in 1792, when he planted fruit trees. In the same year the French navigator D'Entrecasteaux visited the south portion of the island and surveyed the coast. In 1798 Bass sailed through the strait which now bears his name, and discovered that Van Diemen's Land was an island. In 1800 the French explorer Baudin, in command of the ships *Géographe* and *Naturaliste*, surveyed the south of the island, and reports of his proceedings having reached the British officials at Sydney, they determined to forestall the French and take possession of Van Diemen's Land, which, not forming part of the mainland of Australia, had not become British by the occupation of Port Jackson.

In 1802 the *Cumberland*, a small schooner, landed at King's Island, in Bass Strait, and in 1803 Lieutenant Bowen was sent by Governor King of New South Wales to form a settlement on the south coast of Van Diemen's Land. He had aboard his two ships, the *Lady Nelson* of 60 tons, and the whaler *Albion* of 306 tons, three officials, a lance-corporal and seven privates of the New South Wales corps, six free men and twenty-five convicts, together with an adequate supply of live stock, and landed at Risdon, near Hobart, where he was joined shortly afterwards by fifteen soldiers and forty-two convicts. In 1807 Colonel Paterson occupied Port Dalrymple on the north side of the island. During the same year Colonel Collins, who had failed in an attempt to colonize the shores of Port Phillip, transferred his soldiers, convicts, and officials to the neighbourhood of Hobart, and was appointed commandant of the infant settlement. Provisions were scarce and dear, communication with the rest of the world was infrequent, and in 1807 the community was threatened with starvation, and flour was sold at £200 per ton. The difficulties of the settlers were increased by the determined hostility of the aborigines, who, although of the same race as the "blacks" of Australia, appear to have been more ferocious and more warlike. The first collision took place at Risdon, a few days after the landing of Lieutenant Bowen's expedition, and from 1802 till 1830, when an unsuccessful attempt was made to drive the natives to one corner of the island, they were always at war with the settlers. In 1831, when Mr. George Robinson induced the remnant of the blacks to leave their native land and take refuge, first in South Bruni and subsequently in Flinders Island, their numbers had diminished from 5000, the original estimate of the aboriginal population, to 203. In 1842 there were only 44, in 1854 they had diminished to 16, and the last pure-blooded Tasmanian died in 1876, at the age of seventy-six. There are, however, a few persons possessing more or less aboriginal blood in some of the islands of Bass Strait.

Some persons who had settled at Norfolk Island when that island became a penal depot were transferred to Van Diemen's Land in 1805. But the growth of population was extremely slow, and in 1818 a census showed that there were only 3240 people on the island, including officials, military, and convicts. Whatever prosperity was enjoyed by the free inhabitants had arisen from the expenditure by the Imperial Government upon the convict establishment. But in that year settlers began to arrive. Every free immigrant was presented with a tract of land in proportion to the amount of capital brought by him to the colony—640 acres for every £500—and he was allowed to include in the estimate of his capital the passage money of himself and family, as well as the value of his furniture, his farming implements, and any live animals that he brought with him. The result was that no men took up land unless they were possessed of some means, and they were not compelled to part with a large proportion of it to pay for their farms, with the almost invariable result that they would be compelled to have recourse to the local banks or other financial institutions. Every free settler was allowed the services of a number of convicts, termed locally assigned servants, proportionate to the size of his holding. These men and women were fed and clothed by the settler in return for their labour, and the Government was relieved from the expense of their support and supervision. The assignment system was eventually abandoned, in consequence of the evil moral result of what was practically slavery, but it certainly increased the prosperity of the community. In 1821, when the next census was taken, the population had grown to 7400; the sheep numbered 128,468, the cattle 34,790, horses 550, and 14,940 acres of land were under crops.

Up to this date Van Diemen's Land had been administered as a penal settlement, but the settlers and emancipists agitated for a free press and for trial by jury, and their requests were gradually granted. Courts of justice were substituted in 1822 for courts-martial; and in 1825 the colony was made independent of New South Wales, and Colonel Arthur was appointed governor. In 1828 the Van Diemen's Land Company commenced sheep farming on a large scale in the north-west district of the island under a charter granted three years before, and in 1829 the Van Diemen's Land Establishment obtained a grant of 40,000 acres at Norfolk Plains for agriculture and grazing. In 1834 Portland Bay, on the mainland of Australia, was occupied by settlers from Van Diemen's Land, and in 1835 there was a migration, large when compared with the population of the island, to the shores of Port Phillip, now Victoria. At that date the population was 40,172, a large proportion being convicts, for in four years 15,000 prisoners had been sent out. The colony was prosperous, but the free settlers were not at all satisfied with the system of government, and an agitation commenced in Van Diemen's Land, as well as in New South Wales, for the introduction of representative institutions and the abolition of transportation. This system was abolished in New South Wales in 1840, after which date the island was the receptacle for all convicts not only from the United Kingdom, but from India and the colonies.

Gold was discovered in Victoria in 1851, and transportation to Van Diemen's Land finally ceased in 1853; in the same year representative institutions were introduced and the name of the colony was changed to Tasmania, but it was not till 1856 that it obtained responsible government.

The discovery of gold in Victoria produced a very remarkable effect upon Tasmania. All kinds of produce brought fabulous prices, and were exported to Victoria in such quantities that they rose from a value of £665,790 in 1851 to £1,509,883 in 1852, and £1,756,316 in 1853, while the population diminished in an equal ratio. It was estimated that in 1842 there were 38,000 adult males in the colony, but in 1854 their numbers had diminished to 22,261. For many years the island was inhabited by grey-beards and children; the young men and women of all classes, so soon as they had reached manhood and womanhood, crossed Bass Strait and entered upon the wider life and the more brilliant prospects which first Victoria and subsequently New South Wales and Queensland afforded them. But even in its darkest days the fine climate of the island induced a steady immigration of retired officers, civil and military, from India, while the more wealthy inhabitants of the mainland of Australia spent a portion of their summers in the cool and exhilarating atmosphere of the island. It was not till the 'sixties that Tasmania embarked upon a new lease of prosperity. In the early days little or nothing was known about the western half of the island. The lake and mountain country was covered with forests, which rendered it almost worthless for agricultural and pastoral purposes; except in the immediate neighbourhood of the navigable rivers—the Mersey, the Forth, and the Leven—the timber had no commercial value, and the land would not pay for clearing. The mineral wealth of this large district was not suspected, although coal of fair quality had been found between the Dee and the Mersey rivers in 1850, and gold had been discovered in two or three localities during 1852. In 1860 two expeditions were equipped by the Government for a search for gold and other minerals, and although it was some years before there was any important result, the discoveries of these explorers directed attention to the mineral wealth of the island. In 1869 the mining industries were so unimportant that they were not even mentioned in the colonial statistics. In the following year an export of gold was noted of 2141 oz., valued at £7475. Since that date the gold industry has attained important dimensions. No tin was raised in 1872, but in 1873 four tons of tin ore, valued at £220, were exported, and in 1879 the renowned Mount Bischoff on the north-west coast was discovered. Silver, bismuth, and copper have also been discovered, and Mount Lyell, where the ore contains gold, silver, and copper, promises to rival Mount Bischoff in profitable richness.

The development of the mining, agricultural, fruit-growing, and pastoral industries has withdrawn the attention of the colonists from other sources of wealth. No country in the world possesses more magnificent forests, and considerable quantities of black-wood and Huon pine have been exported to Australia, while the blue and red gum have been largely employed in building houses, jetties, and wharves in Victoria and New South Wales, and more recently in South Africa and at the Dover harbour works. There is no reason why the ornamental woods which abound should not be made up in the state and an export trade in furniture created. The fisheries are comparatively neglected. In the early days a large section of the community was employed in the pursuit and capture of the whale. For many years shore whaling was carried on at many places on the coast; the pursuit was exciting, profitable, and popular. But by degrees the female cetaceans abandoned their old breeding-grounds, and the occupation came to an end. Deep-sea whaling was carried on very extensively. In 1838 the produce of the fisheries was valued at £137,000; in 1848 38 whalers, with a tonnage of 7260 tons and with crews of 1100 men, sailed from Hobart. The discovery of gold, by increasing wages, checked the industry, and in 1862 the export of sperm and black oil had declined to £59,210, in 1872 to £47,574, and in 1886 to £9463. It is generally supposed that the whale of the Southern seas is nearly extinct, but there is apparently no very valid reason for the belief. There is little or no attempt at deep-sea fishing. The fish are far superior in flavour to those which inhabit the warmer water surrounding the Australian continent. The trumpeter, trevally, rock-cod, and king-fish are equal to the best fish found in the northern hemisphere; the flounder is a formidable rival to the sole, and the crayfish to the lobster. The salmon-trout and trout have been thoroughly acclimatized in the rivers and lakes, but no attempt has been made to secure the harvest with which the shores abound. Nor has Tasmania taken full advantage of the difference in the seasons between the southern and the northern hemisphere. Apples and pears shipped in the Tasmanian autumn arrive in England in March, April, and May, at the period when the European and American varieties have become tasteless through having been stocked since September. But the colonists have allowed the dairy farmers of Victoria and New South Wales almost to monopolize the butter and poultry trades, in which a similar advantage may be taken of the difference in the seasons.

Tasmania possesses one great advantage over her neighbours through her temperate and salubrious climate. The death-rate is only 14·10 per thousand. The mean temperature of the year, as estimated from observations extending from 1841 to 1879, is about 50·10°. The mean at Hobart was 54·4°, at Launceston 56·6°, and at Oatlands, which is in the centre of the island and 1400 feet above sea-level, was 51·76°. The mean number of days on which rain fell was 51, and the average annual fall 18·45 inches. Snow is rarely seen, except in the mountains. The average temperature at Hobart of January, the hottest month, is 63°, and of July, which is mid-winter, 45°.

The first sod of the railway which was to connect Launceston with Deloraine was turned by the late Duke of Edinburgh in 1868, and the line was opened for traffic in 1871. Originally constructed by a private company, it fell into the hands of the Government, which has since become the owner of all the railways in the island, with the exception of that between Emu Bay and Bischoff, 48 miles, and the Mount Lyell, 15 miles. The gauge is 3 feet 6 inches, the total mileage 488 miles, and the cost of construction about £4,000,000.

The political history of the colony since the inauguration of responsible government, until it became one of the states of Federated Australasia, was not important. State aid to religion, which was given to any denomination which would receive it, was abolished; local self-government was extended to the rural as well as to the urban districts; a policy of semi-protection was introduced; the island was connected by a submarine cable to the mainland of Australia, and thence to the rest of the civilized world; and the population, which was only 99,328 in 1870, was nearly doubled. Like her neighbours, Tasmania organized a defence force, and was able to send a contingent to South Africa in 1900.

As one of the states of Australia, Tasmania returns six senators and five representatives to the Federal Parliament. The local constitution resembles that of the other Australasian states, inasmuch as the executive government of four ministers is responsible to the legislature, which consists of a Legislative Council and House of Assembly. The former is composed of eighteen members, elected for six years by all natural-born or naturalized subjects of the Crown who possess either a freehold worth £20 a year or a leasehold worth £80, all barristers and solicitors on the roll of the Supreme Court, all duly qualified medical practitioners, and all British subjects holding a commission or possessing a degree. The House of Assembly is elected by owners or occupiers of property, or adult males who are in the receipt of £60 per annum as income and have resided in the colony for three years.

GEOGRAPHY.

The general physical features of Tasmania were most graphically described by Count Paul de Strzelecki in his work, *Physical Description of New South Wales and Tasmania* (London, 1845), and soon afterwards many of its geological features were again briefly sketched by J. Beete Jukes (*A Sketch of the Physical Structure of Australia*: London). Although the researches of many local observers have since added to our knowledge of the physical details, the descriptions of the main features as recorded by these two accomplished observers are wonderfully accurate, and even as regards local details are still, so far as they extend, most valuable sources of reference. The main axis of the Great Cordillera—so termed originally by Sir Roderick Murchison—bordering the eastern coast-line of Australia, may be traced across Bass Strait in the chain of islands forming the Furneaux and Kents Group, which almost continuously link Tasmania with Wilson's Promontory, the nearest and most southerly part of the Australian mainland. Tasmania is wholly occupied by the ramifications of this chain, and in itself may be said to embrace one and all of its characteristic features.

If we take our stand near Lake Fergus, to the east of Lake St Clair, we find that we are situated nearly in the centre of an extensive plateau—a smaller Tasmania—with an elevation, especially on the northern side, of between three and five thousand feet above the sea-level. This elevated plateau extends from Dry's Bluff in the north to the Denison Range in the south-west, and although often receding at points adjacent to the sources of the principal rivers, invariably presents a bold crested front to the north, west, and east. At its greatest elevation it is comparatively level, and contains many extensive fresh-water basins, such as Lake Augusta, Lake St Clair, Lake Sorell, Lake Echo, Lake Crescent, Arthur's Lake, and the Great Lake. The last is estimated to be about 90 miles in circumference. The marginal crests of this mountain table-land, together with its upper surface, composed principally of diabase, are known locally as "Tiers," and have a very commanding aspect in the neighbourhood of Longford, Westbury, Deloraine, and Chudleigh. The extent of the principal elevated plateau is best appreciated when we consider that it maintains its general altitude in a westerly direction from Dry's Bluff (4257 feet) on the north to Cradle Mountain (5069 feet) in the north-west, a distance of nearly 50 miles; from Dry's Bluff in a south-westerly direction to Denison Range, a distance of over 60 miles; and from Dry's Bluff to Table Mountain in a southerly direction, a distance of above 43 miles. This plateau itself again rests upon a more extended table-land, composed mainly of metamorphic schists or slates. The level of this table-land stretches westwards, and, including the Middlesex Plains, the Hampshire Hills, and the Emu Plains, maintains an altitude of 1200 to 2000 feet. Its limits follow the coast-line more or less closely, the space between it and the sea often broadening out into low-lying tracts not much raised above the sea-level. Here and there, rising abruptly from its surface, are to be seen isolated peaks, chiefly of schistose formation, the most characteristic of which are Valentine's Peak (3637 feet) and Mount Pearse. Ridges and plateaux of a similar character, but more or less isolated, such as Ben Lomond (5010 feet) and Mount Wellington (4166 feet), are to be found in the north-east and south-west of the island. Towards the extreme west and south, granites, metamorphic mica, and quartzose schists, with overlying slates, grits, and limestone of Cambro-Silurian age, reappear again and again in anticlinal and synclinal ridges, which trend north and south, the most characteristic being the Huxley, Owen, Sedgwick, Franklin, and Arthur Ranges. These rocks may also be seen following the south coast, and evidently occupying nearly all that extensive mountain region to the south of the river Huon. Settlement of population has taken place principally among the plains and lower levels of the north-western, midland, and south-eastern parts of the island, following in the main the rocks of Tertiary and Mesozoic age. In the Recent Tertiary period the soils of these plains and valleys have been greatly enriched by extensive outbursts of basalt with accompanying tuffs. These comparatively level sheets of basalt are often of great extent in the midland, north-western, and north-eastern districts, and there is ample evidence to show that, as in France and other parts of the world, they are invariably intimately associated with the ancient Tertiary lake systems. These basalts produce a very rich chocolate soil, and were it not for their influence, the greater part of what is now the most fertile part of the island would have been comparatively poor or altogether sterile.

Flora.

The appearance of the island throughout is wonderfully beautiful, with its open plains, bordered by far-extending precipitous mountain tiers, its isolated shaggy peaks and wooded ranges, and its many noble rivers and lakes. Its coasts for the most part, especially towards the south, are bold, and frequently indented with splendid bays and harbours (such as the Derwent where Hobart, the capital, is situated), affording ample shelter and safe anchorage for ships. On the western side one is reminded of scenes in the highlands of Ross-shire and Inverness-shire in Scotland, from the picturesque character of the blue, white, and pinkish crystalline peaks and the fantastic outlines of the mountain ranges which rise abruptly to a height of from 2000 to nearly 3000 feet above the Button Grass Plains. The vegetation which prevails among the older schistose rocks of the west and extreme south presents a totally different appearance to that which occurs in the more settled districts of the east. The western vegetation, as compared with that of the east, presents as marked a contrast as do the prevailing rocks upon which it flourishes. The characteristic trees and shrubs of the west include the following genera, viz.: *Fagus, Cenarrhenes, Anodopetalum, Eucryphia, Bauera, Boronia, Agastachys, Richea, Telopea, Grevillea, Orites, Athrotaxis, Dacrydium, Phyllocladus.* On the eastern side the plains and rocky ridges, where not artificially cleared, are occupied by shaggy and often sombre forests mainly composed of the following genera: *Eucalyptus* (gum tree), *Casuarina, Bursaria, Acacia, Leptospermum, Drimys, Melaleuca, Dodonea, Notolea, Exocarpus, Hakea, Epacris, Xanthorrhœa, Frenela.* The mountain slopes and ravines of the east have a well-marked vegetation. In character it is more akin to, and in many cases identical with, that of the west. The tree fern (*Dicksonia antarctica*) in the mountain ravines is especially remarkable. The following genera are also found in such positions in great luxuriance, viz.: *Fagus, Anopterus, Phebalium, Eucalyptus, Richea, Cyathodes, Pomaderris, Prostanthera, Boronia, Gaultheria, Correa, Bedfordia, Aster, Archeria, Atherosperma,* &c. In the extreme west the trees and larger shrubs do not appear to ascend the schistose rocky mountain slopes of the central and eastern parts. The flora and fauna as a whole are almost identical with the flora and fauna of the continent of Australia, and there is, even now, sufficient evidence to show that both have been derived immediately from ancestors which at least had established themselves in Australia and Tasmania during, and possibly even prior to, the dawn of the Tertiary period.

GEOLOGY.

Geology.

Distribution of the Principal Rock Systems.—In a general way it may be stated broadly that the oldest rocks (in which the precious metals usually occur), ranging from the Pre-Cambrian to the Devonian, are largely represented in Tasmania, forming, with the associated granites, gabbros, and porphyries, remarkably rugged ranges in the north-eastern part of the island in the vicinity of the gold and tin mining centres, as at Asbestos Ranges, Beaconsfield, Lefroy, Branxholm, Gladstone, Gould's Country, George's Bay, and Schouten and Maria Islands. In the north they occur in the vicinity of Chudleigh, Mount Roland, Mount Claude, and Latrobe. In the western highlands—the region of the famous tin, silver, copper, lead, gold, and other mining centres—these older and richly metalliferous formations occupy a broad marginal strip nearly 200 miles in length and 50 miles in width.

Pre-Cambrian.—The rocks of Pre-Cambrian age consist mainly of highly crystalline schists, gneissoid micaceous schists, and quartzites. Rocks of this age are found in the neighbourhood of Port Davey, Davey river, Arthur, Frankland, and Wilmot Ranges, the western border of Macquarie Harbour, Mount Heemskirk, Parson's Hood, Mount Roland, Latrobe, and the Asbestos Ranges.

Cambrian.—Rocks determined to be of Cambrian age are found associated with gneissoid mica-schists at Caroline Creek near Latrobe. They consist mainly of rusty tilted sandstones, thinly bedded.

Silurian (Lower and Upper).—The Silurian consist mainly of hydro-mica schists, clay, slates, sandstones, grits, conglomerates, and fine-grained, massive blue, grey, and white limestones. The rocks of the Lower Silurian division, so far as known, have been divided into two groups. These are, in ascending order:—

(1) *Auriferous Slate Group*, consisting mainly of dark blue clay slates very much tilted and folded, and frequently penetrated in their faultings and dislocations by quartz reefs and veins.

(2) *Gordon Limestone Series.*—The rocks of this group consist mainly of massive cave limestones and conglomerates, as at Ilfracombe, Chudleigh, Ida Bay, Florentine, Franklin, and Gordon rivers, with numerous corals and shells.

The rocks of the Upper Silurian division are generally divided into three groups, in ascending order, as follows:—

(1) *Hydro-mica Schist Group*, consisting of the prevailing silvery hydro-mica schists and associated conglomerates, as at Mount Lyell, Honeysuckle Hill, and elsewhere.

(2) *Brachiopod Sandstone Series*, consisting mainly of red and whitish highly-tilted sandstones, rich in various forms of Brachiopods, notably Pentamerus and Orthis, as at Queen River and Heazlewood.

(3) *Eldon Valley and Zeehan Clay Slate Series*, consisting of a series of highly contorted or tilted clay slates, schists, and thin bands of limestone, containing Calymene and other trilobites, also Spirifers and Brachiopods. The rocks of this division are frequently penetrated by dykes, lodes, and veins containing gold, silver, copper, lead, and other valuable metals.

Devonian.—It is doubtful if the rocks referred to this system can be permanently retained, and whether it may not be found necessary, as originally suggested by Mr Jukes, to abolish this system in classification, and to class part of the series with the Silurian, and class part of the uppermost series with the Permo-Carboniferous system.

Permo-Carboniferous.—The characteristic rocks of Permo-Carboniferous age chiefly consist of thin regular horizontal bands of silicious conglomerates and grits, blue slaty shales, limestones, argillo-arenaceous and argillo-calcareous mudstone rocks of a yellow or whitish appearance, with intercalated beds near its upper limits in some places, composed of white, red, and yellow sandstones, fine greyish laminated friable shales, and occasionally thin coal seams. The members are, for the most part, extremely rich in fossils. These rocks are mainly deposited throughout the eastern and midland parts of the island, and are found fringing the whole of the great central plateau of greenstone. There exists also a notable patch, more recently discovered, near the mouth of the Henty river. The typical remains of this period are two species of a genus of Coniferæ (*Nœggerathiopsis*); characteristic net-veined ferns (*Gangamopteris, Glossopteris*); lycopods (*Tasmanites, Schizoneura*). The remains of the oldest known Tasmanian insect—a species of some form of Neuroptera—has been found associated with these plant remains in the Mersey Coal Measures. The fossils of the marine beds of the system are very numerous, but the characteristic forms, consisting of large-winged Spirifers and abundant lace-like Fenestellæ, alone enable any one easily to identify the rocks in which they are found.

Mesozoic Period.—The rocks of Mesozoic age consist mainly of variegated sandstones regularly or falsely bedded, shales, and blue and white clays. These members are often of great thickness, and extend throughout the midland, southern, and south-eastern districts. They frequently contain seams of coal of considerable thickness and of fair quality, as in the Fingal district, where the output is about 40,000 tons yearly. The beds of the system are, as a rule, distributed in district basins, often greatly concealed, altered, and otherwise disturbed by the more recent intrusions of the diabasic greenstones. On this account, and because of the great sameness of the fossil plant remains, there is great difficulty in attempting to separate the various members of the period, or system, into distinct subdivisions. The formations, as a whole, probably cover the whole period from the close of the Permo-Carboniferous age to the beginning of the Tertiary period. The marine cretaceous rocks, such as the Rolling Downs and Desert Sandstones of Australia, are nowhere represented in Tasmania.

Cainozoic Period (Tertiary System).—Taken as a whole, the general features of the Tertiary system in Tasmania correspond with those of the same system in the mainland of Australia. The rock formation may be conveniently divided into two principal divisions and four groups, in descending order, as follows:—

Neogene—

(1) Older raised terrace drifts, often overlying the immediately preceding widespread extrusions of olivine basalt.

Palæogene—

(2) Basaltic sheets and associated tuffs overspreading the Tertiary marine and lacustrine formations.

(3) Lacustrine deposits of great thickness and extent, composed of sands, clays, lignites, travertines, and sometimes including auriferous and stanniferous drifts; contains the remains of a rich and varied flora.

(4) Marine deposits at Heathy Valley, Flinders Island, and fringing the sea at Table Cape and Cape Grim.

Palæogene Epoch.—Middle and Lower Tertiary.

Marine Formations.—The marine formations occur in isolated patches fringing the north-western coast and the Islands of Bass Strait, notably near Cape Grim, Table Cape, and Heathy Valley, Flinders Island. From the character of the molluscs and the small percentage of species having living representatives (not exceeding 2 per cent.), it is clear that these marine beds must be placed at the base of the Palæogene group, *i.e.*, equivalent to the early Eocene of other countries.

Lacustrine Formations.—The more important lacustrine formations, as might be expected, are mainly found in the original valleys and eroded basins of the earlier rocks, and generally consist of regular or irregular bands of white, grey, or ferruginous sandstones, alternating with grits; blue, white, yellow, or blackish clays; lignites; and sometimes, in the neighbourhood of the old slates and crystalline rocks, the ancient channels formed in them contain drifts of a richly auriferous or stanniferous character. Many of the formations are found along the course of existing rivers and watercourses in the form of raised bordering terraces. In other places, as in the Launceston Tertiary Basin, they occupy the floor of broad undulating plains, covering an area of not less than 600 square miles, and ranging from 400 to 1000 feet in thickness. Being comparatively of a loose and incoherent nature, the beds are unable to resist the eroding influences of air and water, and are therefore greatly denuded along the course of existing rivers and their tributaries. The clays and ferruginous sandstones are in most places replete with the remains of a luxuriant vegetation, among which the leaf impressions of forms more allied to the existing European flora are especially noticeable, such as those belonging to certain extinct species of the oak, elm, beech, laurel, willow, and elder. With these occur ancestral forms of banksia, lomatia, eucalyptus, pittosporum, cinnamon, fig, araucaria, and other conifers. It is of especial interest to note that the ancestral forms of the existing floras of the world had already attained a very high state of development and specialization into well-known generic types, which were then worldwide in distribution and not, as at present, restricted to particular widely separated regions. The mixture in Tertiary formations of the elements of the existing floras of Europe and Australia is of the greatest interest, and has been ably investigated by the late Professor Von Ettingshausen.

Fedlspathic Basalts and Tuffs.—One of the most remarkable features of the Tertiary period throughout Australia and Tasmania marking the close of the Palæogene epoch, is the eruption of extensive sheets, flows, and accumulations of feldspar basalts, with their associated tuffs. It is evident that great volcanic activity prevailed generally at this time, especially in the neighbourhood of ancient lakes, estuaries, and river systems. Considerable areas in such places are covered by repeated flows or sheets of basalt or scoriæ—overwhelming ancient Tertiary forests, and filling ancient valleys, lakes, estuaries, and river beds. In the tuffs, overlaid by overflows of basalt, at Breadalbane, Cora Linn, Geilston, One Tree Point, and Little Badger Corner, there have been discovered silicious and calcareous trunks of fossil woods of banksia, araucaria, and other extinct forms of conifers, together with fossil bones and teeth of extinct forms of marsupials allied to the existing *Hypsiprymnus* and *Phalascomys*.

Upper Tertiary (Neogene Epoch).—In Tasmania a series of deposits occur, generally resting either upon the Palæogene basalts or the lacustrine or marine beds. These deposits consist mainly of clays of various shades of colour, ferruginous sands, coarse and fine, and more conspicuously of gravels and pebbles frequently conglomerated, among which in many localities, as at Longford, occurs a wonderful abundance of water-worn pebbles derived from the silicified stems and branches of conifers and other fossil trees. The apparent absence of marine formations and of the newer basalts, so common in Victoria, renders it difficult to mark the upper limits of this division with any degree of satisfaction. As regards the principal divisions of this epoch, there is good reason for the belief that the paucity of life and the enormous denudation are in a large measure due to a growing refrigeration of the climate, and to a much greater rainfall than at present. Whether this supposed change in the direction of a colder climate became sufficiently intense within the period to produce local ice-sheets and glaciers—of the former existence of which there is abundant evidence in the valleys and sub-alps of the Western Highlands, notably along the deeply-cut ravines of the Mackintosh, Franklin, King, and Henty rivers—it is difficult to determine, although local geologists are inclined to this view.

Post-Tertiary Period.—The nature of the Post-Tertiary rock formations and of their principal divisions may be ascertained from the following summary, arranged in descending order :—

Human Period—

(1) Alluvium of recent rivers, lagoons, lakes, seas, &c. ; peat ; unconsolidated sands along the coasts ; native shell-mounds, with burnt embers and rudely-chipped flint implements belonging to the extinct Tasmanian race, all around the coast-line, especially noticeable along the commanding headlands of the estuaries of the Derwent and Tamar rivers ; talus-drifts on slopes, and at base of mountains, cliffs, &c.

(2) Consolidated sand-dunes, such as the Helicidæ sandstone, Flinders Island, associated with and including the raised-beach terraces on Flinders, Cape Barren, Badger, King and Kent Group islands, and along certain parts of the northern coast. The only example known of a raised sea-beach in the southern part of Tasmania occurs in one of the minor bays inside the heads at Blackman's Bay on Forestier's Peninsula.

Pleistocene Period—

(1) Cave deposits, with bone-breccia underlying stalagmitic floor, as at Chudleigh, from which bones of animals still living were obtained.

(2) Esker drifts, as at Pig Island, Newnham, Stevenson's Bend, and Invermay, on the Tamar, consisting of irregular beds of water-worn pebbles; pebbles of silicified and ferruginous fossil pine and other woods, including fossiliferous fragments of Palæogene leaf-beds, &c.

(3) Lower terrace drifts, belonging to the later pluvial period, at successive levels in the main valleys of the North Esk and other rivers.

It is very probable, during the earlier Cretaceous period, that Tasmania was separated from the southern spur of the continental portion of the Australian cordillera by a narrow strait, as at present ; but there is good evidence at Table Cape, Flinders Island, and Kent Group that when the bed of the Cretaceous (or perhaps Eocene) sea was finally elevated on the mainland, the floor of Bass Strait partook in the general movement, thus forming a biological bridge, for a time connecting Tasmania and Australia, and permitting the migration of plants and animals heretofore isolated in terrestrial provinces of narrower limits. The smaller, and perhaps more local, depression which again severed Tasmania from the mainland probably occurred towards the close of the Tertiary period, prior to the evolutional development of the giant marsupials of the mainland, viz., *Diprotodon*, *Nototherium*, and Marsupial Lion (*Thylacoleo*), &c. ; and this may account for the fact that no remains of these giant marsupials have been discovered in Tasmanian rocks. It is most probable, therefore, that the destruction of the connecting-link of the previously upheaved Tertiary marine beds in the region of Bass Strait was accompanied by a local subsidence of the land, perhaps during the earlier Pleistocene period, of which there is also some evidence along the western and southern coast-line of Tasmania. The fact that the older lacustrine leaf-beds of Tertiary age, in the Launceston, Derwent, and Macquarie harbour basins, are now found at a considerable depth below the existing sea-level (proved to a depth of from 300 to 400 feet below sea-level in some places) is in harmony with this view. The very much more recent elevation of the land on the north-east coast and the islands of Bass Strait during the recent or human period, as evidenced by the raised sea-beaches containing shell remains in all respects identical with the living species in the same localities, is quite local in character, as there is no evidence of this final movement southwards. It was also certainly a much more limited vertical oscillation, as it failed to reconnect completely the island of Tasmania with the Australian mainland.

Rainfall.

The western prevailing winds—particularly the north-western —carry the rain-bearing clouds. It altogether depends upon the directness of the exposure of the land surface of the various parts of its mountainous and other exposed regions to these western winds what the magnitude of its rainfall may be. The elevation-divide between the western and eastern parts of the island rises generally to a height of between 3000 and 5000 feet, and consequently the parts to the east of such rain-draining heights are more or less robbed of the prevailing rainfall of the western border. This is clearly revealed by the following analysis for the year 1900 :—

District.		Altitude.	Average Rainfall.
		Feet.	Inches.
N.W., average 39·88	Great Lake	3700	33·65
	Glengarry	51	38·04
	Waratah	2000	79·02
S.W., average 33·24	Mount Lyell	1230	115·6
	Cape Sorell	40	42·82
	Glenora	175	22·79
N.E., average 22·63	Boobyalla	15	25·74
	Cullenswood	900	25·55
	Mathinna	...	30·81
S.E., average 21·68	Apslawn	30	30·06
	Bothwell	...	23·45
	Oatlands	1400	20·95

The general average for the eastern district over a period of years was 22·07 inches ; for the western, 37·55 inches ; and for Tasmania, 26·69 inches.

STATISTICS.

Population.

In 1901 the state contained 174,230 people, viz., 90,265 males and 83,965 females, giving a density of 6·6 persons per square mile. The population in 1870 was 100,765, but the discovery of Mount Bischoff two years later, though it greatly stimulated speculation and induced a large influx of immigrants, did not put a stop to the outflow, for in 1878 the population did not number 110,000. In 1880 the population was 114,762, and in 1890, 145,290.

Like all the Australian colonies, Tasmania shows a decline in the birth-rate ; in 1901 the births were 4930, which is smaller than the number recorded ten years previously, and much below the ratio per thousand then recorded. From 1870 onwards the average birth-rate per 1000 in five-yearly periods was:—

Periods.	Births per 1000 of Population.	Periods.	Births per 1000 of Population.
1871–75	29·72	1886–90	34·59
1876–80	31·54	1891–95	32·18
1881–85	35·02	1896–1901	28·29

The number of illegitimate children born in 1901 was 193, which gives a ratio of somewhat over 3·9 per cent. of all births, and this may be taken as the present average, compared with 3·8 prior to 1890. The climate is probably more healthy than that of any of the Australian states, although, owing to the large number of old people in the colony, the death-rate would appear to put Tasmania on a par with New South Wales and South Australia. Grouping the deaths in five-yearly periods, the following results are attained:—

Periods.	Deaths per 1000 of Population.	Periods.	Deaths per 1000 of Population.
1871–75	15·64	1886–90	15·16
1876–80	16·52	1891–95	13·14
1881–85	16·00	1896–1901	12·00

There has therefore been a gradual and substantial improvement in the health conditions of the state. The annual marriage-rate is about 6·9 per 1000 persons, which is considerably below the average of Australia generally, and is accounted for by the continued emigration of men unmarried and of marriageable ages; this emigration had ceased in 1900, and the marriage-rate may be expected to rise. For 1901 the rate was 7·71 per 1000. The chief towns are Hobart (population 34,682) and Launceston (population 21,220).

Education.

Half the population are adherents of the Church of England, and about 18 per cent. Roman Catholics; Wesleyans number nearly 16 per cent., and Presbyterians about 6½ per cent. Instruction is compulsory upon children over six years of age and under thirteen years in the towns of Hobart and Launceston, but not in the rural districts. Special religious instruction is allowed to be given after school hours by teachers duly authorized by the various religious denominations, and this privilege is somewhat extensively used by the Church of England. The schools are not free, as small fees are charged; but these are not enforced where parents can reasonably plead poverty. At the beginning of 1901 there were 327 state schools, with 18,693 pupils on the roll, and administered by 603 teachers; there were also 243 private schools, with 525 teachers, and an enrolment of 11,940 scholars; there were therefore 30,633 children receiving instruction, out of about 40,000 children of school age. The expenditure in 1901 upon primary instruction was £59,618, but in addition to this sum £8143 was expended upon school premises, while the revenue from fees in the same year was £10,945. The net cost, excluding expenditure on school premises, was £3 8s. 3d., and including that expenditure £3 19s. 8d. per scholar in average attendance. The University of Tasmania has an endowment of £4000, and a revenue of £748 from fees and £968 from other sources, making a total of £5716. The students attending lectures in 1901 were 49, of whom 45 matriculated, and the number of degrees conferred to the close of that year was 146; the great majority of these degrees were granted *ad eundem gradum.*

Finance.

The revenue is chiefly obtained through the custom-house, but the Federal tariff has had the effect of considerably reducing the receipts from this source. In 1900 the state raised £1,054,980 on account of the public revenue, which is equal to £6 2s. 3d. per inhabitant; of this sum £490,916 was obtained from import and excise duties, and £153,594 from other taxation; the railways returned £202,075, and the posts and telegraphs £97,393, while from public lands was obtained £67,498, and from other sources £43,504. The expenditure was £923,731, thus distributed: railway working expenses, £160,574; posts and telegraphs, £84,539; public instruction, £52,614; interest and charges upon debt, including sinking funds, £320,151; and other services, £305,853. The interest and other debt charges come to £1 17s. 1d. per inhabitant, and represent from 31 to 43 per cent. of the expenditure of the state. The public debt in 1900 was £8,511,005, which sum is equal to £49 6s. 2d. per inhabitant. In 1871 it was £1,315,200, in 1881 £2,003,000, and in 1891 £7,110,290. The debt was represented by debentures and inscribed stock to the amount of £7,690,000, and local inscribed stock, £821,005. The expenditure upon works may be divided into that on revenue-yielding works, viz., railways, £3,910,229, and telegraphs, £130,197; and that on works not yielding revenue, £4,205,732. For local government purposes Tasmania is divided into municipalities, town boards, and road trusts. The rates are assessed on an assumed annual value, which in 1900 was £1,417,547, corresponding to a capital value of upwards of £28,000,000. The bulk of the revenue of the local government bodies is obtained from rates. The sources of revenue in 1900 were: Government endowment, £23,537; general rates, £84,564; special rates, £6796; and other sources, £41,867. The outstanding loans of municipalities amount to £516,952, of which £234,100 is owing by Hobart and £281,152 by Launceston; the latter has accumulated a sinking fund of £32,390 against its indebtedness.

Defence.

Tasmania has a partially-paid force of 255, and a volunteer force of 2257, and a paid staff of 42; the cost of defence is £17,990 per annum, but of this sum £4998 represents Tasmania's contribution to the maintenance of the Australian auxiliary squadron.

Mining.

Mining is now the foremost industry, the exports of minerals amounting in 1900 to £1,638,672, compared with pastoral produce exported valued at £391,918, agricultural produce and fruit, £478,678. Tasmania produces gold, tin, silver, and copper, and in 1900 the production of these minerals was valued at: gold, £316,220; tin, £270,998; silver, £252,080; and copper, £901,660. Beaconsfield is the chief goldfield, 26 miles north-west of Launceston. There are about 1500 persons employed mining for gold on the various fields. The Mount Zeehan and Dundas districts produce almost the whole of the silver at the present time, and most of the ore is sold to agents of the Australian and German smelting works. Tasmania is the largest producer of tin in Australasia, and a very large proportion of the tin hitherto produced has been obtained from alluvial deposits, the lodes, except at Mount Bischoff, having, comparatively speaking, been neglected. The Mount Bischoff mine, which is worked as an open quarry, is the largest producer of tin, and (with an original capital of £30,000) has paid £1,732,500 in dividends. The number of tin miners in the state is about 1170. The production in 1900 was £270,998, which represents about four-fifths the value of what was obtained ten years previously. Tasmania takes the lead amongst the states in copper production: in 1896 there was a small export of £1659; in 1897 the export grew to £317,437, in 1898 to £378,565, in 1899 to £761,880, and in 1900 to £901,660. This expansion was chiefly due to the enterprise of the Mount Lyell Mining and Railway Company, whose mine is situated at Gormanston. A sum of £400,000 was expended by the company on construction and development works before any return was received from the mine, but up to the end of 1900 £670,000 had been paid in dividends. Up to the 28th December 1900, 863,061 tons of material had been dealt with, the quantity of gold won being 97,854 ounces, silver 2,443,901 ounces, and copper 27,155 tons. Coal-mining is carried on in various districts in the island, but the principal mines are at Mount Nicholas and Cornwall, in the Mount Nicholas Range; the output of the field is increasing, but no export trade is at present possible, the mines being situated too far from the sea-board. The number of men employed in coal-mining is 150, and the output about 46,000 tons per annum.

Manufactures are on a very small scale, the number of establishments being about 260, and the hands employed 3800.

Agriculture.

After being much neglected, agriculture received renewed attention in 1890, the area of land under wheat being increased from 32,452 acres in 1890 to 51,825 acres in 1901, and under oats from 20,740 acres to 45,073 acres, the total area being advanced from 157,376 acres to 224,352 acres. The area under crop, at intervals of ten years, was as follows: 1861, 163,385 acres; 1871, 155,046 acres; 1887, 148,494 acres; 1891, 168,121 acres; and 1901, 224,352 acres. Wheat is the principal crop, and the yield is larger per acre and less variable than that of the Australian states: for the ten years ending with 1901 the average yield was 18·9 bushels per acre, ranging between 15 bushels in 1894 and 27 bushels in 1899. The oat crop is also much above the Australian average, and during the ten years ending 1901 the yield ranged between 22 bushels in 1897 and 38 bushels in 1899. Tasmania is renowned for its fruit crops, and now that this fruit has found an opening in the British market, renewed attention is being directed to the industry. In 1901 there were 7888 acres of apples, 1053 acres of pears, 766 acres of apricots, 826 acres of plums, 531 acres of cherries, 354 acres of peaches, 1755 acres of strawberries, gooseberries, and raspberries, and 979 acres of currants. The crop for the same year included 551,251 bushels of apples, 59,480 bushels of pears, and nearly 60,000 bushels of other fruit. Tasmania finds its best markets for fruits in New South Wales and in Great Britain. The total value of the produce of Tasmanian farms now exceeds £1,020,000, which is equivalent to £4 11s. per acre cultivated and £5 18s. per inhabitant. The areas devoted to the principal descriptions of crops in 1901 were:—

	Acres.		Acres.
Wheat .	51,825	Potatoes . . .	23,068
Barley .	4,502	Grass for seed . .	2,302
Oats .	45,073	Hay	61,541
Peas .	9,824	Green crops . .	3,749
Turnips .	4,743	Gardens and orchards	13,001

Live stock.

Tasmania shows a decline in sheep-breeding, yet the state is singularly well adapted for sheep-raising, and its stud flocks are well known and annually drawn upon to improve the breed in the other states. Nor have the other branches of the pastoral industry shown much expansion, as the following table will show :—

Year.	Sheep.	Horned Cattle.	Horses.	Swine.
1861	1,714,498	87,114	22,118	40,841
1871	1,305,489	101,540	23,054	52,863
1881	1,847,479	130,526	25,607	49,660
1891	1,662,801	167,666	31,262	73,520
1901	1,683,956	165,516	31,607	68,291

Commerce.

The shipping increased considerably during the ten years preceding 1900 ; in 1888 the tonnage inwards was 385,650, and in 1900, 618,963. Hobart is now a place of call for several of the European steamship lines, and the state is becoming increasingly popular as a summer resort for the residents of Melbourne and Sydney. The growth of the shipping trade will be seen in the following table, which also gives the imports and exports at ten-yearly intervals ; it is not necessary to give the tonnage of shipping leaving, which is practically the same as that entering:—

Year.	Shipping entered.	Imports.	Exports.
	Tons.	£	£
1861	113,610	954,517	905,463
1871	107,271	778,087	740,638
1881	192,024	1,431,144	1,555,576
1891	514,706	2,051,964	1,440,818
1900	618,963	2,073,657	2,610,617

Tasmania does a large trade with Victoria, the imports in 1900 being valued at £908,722, and the exports at £388,913 ; with Great Britain the trade was, imports, £628,663, and exports, £688,600 ; and with New South Wales, imports, £337,672, and exports, £613,161. A considerable portion of the goods from both New South Wales and Victoria are of British origin. The principal exports in 1900, and their values, were : fruit, preserved and green, £279,988 ; oats, £39,901 ; potatoes, £103,223 ; hops, £19,870 ; hides, £67,941 ; wool, £261,214 ; bark, £29,405 ; timber, £42,213 ; silver ore, £252,080 ; copper, £901,660 ; tin, £270,998 ; and sheep, £51,092. The imports represent £12 and the exports £15 2s. per inhabitant. The chief ports of the colony are Hobart, imports in 1900, £776,918, and exports, £755,470 ; Launceston, imports, £808,326, and exports, £707,053 ; and Strahan, imports, £287,995, and exports, £868,239.

Railways.

The railways open for traffic in 1900 had a length of 594 miles, of which 439 were Government lines ; there were also 18 miles in course of construction, making the total mileage of the state 612. The progress of railway construction will be seen from the following figures: open for traffic, 1871, 45 miles; 1881, 168 miles; 1891, 425 miles ; and 1900, 594 miles. The railways, both State and private, are of 3 feet 6 inch gauge. The capital expended on Government lines up to 1900 was £3,659,069, and the gross earnings in that year £202,959, and the working expenses £160,487, leaving £42,472 as the net earnings. This last-mentioned sum is equal to 1·16 per cent. on the capital expenditure ; and as the average interest upon outstanding loans is 3·73 per cent., the railways are carried on at a loss of 2·57 per cent. On the other hand, the private railways show excellent returns; the Emu Bay and Mount Bischoff line, 98 miles in length, constructed at a cost of £396,796, returned in 1900 about 3 per cent., and the Mount Lyell Company's railway, 22 miles long, costing £220,333, returned over 8 per cent.

The roads maintained by the road trusts and boards of the colony extend over 6368 miles, of which 2987 miles were macadamized ; the annual expenditure thereon is over £25,000.

Posts and telegraphs.

There were 371 post offices and receiving offices in 1900, and there were also 322 telegraphic stations. The postal officials numbered 828, and 317,000 postcards, 10,590,000 letters, 1,900,000 packets, and 6,637,000 newspapers were received and despatched. The postal revenue amounted to £99,864, and the expenditure to £84,539 ; these sums include telegraph and telephone business. The telegraph messages sent numbered 370,225. The telephone system is being rapidly extended, and at the beginning of 1901, 1194 miles of line were being worked.

Banking.

There are four banks of issue, of which two are local institutions ; their united assets amounted in June 1901 to £3,315,120, and their liabilities to £3,353,863. The note circulation was £151,340, and the deposits £3,178,846, of which £1,759,292 bore interest. The coin reserve and till money amounted to £577,589. Post office and trustee savings banks are working side by side. Sums of one shilling and upwards may be deposited, and interest is allowed on sums under £150 at the rate of 3 per cent. per annum. The following table shows the progress of the savings banks since 1871, the number of accounts open at Hobart and Launceston being almost the same :—

Year.	Depositors.	Amount at Credit.
1871	8,500	£217,413
1881	14,728	369,278
1891	26,916	554,417
1901	42,509	1,009,098

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(G. C. L. ; T. A. C.)

Taste. See Physiology : *Special Senses.*

Tata (Totis), a market-town of Hungary, 57 miles west of Budapest. Near the town is a romantic lake, on the shore of which stands the old castle of the Counts Eszterházy, with a rich picture gallery and other collections, and a park of 140 hectares, much frequented by the citizens of Budapest. Population (1891), 6925; (1901), 7220.

Tatar Bazardjik, or Tatar Pazardjik, chief town of a department in eastern Rumelia, Bulgaria, on the Upper Maritza, and on the Sofia–Constantinople railway, 74 miles E.S.E. of Sofia and 23 miles W. of Philippopolis. Situated at the junction of several roads, it began to acquire importance in the 15th century, when it was known as the small Tataren Markt, and also as Pazar of the " Markt." Occupying a low situation, it is rather subject to flooding in winter. The railway station on the opposite side of the river is reached by a wooden bridge resting on sixteen stone pillars. The town is an important centre of the rice trade, which has much increased, and it has also some trade in cocoons. Population (1892), 16,343. Though originally almost wholly Turkish, the inhabitants are now mainly Bulgarian, the Turks numbering less than one-tenth.

Tate, Sir Henry, Bart. (1819–1899), English merchant and founder of the National Gallery of British Art, was born at Chorley, Lancashire, in 1819. His father, a minister of religion, put him into business in Liverpool. He became a prosperous sugar-broker, and about 1874 removed to London, where he greatly increased the operations of his firm and made " Tate's Cube Sugar " known all over the world. He had early in his career begun to devote large sums of money to philanthropic and educational purposes. He gave

£42,000 to the Liverpool University College, founded in 1881; and a still larger sum to the Liverpool hospitals. Then, when he came to London, he presented four free public libraries to the parish of Lambeth. His interest in art came with later years. He was at first merely a regular buyer of pictures, for which he built a large private gallery in his house at Streatham. He was also the friend of many painters and others interested in art, and every year he invited them to a large dinner-party just before the opening of the Royal Academy exhibition. Gradually his gallery came to contain one of the best private collections of modern pictures in England, and the owner naturally began to consider what should be done with it after his death. It had always been his intention to leave it to the nation, but in the way of carrying out this generous desire there stood several obstacles. The National Gallery could not have accepted more than a selection from Tate's pictures, which were not all up to the standard of Trafalgar Square; and even when he offered to build a new gallery for them, it was found difficult to secure a suitable site. What Tate offered was to spend £80,000 upon a building if the Government would provide the ground. This proposal was made to Mr Goschen, while he was Chancellor of the Exchequer, through the good offices of Mr Humphry Ward. But it was not until Sir William Harcourt had succeeded to the Chancellorship in 1892 that Tate's offer was finally accepted. One possible site at Blackfriars was refused by the City Corporation; another at South Kensington was found to be already allotted to the future College and Museum of Science. However, the demolition of Millbank Prison left a large plot of ground vacant upon the Embankment at the Middlesex end of Vauxhall Bridge, and this Sir William Harcourt presented to Mr Tate, on condition that the control of the new building should be placed in the hands of the Trustees of the National Gallery, of whom Mr Tate himself was one at the time. The total sum spent upon construction was much more than £80,000; in fact, it was said to approach a figure twice as large. The gallery was opened by the Prince of Wales on 21st July 1897, and a large addition to it was completed just before the donor died. It contained sixty-five pictures presented by him; nearly all the English pictures from the National Gallery painted within the previous eighty years; the pictures purchased by the Royal Academy under the Chantrey Bequest, which had previously hung in South Kensington Museum; and seventeen large works given to the nation by Mr G. F. Watts, R.A. Mr Tate was created a baronet in the year after the Tate Gallery, as it became the custom to call it in order to avoid confusion between it and the National Gallery, had been opened. He died at Streatham on 5th December 1899.

Tatian, Diatessaron of.—Since the appearance of the article on Tatian in the ninth edition of this work (vol. xxiii. p. 80 f.) an Arabic version of the Diatessaron has been published at Rome by Agostino Ciasca from two MSS., together with a Latin translation; the Latin was afterwards rendered into English by J. Hamlyn Hill, and the Arabic by Hope W. Hogg. Of the two manuscripts, one, now in the Vatican library, is of about the 12th century; it was brought from the East in 1719 by S. Assemani, and its existence had long been known to scholars, although it had not been examined in detail. The other, now in the Borgian Museum, was sent from Egypt as a present to the Pope in 1886 by a Uniat Copt named Halīm Dōs Ghālī, and is of a somewhat later date, although it contains, on the whole, a purer text. The two MSS. are derived from a common source, which, as we learn from the introduction and colophon to the Borgian MS., was a version made by Ibn-aṭ-Ṭayyib (died 1043), a Nestorian monk who was secretary to Elias I., patriarch of Nisibis, from a Syriac MS. of the Diatessaron which was in the handwriting of one Ibn-ʿAli, who appears to have flourished *circ.* A.D. 900. Each of the MSS. states, either in the introduction or the colophon, that what it contains is the Diatessaron compiled from the four Gospels by Tatianus (Borg. MS., coloph. *Tatianus*); in each case, however, the text shows signs of many accretions, which appear to be drawn from the ordinary text of the [Arabic] gospels.

We have therefore at the present time three main streams of evidence for the study of the Diatessaron of Tatian, viz., the Arabic version from the Syriac; the Armenian version of Ephraem's gospel commentary in Syriac, which has the Diatessaron for its basis; and the so-called Codex Fuldensis (edited by Ernestus Ranke in 1868), in which the text of the Vulgate has been introduced into an arrangement of the Gospel narrative which is that of the Diatessaron. It is upon these, in the main, that the study of the work must be based; unless, indeed, a Syriac or Greek text should be discovered. The whole matter is still under study, but the opinion of scholars seems to be in favour of a Syriac rather than a Greek original for the work. It has been suggested by Mr Rendel Harris, with no little plausibility, that the Diatessaron shows signs of being based in part upon one or more already existing compilations. On the other hand, it is clear that it depends ultimately upon the four Gospels as we know them, and no others; and these substantially in their present forms, including, for example, the concluding verses of St Mark. As to the history of the Diatessaron itself, it is summed up as follows by Mr Hope W. Hogg: "It would seem that at a quite early stage the Diatessaron was very widely if not universally read in the Syriac churches, and commented on by scholars as the Gospel; that in time it fell under the condemnation of some at least of the Church leaders [Theodoret, Rabbūlā], who made violent efforts to suppress it; that it could not be suppressed; that a commentary on it was (perhaps in the 5th century) translated into Armenian; that it was still discussed by commentators, and new Syriac MSS. of it made in the 9th century, and thought worth the labour of reproduction in Arabic in the beginning of the 11th century; that MSS. of the Armenian volume continued to be made down to the very end of the 12th century, and of the Arabic edition down to the 14th century; but that this long life was secured at the expense of a more or less rapid assimilation of the text to that of the great Syriac Bible, which from the 4th century onwards became more and more exclusively used—the Peshitta."

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Tátrafüred (German, *Schmecks*), a famous spa and summer resort of Hungary, in the Tátra Mountains, 3330 feet above sea-level, in the midst of wild, romantic scenery. Although the first house was built here in 1797, the place only came into repute about 1870. It consists chiefly of three large establishments and several hotels.

Taunton, a municipal and parliamentary borough and market town, Somersetshire, England, in the Wellington parliamentary division of the county, 45 miles south-south-west of Bristol, on the river Tone and the Great Western railway. A bridge was erected in 1895 across the river, connecting the town proper with its northern part. Vivary Park was laid out in 1896. A recreation ground was opened in 1895, and in 1897 the corporation commenced a scheme for connecting the Parade with Park Street. Population (1881), 16,614; (1891), 18,961; (1901), 21,078.

Taunton, a city of Massachusetts, U.S.A., capital of Bristol county, in the south-eastern part of the state, at an altitude of 40 feet. The city has an irregular plan, is divided into eight wards, has a good water-supply by pumping, and is well sewered. It has extensive and varied manufactures; in 1900 there were 284 establishments, with a total capital of $11,737,399, employing 2102 hands, and having a product valued at $12,594,814. The principal items of manufacture were cotton goods, value $4,593,466; foundry and machine-shop products, $2,636,390. In 1900 the assessed valuation of real and personal property was $19,885,835, the net debt was $1,424,573, and the rate of taxation $18.60 per $1000. Population (1890), 25,448; (1900), 31,036, of whom 9140 were foreign-born and 226 negroes.

Taunus, a wooded, hilly district in the Prussian province of Hesse-Nassau and the grand-duchy of Hesse-Darmstadt. It lies between the Rhine and the Main on the south and the Lahn on the north, and stretches some 55 miles east and west. But while its southern slopes stand 5 to 10 miles back from the Main, they leave only a very narrow strip of low ground alongside the Rhine, between Biebrich and Bingen; and after the Rhine turns at Bingen, they overhang it as precipitous crags, many of which are crowned with picturesque feudal ruins. The range or system has an average elevation of 1500 feet, but the individual summits are some 1000 to 1300 feet higher. The loftiest peaks occur in the east, where the imposing cluster of Grosser Feldberg (2890 feet) Kleiner Feldberg (2715 feet), and Altkönig (2620 feet), dominate the Wetterau and the valley of the Main. Above the Rheingau, or the slopes which stretch down to the Rhine between Biebrich and Bingen, the altitude averages 1500 to 1700 feet. The geological core of the system consists of primitive argillaceous schists, capped by quartzite and broken through in places by basalt. On the northern side, which sinks on the whole gently towards the Lahn, the greywacke formation attains a considerable development. The hills are almost everywhere well wooded, the predominant trees being firs and beeches. The lower slopes are, wherever possible, planted with vineyards, orchards, and chestnut and almond groves. The vineyards of the Rheingau are specially famous, and yield brands of wine—*e.g.*, Johannisberger, Steinberger, Rüdesheimer, Marcobrunner, Hochheimer, Rauenthaler, Assmannshäuser, and others—which enjoy the highest reputation amongst the vintages of Germany. The Taunus is also famous for the number and efficacy of its mineral springs, which annually attract thousands of visitors to the celebrated spas of Wiesbaden, Homburg, Ems, Schlangenbad, Schwalbach, Soden, and Nauheim, whilst the waters of Selters and other springs are exported in vast quantity. The sheltered position and warm climate have led also to the establishment of the health resorts of Falkenstein (1875) and Schmitten, and to other places, such as Königstein, Cronberg, and Oberursel, being much frequented by pleasure-seekers in summer. And the attractions of the climate are supplemented by the natural scenery, as well as by historical associations. Above Falkenstein stand the ruins of the ancestral castle of Kuno, the powerful archbishop of Treves; above Königstein are the remains of the former fortress of that name belonging to the Electors of Mainz, and destroyed by the French in 1796; on Altkönig, two concentric fortified lines, 4557 and 2982 feet in circumference, date from ante-Roman times; the family seats of Eppstein, Katzenelnbogen, and Scharfenstein are famous; there are also the once celebrated Cistercian abbey of Eberbach, founded in 1116, and the former pilgrimage resort of Kiedrich. Eltville, at one time the chief town of the Rheingau, and frequently the residence, in the 14th and 15th centuries, of the archbishops of Mainz, is associated with Gutenberg and the earliest years of the art of printing. But perhaps the most interesting of the historical memories of this region are the traces of the ancient Roman palisaded moat, or fortified boundary of the empire (*limes*), which stretched from the Rhine at Rheinbrohl (below Coblenz) along the summit of the Taunus to the Main at Miltenberg, and was indeed carried on to the Danube. On the southern or Roman side this fortified line was backed by several castles, one of which, the Saalburg, survives in part, and, after being restored to its original appearance, was in 1901 converted into a national (German) museum, one of the most instructive historical memorials of ancient Roman life to be found north of the Alps. The original edifice, or rather edifices, for there seem to have been at least three successive forts built on the same site, were constructed in the 1st and 2nd centuries of our era. In this same region, though 40 miles to the west of the Saalburg (which crowns the crest of the Taunus, 4 miles north-west of Homburg), there is a modern national monument, the colossal figure of Germania, which stands on a bold spur of the Taunus 740 feet above the Rhine. It was erected in 1883 to commemorate the war of 1870–71 and the re-creation of the German empire in the latter year. The steep crags of the western end of the Taunus, where they abut upon the Rhine, are rich in the romantic associations of the great river. Here are the rock of the siren Lurlei or Lorelei; the old castles of Stahleck and Pfalz, which belonged to the Counts Palatine of the Rhine; and the quaint mediæval towns of Kaub and Sankt Goarshausen. Yet another, though a sorrowful, association clings to the Taunus, in Schloss Friedrichshof, at the foot of the Feldberg and Altkönig, immediately north of Cronberg, built in 1889–97 for the Empress Frederick, and the place where she died in 1901. In addition to Frankfort, Bockenheim, Höchst, and Biebrich are centres of manufacturing industry.

Taurida, a government of South Russia, including the peninsula of Crimea and a tract of the mainland. It has an area of 24,540 square miles, of which 6990 square miles belong to Crimea. This peninsula continues to afford a favourite field for geological research. Its south-eastern coast is occupied by mountains, while the remainder consists of a plateau of dry prairie land (steppe), which attains its highest level of about 700 feet at the north-western foot of the mountains, and gently slopes towards the north-west. A secondary plateau, Eupatoria Plateau, shoots off to the western extremity of the peninsula. The mountains which fringe the south-east coast consist of several parallel chains separated by longitudinal valleys. The main chain begins, in the south, at Cape Fiolent, where the cliffs rise sheer from the sea for from 2000 to 2500 feet. Farther eastwards the range slightly retreats from the coast inland, its highest summit, Tchatyr-dagh, lying 8 miles from the sea. The main range has on its summit a succession of flat surfaces (*yailas*), which might well be compared to the Alpine meadows but for their much poorer vegetation.

Several mountain passes (*bogaz*) intersect these plateaux, but only six of them are available for carriage roads. The highest summits of the main range, rising from 4000 feet to 5000 feet, are found in its middle section, the principal peaks being Tchatyr-dagh, or Ekliz-Burun (5005 feet), Roman-hosh (5061 feet), Kemaligherek (5012 feet), and Western Karadagh (3731 feet). Geologically the main range consists of clay slates—very capriciously bent in all directions, but having a general dip towards north-west—intersected by veins of marble and quartz, and covered with sandstones, conglomerates, and limestones. They belong to the Titanic division of the Jurassic age, which is intermediate between Jurassic and Chalk, and masses of trachitic and crystalline rocks protrude from beneath them. The second chain consists of conglomerates, sandstones, marls, and limestones, belonging to the Chalk, also dipping north-west, and falling towards the south-east in steep crags, in which thousands of small caverns probably inhabited in prehistoric times by Tauro-Scythians, are excavated. The Chalk deposits are covered with the oldest Tertiary nummulitic sandstones. The highest summits of this second chain rise from 1550 to 1900 feet. A valley from 10 to 13 miles wide separates it from the main chain, and several rivers pierce it in delightfully picturesque gorges. A second valley 2 or 3 miles wide, which is followed by the railway from Simferopol to Sebastopol, separates the second chain from a third, which is only from 500 to 850 feet high, and consists of Middle Tertiary clays and sandstones belonging to the Mediterranean and Sarmatic divisions, which also dip north-westwards, but only by three or four degrees. This range is limited to the south-western part of the peninsula. A fourth range composed of younger Tertiary deposits may be traced in the southern parts of Crimea. The peninsula is badly watered on both the south-east and the north-west slopes of the mountains. The short rivers of the former carry considerable quantities of water, but they dry up in the summer. In the steppes, indeed, which cover the largest portion of the peninsula, water can only be obtained from wells, which have to be dug from 200 to 280 feet deep; but artesian wells have begun to be made, and there are now several dozens of them, supplying large quantities of water. The character of the climate can best be judged by comparing the following observations taken at three different stations:—At Melitopol, in the steppe region, the average temperature for the year is 48° F., for January 20°, and for July 74°; at Simferopol, in the mountain region, the average temperature for the year is 50° F., for January 31°, and for July 70°; on the south coast, at Yalta, the average temperature for the year is 56° F, for January 39°, and for July 75°. As a rule the thermometer seldom falls on the south coast below 17 or 20 degrees. The yearly rainfall is small everywhere, being on an average only 13·8 inches in the steppes, 17·5 inches at Simferopol, and 18·8 inches at Yalta. It varies greatly, however, from year to year, so that Simferopol experiences such extremes as 7·5 inches and 26·4 inches. The vegetation widely differs, of course, in the steppe region and on the south coast. In the steppe region the prairies are covered in early spring with a great variety of grasses and Liliaceæ, growing very thickly, but in July and August the prairies are so parched by the sun that everything but the common desert plants die off, while the air is filled with clouds of dust; parts of the steppes, too, are impregnated with salt, and are covered only with the usual Salsolaceæ and Artemisiæ. The mountains, on the contrary, are covered with beautiful forests of beech, oak, and elm, mixed with the northern fir and thickly interwoven with the ivy and the vine. As to the flora of the southern coast, it has a great number of acclimatized plants, and bears a great resemblance to the vegetation of Tuscany.

The population of the peninsula in 1897 was only 853,900 (domiciled only), of whom nearly 150,000 lived in towns. Though large numbers of Tatars left Crimea after the war, the race still forms the main element in the population, but there are also numbers of Germans, Bulgarians, Czechs, Esthonians, Greeks, Jews—who have acquired the habits of the Tatars—Karaites, and Tziganes. The prairies are chiefly owned by private persons, the descendants of the Tatar beys. Cattle-breeding, which was formerly the chief occupation of the people, is on the decline; large areas have been and are being turned into fields, and there are now in Crimea only 66,000 horses, 150,000 cattle, and less than 1,000,000 sheep. No less than 1,080,000 acres are now under crops in Crimea, chiefly wheat and barley. There are also numerous plantations of tobacco, and gardening is rapidly spreading, its returns being estimated in 1899 at 2,000,000 roubles. Nearly 19,000 acres are under vineyards, and 3½ million gallons of wine are obtained annually. Salt is extracted to the amount of nearly 200,000 tons per annum. Industries are represented by ship-building, flour-mills, iron works, jam and pickle factories, soap works, and tanneries. The Tatar population excels in a great variety of domestic industries, and especially in the working of leather, wool, and metal.

The mainland part of Taurida consists of prairies, less than 150 feet high, and sometimes sandy and waterless in the south-west, and from 150 to 400 feet high in the north-east. It had in 1897, 904,673 inhabitants, chiefly Great and Little Russians, but including nearly 50,000 Germans and 25,000 Bulgarians and Jews. The chief occupation of the people is agriculture, and every available patch of land has been brought under the plough. The increase in the area under all crops in the ten years 1889–99 was fully 39 per cent. for the whole province, which had in 1900 no less than 6,755,200 acres under cereal crops alone. The average annual yield in 1895–99 for the whole of the province was, rye 2,178,000 cwt., wheat 9,698,000 cwt., oats 1,431,000 cwt., barley 8,749,000 cwt.—all cereals, 25,535,000 cwt.; also 2,053,000 cwt. of potatoes. There were further, in 1899, 7680 tobacco plantations, covering over 8150 acres, and 32,300 acres under vineyards (crop over 600,000 cwt.), while gardens covered about 15,500 acres in Crimea alone, the average annual export of fruit in 1895–99 being 300,000 cwt. Cattle-breeding is extensively engaged in, there being in 1897 in the whole province 341,000 horses, 414,000 horned cattle, 2,226,000 sheep, and 172,000 swine. Salt, of which about 210,000 tons are obtained annually, is the only mineral raised in the province, but the iron industry, and especially the manufacture of agricultural machinery, has greatly developed, Berdyansk, on the Sea of Azov, being now perhaps the first town in Europe for agricultural machinery. The export trade is considerable, the chief ports being Sebastopol, Eupatoria, Theodosia, and Yalta on the Black Sea, and Azov and Berdyansk on the Sea of Azov. In the foreign trade all ports were visited in 1899 by 541 ships, the exports amounting to 596,500 tons and the imports to 71,000 tons; but in the coasting trade they were visited in 1898 by 10,360 ships of 5,935,480 tons. The traffic on the railways is also very great, the yearly imports by railway being 822,000 tons, and the exports 677,000 tons. The government is divided into eight districts, the chief towns of which are Simferopol (48,821), which is also the capital of the government; Eupatoria (17,915), and Theodosia (27,238), in Crimea; and Aleshki (9119), Berdyansk (27,279), Melitopol (15,120), Perekop (5285), and Yalta (13,269), inland. Sebastopol and Kerch-Yenikale are separate townships (*gradonachalstvo*) under military governors; and there are several villages, such as Bolshoy, Tokmak, Andreevka, and Mikhailovka, with a population of over 7000. (P. A. K.)

Taus (Czech, *Domažlice*), the chief town of a government district of Bohemia, on the border of the Bohemian Forest, 29 miles south-west of Pilsen. The manufactures comprise ribbons, hosiery, machinery, sugar, pottery, glass and mirrors, beer, &c., and there is some trade in corn and timber. Taus was the scene of a Hussite victory on the 14th August 1431, and some interesting MSS. of that period are preserved in the Rathhaus. Population (1890), 7703; (1900), 7555, chiefly Czech.

Tavistock, ancient parish, market town, and railway station, Devonshire, England, in the Tavistock parliamentary division of the county, 15 miles north of Plymouth, in the valley of the Tavy. The copper-mining industry is in a depressed condition, but there is a trade in arsenic which is extracted from the copper ore. A cottage hospital and dispensary was erected at Spring Hill in 1896. Population (1891), 5043; (1901), 4728.

Tavoy, a district in the Tenasserim division of Lower Burma, lying between the Bay of Bengal and Siam. Population (1881), 84,988; (1891), 94,921; (1901), 109,131. In 1891 92,556 were Buddhists and Jains, 796 Mahommedans, 326 Hindus, 94 aborigines (mostly Karens), and 1149 Christians, of whom 1039 were natives, chiefly Karens.

Area, 5308 square miles; 303 villages in 1898-99, paying a revenue of Rs.306,673. The total acreage of the district is 3,397,120 acres, and of this 358,400 are under forests, 1,876,035 are uncultivable, 1,044,612 are available for cultivation, and 111,285 were cultivated in 1898-99. There were 6788 acres of fallow. The rainfall in 1898-99 was 197·26 inches. The great bulk of the cultivation is rice, but there are many orchards. The town of Tavoy, standing on the river of that name, had a population of 15,099 in 1891. A considerable amount of coasting trade is carried on with the other parts of Burma and the Straits Settlements.

Taxation is that part of the revenue of a state which is obtained by compulsory dues and charges upon its subjects. The state may have revenue from property of its own. In past times one of the principal sources of the revenue of the sovereign was in fact property of some sort, of which the Crown lands in Great Britain, still administered by the Government, are a remnant. In other countries, even at the present time, there is a large public domain yielding revenue. Local authorities also largely own property from which a revenue is obtained. But as a rule, and in spite of what has often been the practice in the past, and of exceptions which may still exist in some countries, a Government obtains the money required for its expenses by means of taxation. Some of the apparent exceptions, moreover, appear to be only exceptions in name. It is contended, for instance, that the revenue from land obtained by the Government of India is in reality of the nature of a land rent—a species of property owned by the Government. But the fact of a Government levying so general a charge may be held *ipso facto* to convert the charge into a tax, having much the same economic effects and consequences as a tax. When, moreover, a state receives a revenue from property, some of the economic consequences may be the same as if it received the money by means of a tax. In both cases there is absorption and administration by the state of so much of the income of the community, and it may be a question whether the private ownership of the property would not be more expedient both for the state and its subjects than state ownership is, in spite of the apparent advantage to all concerned in the state getting so much of its income without the compulsion of a tax.

The Different Kinds of Taxes.—In the economic development of states taxes have come to be grouped in different ways, according to variations in the method of levying them or the means of enforcing compulsion or other differences. One of the most usual divisions is into *direct* and *indirect* taxes. Taxes are distinguished as direct, because they are charged directly upon the taxpayer from whose income they are supposed to be taken. Indirect taxes are those where it is recognized from the beginning that the individual who pays in the first instance usually passes on the charge to some one else, who may again pass it on until it finally reaches the subject who bears the burden. The income tax, a direct charge upon all incomes above a certain limit, is the principal type in the United Kingdom of a direct tax. In France there is a group of taxes known by that name—a land tax, a personal and furniture tax, a door and window tax, and a trade licence tax. In the United States there are mainly assessments of the capital value of property, usually for state and local purposes only, and not for the central Government. Among the indirect taxes the most important are excise and customs duties (see Excise Revenue) upon articles of general consumption, the principal articles almost everywhere being spirits, beer, and tobacco. Sugar, tea, coffee, and cocoa are also among the articles commonly selected. In essential character there is no difference between excise and customs duties, except that excise duties are levied upon articles of home production, and customs upon articles imported from abroad, or brought into one part of a country or empire from another part; but excise duties on the whole are considered more likely to interfere with trade, in consequence of the necessity of supervising the production of the articles affected. Next in importance to excise and customs we have duties levied by means of *stamps* upon documents (see Stamp Revenues), or by charges at the time of registering deeds to which registration is necessary for the purpose of being valid. The charge in one case upon the article at a certain stage of its production, and in the other upon a transaction, is supposed to be passed on by the first payer to others. With these have been usually classed in the United Kingdom certain licence taxes upon traders, although such licences in France are reckoned direct taxes.

This division into direct and indirect is, however, far from logical. To take first the direct taxes. The income tax itself is not, in all cases, really paid to the state directly by the person out of whose income it comes. It is paid, in the first instance, in the case of land or houses, by the occupier, and where the occupier is a tenant it is recovered by him from the owner. In the case of joint stock companies the company pays the state, and deducts the amount from the individual owners of stocks and shares out of whose incomes the amount comes. The ultimate payer in these cases is no doubt reached without delay or many steps, but the process is not quite direct. It is the same with rates. A householder is assessed as occupier, but he may be "compounded for," and really know nothing of the payment, though it is supposed to come out of his income. In the case, again, of a long established land tax or rate many questions may arise as to whether the person who is considered to bear the burden in the first instance really bears it in the end. It is contended by some that the tax becomes in the nature of a rent-charge upon the property affected, and that the state really acts as landowner in levying the charge just as it does in receiving the rent of Crown lands, and with similar economic incidents and consequences. Thus the direct taxes so called may frequently be no more direct than any others.

As regards indirect taxes, again, there appear to be some cases at least where it is by no means certain that the charge is passed on; stamp duties, for instance, especially where moderate in amount, may have the effect of diminishing *pro tanto* the profits in business of the person paying them, or the income which he enjoys. Where they are heavy, as, for instance, with the French registration duties on the transfer of property, there appears to be little doubt that they constitute a deduction from the price which a seller receives, and thus they are direct enough. Sometimes also, when a charge upon a commodity is not of such a figure as to be easily divisible among the ordinary units of retail consumption, so that it can be passed on to a consumer of the articles in the form of an increased price, it may remain fixed upon those who first pay it, at least for a time. This is supposed to have actually happened with the increase of the beer duty in the British budget of 1894 by 6d. per *barrel*—a sum which would not when divided by the pints in a barrel amount to the smallest coin in the realm. When the multure tax, a tax upon milling grain, was imposed in Italy many years ago, it was found that no corresponding increase took place in the price of flour and bread. The trade fell into the hands of the millers on a large scale, who paid the tax out of their increased profits from larger business, while the smaller millers were crushed out; so that this was manifestly the case of a tax, so called indirect, where the whole burden really fell on those who paid the charge in the first instance, and who in theory were supposed to pass it on to others. Even in the case of indirect taxes, therefore, there are important exceptions to the rule that they are indirect.

The division of taxes into direct and indirect is thus based on no real intrinsic difference. It is a classification for convenience' sake, adopted upon a rough observation of conspicuous, or apparently conspicuous, differences in the mode of levying taxes, and nothing more. The division, nevertheless, cannot be passed over without mention, as it is not only a common one in economic writing, but it figures largely in budget statements, financial accounts, and finance ministers' speeches—especially in the United Kingdom and France. In the United Kingdom the distinction has been made familiar by free-trade discussions. Direct taxation in the shape of income tax was substituted for indirect taxation previously levied, in order to relieve trade from the shackles of duties and charges which had become all-embracing. In France the direct taxes above referred to are described officially as direct, having been originally, there is little doubt, the main sources of Government income; and there is equally an official designation of certain heads of revenue as "*contributions et taxes indirectes.*" Quite lately in budget debates in England there has been much comparison of the amounts yielded at different times by direct and indirect taxes respectively.

Other general classifications of taxes have also been attempted, as, for instance, taxes upon real property, and taxes upon personal property, and so on. Classification is indeed only too easy. Applying a characteristic common to some taxes, we can make a group of them, and set them against a group of all the other taxes lumped together. Such classifications are, however, uninstructive, and it has been found practically necessary in financial writing to take the principal taxes by name, or by such a general grouping as that of import or stamp duties, and then describe their nature, characteristics, and incidence. In this way each country has a grouping of its own, though there is a common likeness, and the experience and practice of one country assist the financial study of another. As Adam Smith remarks, there is nothing in which Governments have been so ready to learn of one another as in the matter of new taxes.

Descriptions of Taxes.—Following the practice of authors on finance, we may give a short account of the principal taxes in the United Kingdom, with references in passing to points of comparison or contrast with the taxes of other countries.

The income tax (*q.v.*) for many years has been the most prominent, and latterly it has been the most productive, single tax. At the war rate of 1s. 2d. per £, which was fixed in 1901, the annual yield in a complete year is the very large sum of £35,000,000, or about one-fourth of the total revenue raised by the Imperial Government. Its technical name is the Property and Income Tax, but it is essentially a charge upon all incomes or profits, whether arising from property, or from the remuneration of personal services, or from annuities, income being applied with the widest possible meaning. As originally instituted in April 1798, during the great war with France, under the name of a "triplicate assessment," it was rather a consolidation of various assessed taxes levied upon the luxuries of the rich and upon property, than a wholly new tax. In December of the same year this impost was repealed, and a true income tax of 10 per cent. established on all incomes over £60, with abatements between £60 and £200. It was intended as a temporary tax for war purposes only, and was repealed in 1802, but was reimposed when the war recommenced in 1803, with the limit of abatement reduced to £150. So odious was it that Parliament in 1815, when the war came to an end, ordered the destruction of the documents relating to it. Its efficiency as an instrument of producing revenue was, however, so great as to lead to its revival in 1843, when Sir Robert Peel inaugurated his great free-trade reform and swept away duties on exports, duties on imported raw material, and other imposts hampering the trade of the country. The intention again was that the tax should be temporary, but although the free-trade work was practically completed in the early 'sixties, and Mr Gladstone went so far as to dissolve Parliament in 1874 with a promise that he would abolish the tax if his party were returned to power, it has become a permanent impost. The reasons are that with the tax at a low rate it has been found much less intolerable than during the war, when it was at the rate of 10 per cent., while the pressure of the tax has also been greatly mitigated by placing very high the minimum income subject to it, and giving abatements upon the lower taxable incomes. These expedients have since been carried much farther, till now the minimum income subject to charge is £160 per annum, as compared with £60 when an income tax was first imposed in 1798, £50 in 1806, and £150 when it was revived in 1843, while abatements are given upon incomes above the minimum and under £700. Since these changes there has been a feeling among public men, and men of business generally, that the tax, with all its drawbacks, if usually kept at a low rate, fulfils a useful function as a revenue reserve for emergencies, on account of the ease with which it can be put up and down without disturbing trade. The tax, nevertheless, at the rate of 1s. 2d. per £, again gave rise to loud complaints. As regards this tax at least there is no question of its "directness" in a sense, as it is so contrived that it can hardly be passed on by those who are struck at, though they are not always the same as those who pay in the first instance, as has already been pointed out. There have been great complaints also of injustice by the possessors of temporary and precarious incomes, who have to pay the same rate of tax as the owners of permanent incomes from property, although these complaints have been diminished to some small extent by the raising of the minimum limit of the income assessed and the increase of the abatements on incomes under £700.

The varieties of income charged being very great, and special claims for consideration having been set up at different times, the result has been the formation of an Income Tax Code, defining the methods and rules for assessing the different classes of profits and income, and prescribing the way in which abatements and exemptions are to be obtained. A leading peculiarity is the avoidance of special inquisition into the aggregate of individual incomes. Although it is called a direct tax, the method of levy, as far as property is concerned, is upon the profits at their source, and not as they are distributed among the receivers. The question of the amount of individual incomes only comes before the authorities when claims for exemption and abatement are made. The character of the tax is accordingly much less odious than it would be if an account of individual incomes were invariably demanded, as was the case in the United States during the Civil War, when an income tax existed for a short time.

Other taxes grouped with the income tax by the authorities are house duty and land tax, but they are unimportant by comparison. The house duty replaced a window tax and other charges which were formerly not unimportant, especially in the interval between 1815 and 1843, when there was no income tax. It is a charge upon the occupiers of houses, mainly dwelling-houses, according to the amount of rent, the rate (1901) upon dwelling-houses being 9d. per £, and the yield to the state being about £1,750,000 per annum, as compared with £35,000,000 of income tax at 1s. 2d. The incidence is probably much the same as that of the income tax itself, though there are curious questions as to the ultimate incidence as between owners and occupiers of houses. The land tax is quite unimportant, being an ancient tax upon an old assessment which has long become obsolete, and it interests economists most of all by the illustration it furnishes of what may be called a rent-charge tax—a tax, that is, which has been so long in existence and so fixed in its basis that it becomes in reality a charge upon the property, and not a direct burden upon the person who pays it, as the income tax is upon the person who pays it or for whom it is paid. In 1897 the basis of the tax was varied, but not in any way to affect the principle just stated.

The next great group of taxes is that of the excise (*q.v.*) and customs duties upon commodities. Excise duties are charges upon commodities produced at home on their way to the consumer, and customs duties in the United Kingdom, with an exception to be noticed, are charges upon commodities brought into the country from abroad; and they are of essentially the same nature. Not only so, but excise duties and customs duties are in some cases supplementary to each other, like articles being produced at home and imported from abroad, so that for the sake of the revenue they have both to be taxed alike. Of this in the British system spirits are the best instance.

The total yield of customs and excise in the United Kingdom in 1901 was about £67,000,000 (including the duties imposed up to that date), and the amount from the principal articles was as follows: Spirits, £24,000,000; beer, £13,500,000; tobacco, &c., £13,000,000; tea, £6,300,000; sugar, £6,300,000; wine, £1,500,000, besides minor amounts from a few other articles. With these should also be included a small export duty of 1s. per ton on coal, levied by the machinery of the customs, though its incidence cannot be precisely the same as that of the import duties with which it is classed.

Export duties, it may be observed, are not important in systems of taxation generally, as there are few articles where the charge will not really fall on the wages of labour and profits of capital within the country imposing them; but opium grown in India is a well-known exception, and in the West Indies export duties on principal articles of production, in spite of their incidence, have been found a convenient source of revenue.

The list of commodities selected for taxation, it will be observed, is very small. This restriction to a few articles is obviously a great advantage to trade, but the number could be added to and still remain a small one. Few countries have so short a list of import duties at least as that of the United Kingdom, and in most the number is still so large as to be burdensome and harassing to trade, quite apart from the design to give protection, which raises totally different questions from those of revenue.

One consequence of having few articles is that the duty charged is very high *ad valorem* of the commodities concerned. On spirits the rate is 10s. per gallon, or rather more, on a commodity which costs no more on the average than 1s. to 3s. per gallon to produce. On tobacco the charge is 3s. 4d. per ℔ on an article costing no more, when imported, than about 7d. per ℔; on beer 8s. per barrel, costing perhaps not more on the average than 30s. per barrel; on sugar ½d. per ℔ on an article costing 1d. to 1½d. per ℔; on tea, 6d. per ℔ on an article costing 8½d. per ℔; and so on. Experience has proved that such high charges on a few articles are better on the whole than lower *ad valorem* charges on many articles; but there may be doubts whether the charges in some cases are not higher than is quite expedient.

Included with the excise duties are a railway passenger duty and certain licence taxes. The latter are not strictly of the general character above described as charges upon commodities, but they are of too small amount to deserve further discussion in connexion with Imperial finance, though the licences, as we shall see, bulk more largely in the question of taxation for behoof of local authorities.

The next large group of taxes is that of the stamp duties (*q.v.*), which bring in about £8,000,000 per annum. The principal items are about £1,500,000, derived from a stamp of 1d. upon each cheque or receipt for money paid, and about £5,000,000 derived from a variety of charges on deeds and other instruments, but principally a charge of 10s. per cent. *ad valorem* on the price paid for the transfer of real property and of stocks and shares, and 5s. per cent. *ad valorem* on mortgages. Included are various charges on foreign bonds to bearer, to compensate for the advantage they have in escaping the transfer duty on deeds, through their passing on sale or mortgage from hand to hand. The essence of the compulsion in the case of stamp duties is the invalidity of the documents in courts of law unless the stamp is affixed, besides liability to penalties for not affixing the proper stamps. As things go in matters of taxation, English stamp duties are now very low. In France, besides the stamp duties, there are charges on the transfer of real property amounting to about 6 per cent. on the official registration of the transfer which is necessary to make it effective.

We come next, in dealing with taxation, to a group of charges about which the question has been raised as to whether they are, properly speaking, taxes or not. These are the Post Office charges, yielding about £14,000,000 per annum, and the charges for telegraph service, including telephones, yielding £3,500,000. In the classification of the revenue in English budgets and in official returns[1] these charges are deliberately separated from the above sources of the revenue described as taxes, and classed with "revenue derived from other sources." The correctness of this procedure is questionable. According to old usage, the Post Office was made a state monopoly for the express purpose of levying taxation by means of it. In France the postage on letters is still called the *taxe des lettres.* There is no doubt also, that when postage on letters is charged at the rate of 1d. each, where the cost of collection and delivery, as in the metropolis, is perhaps not more than a tenth of a penny, it is difficult to distinguish the levy from that of any other tax. The excuse, as a rule, may hold good, that the postal charge is only a reasonable one for services rendered, so that the net income of the Post Office really resembles the profit of a business, but the element of taxation appears undoubtedly to enter. The same remark would apply to the charges for passenger conveyance and goods freight made by Governments which carry on railway business, as in Prussia, India, and the Australian states. In strict theory, where the

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[1] See *Statistical Abstract of the United Kingdom for 1900*, pp. 8, 9.

Government makes a charge, it levies a tax. The reasonableness of the charge in a given case is to its credit, but the features of monopoly and compulsion on the tax-payer make the charges difficult to distinguish logically from other taxes. The facts are not in dispute, however they may be described. If the Government derived a large income from post office and telegraph service in excess of the amount expended, the whole income would be generally, and not improperly, described as taxation, but consideration, of course, must be given to the difference made by the working of the service generally for the public advantage rather than for purposes of revenue.

Another source of revenue in British imperial finance is that from fees in courts of justice, patent stamps and the like, which is usually classified, like the income of the Post Office, as revenue derived from other sources than taxes. The amount is not large, though unfortunately it is not exactly known, owing to the fees being treated in many cases as extra receipts, and deducted from the expenditure of the departments by which they are received, so that this part of the national expenditure is not shown in the accounts at all. The proceeding appears to be quite incorrect, whatever excuse there may be for treating revenue like that of the Post Office as non-tax revenue. Fees levied on proceedings in courts of justice are not only taxes, but taxes of the worst sort. They received the special condemnation of Jeremy Bentham. It is a blot on British finance, therefore, that this part of the taxation is treated as if it were not taxation at all, and largely concealed from view in the way described.

Last of all, we have to notice among the Imperial taxes the estate (*q.v.*) or death duties, as they are called—the charges made by Government on the transfer of property from the dead to the living. These have been considerably increased in amount, and the Imperial Government derives in all about £14,000,000 a year from them. Various interesting questions arise regarding them. Logically they are apparently taxes upon the dead, as they limit the area of bequest, but they are felt by the living who receive the estate as if the burden of taxation fell on them. Practically, when a stranger receives the estate of a deceased man, the proper way of viewing the tax would appear to be that it is a share of property claimed by the state against a stranger who has no right in the matter except that which the state gives him, so that it is hardly a tax at all, as the word is usually understood; but when the estate is received by the near relatives of the deceased who were subsisting upon it even before his death, it is undoubtedly felt as a tax by them, and operates as a tax. It is even at times a very burdensome tax, falling upon a family when its sources of income are otherwise diminished, while it has the demerit of striking a small number annually instead of being diffused equally. Death duties also raise the question as to their being taxes upon capital. They are of large amount, even at the lowest rates of 1 to 4 per cent. upon the capital charged, and they have to be paid at such times as to cause their being paid out of capital and not out of income, so that their tendency is to diminish the capital available for productive enterprise. This last feature has not until lately been material in British finance, the income from death duties being less than the amount annually applied to the reduction of the National Debt, while accumulations of capital otherwise were on an enormous scale; but when the yield is so large as £14,000,000 annually, besides £4,132,000 levied for local authorities (see *infra*), and the reduction of the debt is suspended, the tendency of death duties to become serious taxes on capital may perhaps require consideration.

Local Taxation.—Besides the above revenue from taxation for Imperial purposes, large amounts are raised for local purposes. The local authorities derive a large income from private property, and from monopolies such as water, gas, electric light, telephones, and tramway service, which they carry on, and on which the same observations may be made as on the post office and telegraph services; but in addition there is a large amount of taxation, nearly the half of the annual total of local expenditure in the United Kingdom, amounting to about £112,000,000 (1898–99), being probably so derived. The principal portion of this taxation consists of rates, that is, a direct charge upon the income or rental of real property, such as lands, houses, railways, and mines, but mainly lands and houses. In England, in the year referred to, the amount received from rates was £38,000,000, and in Scotland £4,000,000, while in Ireland, although no distinct separation is made in the accounts between rates and income from gas and water undertakings, the amount may be estimated at about £3,000,000, which would give a total of about £45,000,000 as the amount received in the United Kingdom. Rates are thus even a more important factor in taxation than the income tax, and they have given rise to even greater complaints and discussion. Some years ago a special Royal Commission was appointed, under the chairmanship of Lord Balfour of Burleigh, to consider the problems of the rates, and after making one elaborate report this Commission was still sitting in 1902. The most important questions raised in a scientific view appear to be the misconception of the whole problem of local taxation by Governments. Rates were originally imposed, there is little question, when the intention was to tax all local incomes equally, and this is still the intention in the local taxation of the United States as well as the United Kingdom. Rates were imposed, therefore, on all kinds of property and the income arising from them, just as they are imposed in the United States on the capital of the property itself. But it has been found in practice that for various reasons only real property, which is visibly local and cannot be moved away, can be assessed and made to pay. The owners of real property, however, continually urge that they are unfairly treated, and that other property should be rated. Next there has been misconception, arising from the same cause, in the constant attempt to charge the occupier of lands and houses with rates, although the real effect of the rates must be, as a rule, to diminish the value of the property affected like an old-established land-tax, so that rates, properly speaking, do not fall upon either owner or occupier. It would be hard, however, to persuade the mass of occupiers in England that they do not pay the rates, so that the expedient of dividing the rates between owner and occupier, though it cannot affect their real incidence to a substantial extent, constantly finds favour. The confusion has been further increased of late years by attempts, as far as towns are concerned, to find a new subject of taxation in what are called *site values*, as if rates themselves were not in reality an appropriation by the state of a portion of the whole value of the property, subject to which all the other interests exist. It would be impossible here even to state all the questions that have arisen about rates; but the essential confusion caused by the neglect of practical men to study the natural history of taxation, as it may be called, must be obvious to every student. The frank recognition that local income taxes are impossible, and that taxation on property for local purposes can only be applied to real property, where it becomes, usually or frequently, in the nature of a rent-charge, would have saved the legislature and the public an infinity of laborious discussion.

Other taxes for local purposes comprise dues and tolls, such as harbour dues, where the money is required for such a definite purpose as a harbour, maintained at the expense of the traffic accommodated. Here again the question arises as to whether the tax is a mere compulsory charge or payment for a service rendered. Such tolls and dues in the British system of local taxation amount to about £8,000,000 a year. Among these may perhaps be included some charges in the nature of *octroi* dues, imposed on commodities entering a town, but not to a great extent. Such dues, in the nature of customs, are very common in Continental cities, and yield large revenue to the local authorities, although they have been very generally, if not quite universally, abolished in the United Kingdom. They have been regarded with much dislike by most economists, and some dues of the kind which existed in London, viz., dues on coal and wine imported, and metage dues on grain, were much opposed until their final abolition in recent years. When of moderate amount, however, dues of this sort appear no more objectionable than harbour dues already mentioned, or any other moderate charges on transactions. If of large amount and very numerous, they hamper trade, as all taxation tends to do, but that is no reason for condemning them specially when the choice lies between them and other forms of taxation.

In addition, we have to notice taxes yielding about £10,000,000 a year, which are levied by the British Government and distributed to the local authorities, just as in France the Government levies certain direct taxes, or *centimes additionnelles*, added to its own direct taxes for the benefit of the local authorities. These taxes in the year 1900–01 were as follows: Additional beer and spirit dues (customs and excise), £1,586,000; excise licences, £3,886,000; and share of probate and estate duty, £4,132,000. The remarks already made on the corresponding taxes levied for imperial purposes of course apply to these. Exceptionally, it may be added, as regards the licence taxes, which occupy quite an inferior place in the British system of taxation for imperial purposes, that the question whether some of them are not really direct in their incidence on the first person charged may also be raised, although they are classed with indirect taxes. Many of the licences are those of brewers, distillers, and publicans, and others in trade, and are paid out of the general profits of the business, so that they can hardly be passed on to the consumers, while other licences are for shooting, for employing carriages and men-servants, and for similar objects, where the charge on the payer is direct. This may be the place to mention that in other countries, as in France, the licence duties on traders are more general than in the United Kingdom, and are levied on an elaborate scale, according to the size of population of the town where the business is carried on, and the rent paid for the premises. They take the place, to some extent, of the income tax, and are usually classed with the direct taxes.

The peculiarity of taxes which are levied by the imperial authority and distributed among the local authorities for disbursement deserves notice. There must be a general cause for such an arrangement when we find it to have been in existence in France and other countries, and to have been introduced into the United Kingdom. And this cause no doubt is the need of the local authorities, and the difficulty of letting them have taxes of their own to levy which do not interfere with the imperial monopoly. The arrangement is obviously objectionable on the score of its conducing to local extravagance, as local authorities are not likely to be so economical with money that comes to them from the outside, as it were, as they would be with money directly taken from their own pockets. Local authorities receive other subventions and aids from the central Government besides the proceeds of these taxes, so that their appropriation for local needs is related to a large question which belongs, however, to the general subject of local government, and not so much to the special subject of taxation.

Incidence of Taxation.—In describing the principal taxes which are employed in the United Kingdom to provide for the national expenditure, observations have necessarily been made upon the incidence, probable or assumed, upon the tax-payer, and on the question how far they may fall equally on the whole community without any special incidence being traceable. The incidence of taxation is, however, a special subject for discussion, and is connected with various large issues, such as that of Free Trade, which are of deep interest to economic students.

The starting-point of discussions as to incidence of taxation is a classical passage in Adam Smith's *Wealth of Nations* (book v. chap. ii.), where he lays down the following maxims with regard to taxes in general: 1. The subjects of every state ought to contribute towards the support of the Government, as nearly as possible, in proportion to their respective abilities; that is, in proportion to the revenue which they respectively enjoy under the protection of the state. 2. The tax which each individual is bound to pay ought to be certain and not arbitrary. 3. Every tax ought to be levied at the time or in the manner in which it is most likely to be convenient for the contributor to pay it. [Adam Smith specially praises indirect taxes on commodities under this head, because the consumer "pays them by little and little as he buys the goods," and "it must be his own fault if he ever suffers any considerable inconveniency from such taxes."] 4. Every tax ought to be so contrived as both to take out and keep out of the pockets of the people as little as possible over and above what it brings into the public treasury of the state. [This last passage is specially directed against taxes which are expensive to collect, or discourage trade, or offer temptation to smuggling, or subject people to frequent visits of the tax-gatherer.] These maxims have commanded universal assent, as they are obviously the common-sense of the subject.

It may be observed, however, that while general maxims are easy, the application presents difficulties, and since Adam Smith wrote, and especially in modern times, new questions of some interest have been raised. Adam Smith does not go minutely into the incidence of taxation. Taxes in his view must come out of rent, or profit, or the wages of labour; and he observes that every tax which falls finally upon one only of the three sorts of revenue "is necessarily unequal in so far as it does not affect the other two," and in examining different taxes he disregards as a rule this sort of inequality, and confines his observations "to that inequality which is occasioned by a particular tax falling unequally upon that particular sort of private revenue which is affected by it." Recent discussion, however, has gone rather to the point which Adam Smith neglected, that of inequality generally, not merely as between different sorts of income, but as between individuals and classes. The whole burden of taxation, it is maintained, should fall equally upon classes and individuals as far as possible, and, if necessary, taxes falling equally upon special sources of private revenue should be balanced against each other in order to obtain the desired result. Along with this view has arisen the question whether the burden of taxation should not be *progressive*—the proportion of the sum taken by the state from the tax-payers increasing with the wealth of the individual; because ability to pay taxes is assumed to be not in proportion to, but to increase with the size of, the income.

What opinion should be held regarding this modern view as to equality in taxation, which differs so widely from anything countenanced by Adam Smith, though his language is echoed in it? The answer must be that, however sound, the view is for the most part far too ambitious. One difficulty is caused by the large proportion of the taxes in almost every system of taxation, and at any rate in the British system, where the exact incidence is in no way traceable, or where there is no sort of general agreement as to the incidence. Out of about 140 millions of revenue for Imperial purposes above dealt with, the whole of the British revenue from post office and telegraph service, and the whole of the stamp revenue, amounting together to over £25,000,000, are derived from charges whose exact incidence cannot be traced. We have seen, indeed, that doubt is even felt as to whether post office and telegraph charges can be treated as taxes at all. To remove nearly one-fifth of the taxation in question from the calculation manifestly goes far to destroy the possibility of answering the question as to the distribution of the whole burden of taxation. However right one may be as to the four-fifths, the answer to the whole might be quite different if we only knew the facts as to the unknowable remainder of the four-fifths. Again, a considerable portion, the death duties, is in a category of its own, these duties falling each year not on a particular class of the community, or a particular kind of property, but on a few individuals only, who are in some cases treated severely, while others may have no cause of complaint. In the course of fifty years, it may be said, the balance will be rectified, and the whole class to which the individuals belong, and the property they own, will be visited in turn, so that this taxation should be credited to them in an account of the incidence of taxes generally; but fifty years is altogether too long a period for such adjustments to be made. Adding the death duties, then, to the post office revenue and stamp revenue, we have a total of about £40,000,000, or nearly a third of the total revenue of about £140,000,000 which cannot be made available for an account showing the incidence of taxation. There remain principally the income tax and one or two minor "direct" taxes yielding just under £40,000,000, and the customs and excise duties yielding about £67,000,000. These, it is said, can be distributed among different classes of tax-payers, because the income tax falls on the owners of incomes of all kinds of property subject to the duty, if their incomes are above a certain limit, while the incidence of customs and excise duties can be ascertained by inquiries as to the consumption of dutiable articles by different classes. Even here, however, formidable difficulties are presented. The payers of income tax, unfortunately, are not one class but many, and although the rate of duty is the same, the definition of income seems imperfect, so that many pay on a much larger assessment of income than seems fair in comparison with other incomes of nominally the same amount, but really of much greater value when all deductions from the gross sum are fairly reckoned. If all who pay income tax are lumped together and contrasted with those who do not pay, then there is a false division to begin with, and there is so far no means of establishing equality or inequality. As regards indirect taxes, again, there appears no small difficulty in ascertaining the relative consumption of different classes, for the simple reason that in the same class so called the habits of consumption differ widely. It is only by a wide extension of the term "working man," for instance, that a class which includes a steady mechanic earning 30s. to £2 a week, who is frequently a total abstainer, and a labourer of inferior capacity and character earning 15s. to 20s. a week, and who is *not* a total abstainer, can be spoken of as one, and credit given to the *one* class for so much taxation on spirits, beer, tobacco, wine, tea, and sugar. There are also geographical differences of a serious kind. On the other hand, the consumption by the income tax paying classes of customs and excise articles must vary indefinitely amongst themselves, according to personal habits, size of families, and even their geographical distribution. A further difficulty is furnished by a question as to whether the employer of domestic servants who gives them their board does or does not bear the burden of the duties on the articles which they consume, and which he buys for their use. Theoretically the burden falls on them as consumers. They would have more real wages, it is said, if the price of the articles they consume was not raised by taxation. But practically most employers are convinced that they pay the taxes for their servants. To establish, therefore, any fair account of the incidence of indirect taxes on different classes of the community, real classes being distinguished, and not a mere rough grouping into so-called classes of units who are altogether heterogeneous, is probably beyond the skill of man.

All this is evident on a view of imperial taxation alone. In studying equality, moreover, local taxation must be brought into view, with even more impracticable differences of opinion as to the real incidence of the taxation. The moment rates are brought into question it is seen at once how impossible it would be to establish equality among tax-payers, when owners on one side and occupiers on the other claim that they each bear the burden of the same taxes, and economists favour the opinion that much of the burden is in the nature of a rent-charge on the property, and in any case is equally diffused over the whole community.

Adam Smith was thus not altogether badly advised in not carrying his investigations into the equality of taxation farther than he did. There was another reason for his so doing in the heaviness of the burden of taxation at the time he wrote, Governments exacting as much as they could, and being only desirous of finding the easiest means of doing so. It is the very lightness of taxation in recent years which has suggested the possibility of comparing the relative burdens of different classes, which would have seemed quite hopeless with a high taxation and an immense variety of high taxes. The conclusion that with good taxes long established the burden of taxation tends to become equal over the whole community was certainly not ill founded in the circumstances of former times, and may be accepted as true even in the present day.

As to progressive taxation based on the assumption that equality requires a larger proportionate charge upon a big income than on one of a smaller amount, the practical application of the principle, if true, would be impossible. A great deal more would need to be known than is now known as to the effect of taxes on different classes, and the aggregate amount of different incomes before such a task could be undertaken. If there is a greater proportionate charge already on the larger incomes, nothing more need be done, and we cannot know that there is not. As to the justice of such a progressive tax, there is a common opinion in its favour among economists, at least to the extent of exempting a certain minimum of subsistence from taxation; but the present writer, after accepting this view in early life on the authority of Mill, must now express the greatest doubt. The ideal is equality, and no measure of a minimum of subsistence can really be devised.

Of course there may be single taxes which are progressive in form, such as the licence tax in France, or the income tax in Great Britain, where progression is established by abatements, or the death duties, where progression by scale is very common. But such progression may arise in a different way and on different principles from those proposed in defence of a general system of progressive taxation. It may be expedient for balancing taxation and roughly redressing palpable inequalities, and may be adopted for that purpose and no other.

Statistical inquiries as to the incidence of taxation or of particular taxes, though ideal or even approximate equality of a palpable arithmetical kind is practically unattainable by Governments, are not altogether to be put aside. The information thus obtainable may be useful as far as it goes, indicating the directions in which the burden of taxation may press, and forming a guide of some utility when changes of taxation are contemplated. Calculations, for instance, as to what people at the lower levels of the income tax must pay because they happen to be struck by every sort of tax as no other class is, and calculations as to the freedom from taxation of large numbers of other classes whose habits of consumption and living enable them to escape the tax-gatherer as the class to which they belong cannot generally do, may help a finance minister in the selection of taxes to be repealed or reduced or to be newly imposed. With every effort after equality he must fail to satisfy all, but friction may be diminished and the work of carrying on government quietly and steadily facilitated.

Taxes and Free Trade.—Taxation ought not to interfere with trade if possible, and the object of Adam Smith's maxims, as we have seen, was largely to erect sign-posts warning finance ministers against the kind of taxes likely to harass traders. There has been much discussion, however, on free trade since Adam Smith's time, and the far-reaching nature of his warnings is not even yet generally understood. There will probably be general agreement as to the wisdom of avoiding taxes which are uncertain and arbitrary, or which involve frequent visits of the tax-gatherer; but so far from there being a general assent in all countries to his maxims as to the expediency of avoiding taxation which takes more from the tax-payer than what comes into the hands of the Government, this is the very characteristic of duties deliberately imposed by most Governments for the purpose of interfering with trade, and frequently called for even in the United Kingdom with a similar object. In a question of taxation, however, for the purpose of meeting the expenses of the Government, all such duties must be ruled out. Taxes, as instruments for advancing the prosperity of a country, are things unknown to the study of "taxation" in the proper sense of the word. The only proper object of taxation is to meet the expenses of the state, and when taxes are used primarily or mainly for some other object they can only be justified by political and economic reasons of a different order from anything that has been under discussion.

On this ground, in an account of taxation proper, one might avoid discussing altogether the question of irregular or illegitimate taxation. But the subject is too popular, perhaps, to be passed over altogether. Generally, then, it may be affirmed that taxation in its essential nature cannot be thought of as a good instrument for promoting trade and the advancement of a country. So far as it operates at all, it operates by diverting trade from the channels in which it would naturally flow into other channels, and this diversion of industry, so far as it goes, must involve loss. People are induced to do things they would otherwise leave alone, or to leave alone what they would otherwise do, because money is given to them out of the pockets of the tax-payers to make it worth their while to do so; but there is palpably loss and not profit in the proceeding. It is urged that in time industries are set up that would not otherwise have existed, and population thereby attracted, this being especially the argument for protective duties in new countries; but even so, there is loss to set against the final gain, if any, and we have not yet had an account in which a balance of loss and gain is attempted. The presumption is that on balance there is loss. In new countries especially the diversion of industry from its natural development cannot but be mischievous, wrong manufactures and industries being set up at the expense of the whole community, instead of those manufactures and industries which would be most profitable.

There is more to be said for the political argument which induced Adam Smith to favour navigation laws, giving a preference to national shipping in national waters, and for a similar political argument in favour of duties on agricultural produce imported into the country, on the ground, as regards navigation, that the prosperity of the shipping industry in particular was essential to the safety of the country, and on the ground, as regards duties on agricultural produce, that the maintenance of a larger rural population and of a larger agricultural production than would exist under natural conditions of perfect free trade was essential to the welfare of the state and even to its very existence in the possible event of a temporary defeat at sea and a partial blockade of the coasts. This is not the place to discuss such political problems, but there is no question of free trade theory involved if the cost to the community of any such taxation is frankly acknowledged.

Sir John A. Macdonald, the great protectionist Prime Minister of Canada, in a conversation with the present writer in 1882, avowed without hesitation that protectionist taxation in Canada was indefensible on economic grounds, and he defended it exclusively for political reasons. Politically one might differ from him, but economists as such must either be silent when political reasons are alleged for taxes that are against fundamental maxims, or must be content to point out the cost of the taxes in order that the communities concerned may decide whether the object in view is obtainable by means of the taxation, and is worth the price.

A great deal has been said as to taxes termed "countervailing duties," which are called for in order to defend free trade itself against the protectionist bounties of foreign Governments. Such duties are obviously taxes outside the limits to be considered in a question of taxation proper. They are to be imposed for other purposes than revenue. As to the claim for them that they will restore free trade conditions by nullifying the foreign bounties which have caused a disturbance of trade, this is really in the nature of a political reason. A country which is so devoted to free trade that it not only practises free trade itself but endeavours to convert others by nullifying their protectionist measures as far as it can, even with immediate loss to itself, departs from the guidance of self-interest so far; but its political action may be justifiable in the long run by other considerations. It seems right to point out, however, that countervailing duties, which are really differential duties of a special kind, are not the good expedient they are supposed to be for nullifying foreign bounties; that experience of differential duties in former times is altogether against them; and that they cannot be enforced without certificates of origin and other causes of harassment and confusion in the conduct of trade.

The extent of the interference with trade, in regard to particular taxes, is also a matter of importance. A particular tax is not necessarily to be condemned because it takes a little more out of the pockets of the people than what the Government receives. Such a defect is a ground for consideration in weighing a particular tax against others, but it is only one inconvenience among many incidental to all taxes.

Some applications of free trade theory in our times in the matter of import duties have been pedantic—the abolition of the shilling corn duty in 1870 by Mr Lowe being typical of this pedantry, though it is not the only instance. No doubt, in theory, this duty, being levied on the import only and not on the home production of corn, took from the tax-payer a shilling on every quarter of grain produced at home which did not go into the exchequer. *Per contra* the tax was wholly unfelt, a shilling a quarter only affecting an average family of four persons to the extent of three shillings per annum, or about three farthings a week, while it was paid little by little, as Adam Smith explains with regard to indirect taxes in general. The amount yielded, moreover, was considerable, being equal to a penny on the income tax, which it is desirable to maintain as a reserve of taxation. When we balance advantages and disadvantages, therefore, the repeal of the corn duty and similar measures would appear to have been sacrifices of revenue without adequate reason.

Rates of Taxation.—Apart from the merits or demerits of particular taxes or groups of taxes, and the questions as to inequality, injury to trade, and the like already discussed, the aggregate of taxation, or rather revenue, of a state may be considered in the most general way, having regard to the proportion appropriated by the state of the total income of the community, and the return made by the state therefor. Here there are the greatest variations. At one time, for instance, during the great wars at the beginning of the 19th century, it was calculated that the British Government expenditure, and the corresponding revenue, mostly raised by taxation, were each equal to about one-third of the aggregate of individual incomes—that is, as £90,000,000 to about £270,000,000. Proportions even higher have not been unknown in history, and it is probable that in Russia, India, Egypt, and in other countries at this moment, in time of peace, the proportion may amount to one-fourth or one-fifth. On the other hand, some years ago in the United Kingdom, before the high expenditure on army and navy began, and before the South African war, it is probable that with an outlay of less than £100,000,000 by the central Government, the proportion of this outlay to the aggregate income of the people was not higher than *one-fourteenth.* At the beginning of 1902, when the South African war was closing, the normal peace expenditure, even reckoned at £160,000,000, did not exceed *one-tenth,* while even peace and war expenditure together in 1901, taking them as close on £200,000,000, did not exceed *one-eighth.* These varying proportions, however, mean different things economically, and it is of obvious interest that, besides questions as to particular taxes, the broad effect of the whole burden of taxation should also be discussed.

The important points in this connexion appear to be: (1) Very large appropriations can be made by the state from the revenue of its subjects without *permanent* injury. The community thereby suffers, but the land and fixed capital remain, and when the high Government expenditure ceases individuals at once have the benefit, subject to possible disturbance at the moment of transition, when many persons employed by the state return to private employment. (2) A state which in ordinary times appropriates one-tenth or some less proportion of aggregate individual incomes is much stronger relatively than a state absorbing one-fourth, one-third, or even a higher proportion. It has much larger resources, which would be available if time were given to develop them. (3) When the proportion becomes one-tenth or less it is doubtful whether the state can do best for its subjects by making the proportion still lower, that is, by abandoning one tax after another, or whether equal or greater advantage would not be gained by using the revenue for wise purposes under the direction of the state, such as great works of sanitation, or water supply, or public defence. In other words, when taxes are very moderate and the revenue appropriated by the state is a small part only of the aggregate of individual incomes, it seems possible that individuals in a rich country may waste individually resources which the state could apply to very profitable purposes. The state, for instance, could perhaps more usefully engage in some great works, such as establishing reservoirs of water for the use of town populations on a systematic plan, or making a tunnel under one of the channels between Ireland and Great Britain, or a sea-canal across Scotland between the Clyde and the Forth, or purchasing land from Irish landlords and transferring it to tenants, than allow money to fructify or not fructify, as the case may be, in the pockets of individuals. Probably there are no works more beneficial to a community in the long run than those like a tunnel between Ireland and Great Britain, which open an entirely new means of communication of strategical as well as commercial value, but are not likely to pay the individual *entrepreneur* within a short period of time.

AUTHORITIES.—The following short list of authors may be useful to the student:—ADAM SMITH. *Wealth of Nations.*—RICARDO-M'CULLOCH. *Principles of Taxation.*—MILL. *Principles of Political Economy.*—BASTABLE. *Public Finance.*—GARNIER. *Traité de Finances.*—COHN. *System der National-Ökonomie.*—WAGNER. *Finanzwissenschaft.*—ROSCHER. *System der Finanzwissenschaft.*

(R. GN.)

Tayabas, the capital of the province of the same name in Luzon, Philippine Islands, until 1901, when the capital was removed to Lucena. It is picturesquely situated on the slopes of the extinct volcano Banájao, and commands a magnificent view of the surrounding country, which is extremely fertile, and is planted in rice and cocoanuts. Its climate, although cool, is very unhealthy, malignant malarial fevers causing a high death-rate. It has a church and convent of large size and massive construction. During the revolt of 1896 a Spanish garrison occupying these buildings was able to withstand a siege of fifty-eight days, at the end of which time it was forced to surrender by lack of food. Tagalog and Bicol are the languages spoken. Population, 15,000.

Taylor, a city of Williamson county, Texas, U.S.A., about 30 miles north-east of Austin, the state capital, on the Missouri, Kansas and Texas, and the International and Great Northern railways, at an altitude of 556 feet. It is in a cotton region, contains gins, oil-mills, and compresses, and handles the cotton crop of the surrounding region. Population (1890), 2584; (1900), 4211, of whom 530 were foreign-born and 1260 negroes.

Taylor, Isaac (1829–1901), English philologist, born at Stanford Rivers, 2nd May 1829, was the eldest son of Isaac Taylor, author of the *Natural History of Enthusiasm.* He was educated at Trinity College, Cambridge, and graduated as a wrangler in 1853. His interests, however, were linguistic rather than mathematical, and his earliest publication was a translation from the German of Becker's *Charicles.* Though of Nonconformist stock, Isaac Taylor joined the Church of England, and in 1857 was ordained to a country curacy. In 1860 he published *The Liturgy of the Dissenters,* an appeal for the revision of the Book of Common Prayer "on Protestant lines" "as expedient for the material interests of the Church, and as an act of plain justice to the Dissenters." He was next appointed to a London curacy, and at this time began his studies in local etymology, which he continued at intervals all his life. *Words and Places in Etymological Illustration of History, Ethnology, and Geography* appeared in 1864. Between 1865 and 1869, when he was in charge of a Bethnal Green parish, these pursuits were laid aside, and he published only *The Burden of the Poor* and the *Family Pen*, a record of the literary work of his own family, the Taylors of Norwich. In 1869 he became incumbent of a church at Twickenham, and here he continued his philological researches. The result was a volume of Etruscan studies, published in 1874, in which he contended powerfully for the Ugrian origin of the Etruscan language. Next year he was presented to the rectory of Settrington, Yorkshire, and began his systematic researches into the origin of the alphabet. This led him to the study of runes, of which he suggested an entirely new interpretation, viz., that they were derived from Greek sources. His *Greeks and Goths* (1879) led to a good deal of controversy, and called attention to the author, who received an honorary degree from Edinburgh. In 1883 appeared his great work *The Alphabet, an Account of the Origin and Development of Letters.* Taylor points out that alphabetical changes are the result of evolution taking place in accordance with fixed laws. "Epigraphy and palæography may claim, no less than philology or biology, to be ranked among the inductive sciences." He was largely indebted to the Egyptian researches of Rougé, which it has now become necessary to reconsider in the light of discoveries in Crete. In 1885 Taylor became canon of York, and two years later dean. His paper on the *Origin of the Aryans*, read at the British Association in 1887, was afterwards expanded into a book. In the following winter he visited Egypt, and his letters from there, when collected under the title *Leaves from an Egyptian Notebook*, aroused considerable controversy from the extremely favourable view he took of the Mahommedan religion. In 1888 three of his essays appeared in the memorial volume of Domesday studies. He also contributed to a good many learned periodicals. A new and revised edition of his great work on the alphabet appeared in 1899. For the last few years of his life he suffered from ill health, and was laid aside from active work for some time before his death in October 1901. (A. Z.)

Tayug, a town near the eastern boundary of the province of Pangasinan, Luzon, Philippine Islands. The Agno river furnishes water for irrigating the low fields in its vicinity. Its inhabitants are agriculturists, and rice is their principal crop. Pangasinan and Ilocano are the languages spoken. Population, 19,000.

Tchad, Lake. See CHAD.

Tchebicheff, Pafnutij Lvovitch (1821–1894), Russian mathematician, was born at Borovsk on 26th May 1821. He was educated at the University of Moscow, and in 1859 became professor of mathematics in the University of St Petersburg, a position from which he retired in 1880. He was chosen a correspondent of the Institute of France in 1860, and succeeded to the high honour of *associé étranger* in 1874. He was also a foreign member of the Royal Society of London. After Lobatchewsky he probably ranks as the most distinguished mathematician Russia has produced. Among the best known of his papers, and also among the earliest, are several dealing with prime numbers, in one of which he established the existence of limits within which must be comprised the sum of the logarithms of the primes inferior to a given number. Another question to which he devoted much attention was that of obtaining rectilinear motion by linkage. The parallel motion known by his name is a three-bar linkage, which gives a very close approximation to exact rectilinear motion, but in spite of all his efforts he failed to devise one that produced absolutely true rectilinear motion. At last, indeed, he came to the conclusion that to do so was impossible, and in that conviction set to work to find a rigorous proof of the impossibility. While he was engaged on this task the desired linkage, which moved the highest admiration of Sylvester, was discovered and exhibited to him by one of his pupils, named Lipkin, who, however, it was afterwards found, had been anticipated by Peaucellier. Tchebicheff further constructed an instrument for drawing large circles, and an arithmetical machine with continuous motion. His mathematical writings, which account for some forty entries in the Royal Society's catalogue of scientific papers, cover a wide range of subjects, such as the theory of probabilities, the theory of consequences, quadratic forms, integration of irrational differentials, gearings, the construction of geographical maps, &c. He died at St Petersburg on 8th December 1894.

Tchelyabinsk. See CHELYABINSK.

Tchernaieff, Michael Gregorovitch (1828–1898), Russian general, of a noble family, was born on 24th October 1828. Educated at the General Staff Academy at Nikolaieff, he entered the army in 1847. He distinguished himself in the Crimean war, and attained the rank of major-general. After serving as divisional chief of the staff in Poland, he went to Orenburg in 1858 as Aide du Chef de la Ligne du Syr-Daria, and the following year commanded an expedition to support the Kirghiz tribes on the borders of the Sea of Aral against the Khivans. He did duty on the staff of the army of the Caucasus for a time, and returned to Orenburg as chief of the staff. In 1864, in command of a force of 1000 men, he made his famous march across the steppes of Turkestan to Chimkent in Khokand, to meet another Russian column from Semipalatinsk, in eastern Siberia, under Colonel Verefkur, in conjunction with which he successfully stormed Chimkent, and then unsuccessfully attacked Tashkend, 80 miles farther south. Wintering at Chimkent, he captured Tashkend the following year. This was contrary to his instructions, and although he was received in St Petersburg with enthusiasm, and presented with a sword of honour by the emperor, he was not again employed in the military service, and retired from it in July 1874. He bought, and edited with great success, the *Ruski Mir* in Slavonic interests, devoting himself to the Panslavic idea. In the summer of 1876 he was appointed commander-in-chief of the Servian army, but on entering Turkey was driven back by Osman Pasha, who followed him into Servia, defeating him at Saitchar and Yavor in July, and the campaign in Servia proved disastrous. He rashly proclaimed Milan king of Servia in September, and in October Alexinatz and Deligrad were in the hands of the Turks, and the road open to Belgrade. An armistice was concluded, and Tchernaieff resigned his command. In 1879 he organized a Bulgarian rising, but was arrested at Adrianople and sent back to Russia. He succeeded Kaufmann as governor of Turkestan in 1882, but his aggressive policy led to his recall two years later, when he was appointed a member of the Council of War at St Petersburg. In 1886 his opposition to the Central Asian Military railway caused him to lose his seat in the Council. He died on 16th August 1898, at his country seat in the province of Mohileff. (R. H. V.)

Tchimkent. See Chimkent.

Tchorlau, or Chorlu, chief town of a sanjak in the vilâyet of Rodosto, European Turkey, situated on an eminence on the right bank of a small tributary of the Erghēnē, about 2 miles from the station on the Constantinople–Adrianople railway, 20 miles north-east of Rodosto. It possesses three mosques and several Christian churches. It has manufactures of woollen cloth (*chayak*) and native carpets, and exports cereals, oil-cloth, carpets, cattle, poultry, fresh meat, game, fruits, wine, alcohol, hides, and bones. Population, 11,500, of whom about one-half are Greeks, one-third Turks, and the remainder Armenians and Jews.

Tchugueff, a town of Russia, in the government and 33 miles by rail E.S.E. of the town of Kharkoff, on the right bank of Northern Donets. It is a great military camp, and had in 1897 a population of 11,877.

Teaching of the Apostles.—The *Didaché*, or *Teaching of the Apostles*, is the most important of the recent recoveries in the region of early Christian literature. It was known to us by name from lists of canonical and extra-canonical books compiled by Eusebius and other writers. Moreover, it had come to be suspected by several scholars that a lost book, variously entitled *The Two Ways* or *The Judgment of Peter*, had been freely used in a number of works, of which mention must presently be made. In 1882 a critical reconstruction of this book was made by Krawutzky with marvellous accuracy, as was shown when in the very next year the Greek bishop Bryennios published *The Teaching of the Twelve Apostles* from the same manuscript from which he had previously given us the complete form of the Epistle of Clement. The *Teaching*, as we now have it in the Greek, falls into two marked divisions: (*a*) a book of moral precepts, opening with the words, "There are two ways"; (*b*) a manual of church ordinances, linked on to the foregoing by the words, "Having first said all these things, baptize, &c." Each of these must be considered separately before we approach the question of the locality and date of the whole book in its present form.

1. *The Two Ways.*—The author of the *Teaching*, as we now have it, has modified the original *Two Ways* by inserting near the beginning a considerable section containing, among other matter, passages from the Sermon on the Mount, in which the language of St Matthew's Gospel is blended with that of St Luke's. He has also added at the close a few sentences, beginning, "If thou canst not bear the whole yoke of the Lord, bear what thou canst"; and among minor changes he has introduced a passing reference to "the church." No part of this matter is to be found in the following documents, which present us in varying degrees of accuracy with the *Two Ways:* (i.) the Epistle of Barnabas (in which the order of the book has been much broken up, and a good deal has been omitted); (ii.) the so-called *Apostolic Church Order*, a book which presents a parallel to our *Teaching*, in so far as it consists first of a form of the *Two Ways*, and secondly of a number of church ordinances (here, however, various sections are ascribed to individual apostles, *e.g.*, "John said, There are two ways," &c.); (iii.) a discourse of the Egyptian monk Schnudi (d. 451), preserved in Arabic (see Iselin, *Texte u. Unters.* 1895); (iv.) a Latin version, of which a fragment was published by Gebhardt in 1884, and the whole by Schlecht in 1900. When by the aid of this evidence the *Two Ways* is restored to us free of glosses, it has the appearance of being a Jewish manual which has been carried over into the use of the Christian Church. The recent recovery of the Latin version is of singular interest, as showing that, even without the Christian additions and interpolations which our full form of the *Teaching* presents, it was circulating under the title *Doctrina apostolorum.*

2. The second part of our *Teaching* consists of precepts relating to church life; these are couched in the second person plural, whereas the *Two Ways* used throughout the second person singular. Its chief features only can be noted here. It orders baptism in the threefold name, making a distinction as to waters which has Jewish parallels, and permitting a threefold pouring on the head, if sufficient water for immersion cannot be had. It prescribes a fast before baptism for the baptizer as well as the candidate. Fasts are to be kept on Wednesday and Friday, not Monday and Thursday, which are the fast days of "the hypocrites," *i.e.*, by a perversion of the Lord's words, the Jews. "Neither pray ye as the hypocrites; but as the Lord commanded in His Gospel." Then follows the Lord's Prayer, almost exactly as in St Matthew, with a brief doxology—"for Thine is the power and the glory for ever." This is to be said three times a day. Next come three eucharistic prayers, the language of which is clearly marked off from that of the rest of the book, and shows parallels with the diction of St John's Gospel. They are probably founded on Jewish thanksgivings, and it is of interest to note that a portion of them is prescribed as a grace before meat in (pseudo-) Athanasius' *de Virginitate.* A trace of them is found in one of the liturgical prayers of Serapion, bishop of Thmui, in Egypt, but they have left little mark on the liturgies of the Church. As in Ignatius and other early writers, the eucharist is regarded as producing immortality (cf. "spiritual food and drink and eternal life"). None are to partake of it save those who have been "baptized in the name of the Lord" (an expression which is of interest in a document which prescribes the threefold formula). The prophets are not to be confined to these forms, but may "give thanks as much as they will." This appears to show that a prophet, if present, would naturally preside over the eucharist. Hereupon follows a section upon apostles and prophets. An apostle is to be "received as the Lord"; but he must follow the Gospel precepts, stay but one or two days, and take no money, but only bread enough for a day's journey. Here we have that wider use of the term "apostle" to which Lightfoot had already drawn attention. A prophet, on the contrary, may settle if he chooses, and in that case he is to receive tithes and first-fruits: "for they are your high priests." If he be once approved as a true prophet, his words and acts are not to be criticized; for this is the sin that shall not be forgiven. The eucharist is to be celebrated every Lord's Day, and preceded by confession of sins, "that your sacrifice may be pure . . . for this is that sacrifice which was spoken of by the Lord, In every place and time to offer unto Me a pure sacrifice." So far we have had no reference to a permanent local ministry; but we now read, "Appoint therefore unto yourselves bishops and deacons, worthy of the Lord, men meek and uncovetous, and true and approved; for they also minister unto you the ministration of the prophets and teachers. Therefore despise them not; for they are your honoured ones, together with the prophets and teachers." The book closes with exhortations to steadfastness in the last days, and to the coming of "the world-deceiver" or Antichrist, which will precede the coming of the Lord.

3. It will now be clear that indications of the locality and date of our present *Teaching* must be sought for only in the second part, and in the Christian interpolations in the first part. We have no ground for thinking that the second part ever existed independently as a separate book. The whole work was in the hands of the writer of the

seventh book of the *Apostolic Constitutions*, who embodies almost every sentence of it, interspersing it with passages of Scripture, and modifying its precepts to suit a later age (4th century); this writer was also the interpolator of the Epistles of Ignatius, and belonged to the Syrian Church. Whether the second part was known to the writer of the *Apostolic Church Order* is not clear, as his only quotation of it comes from one of the eucharistic prayers. Egypt is the country to which we are chiefly pointed by the quotations and allusions of early writers; but their references are mostly to the first part, so that we must be careful how we argue from them as to the provenance of the book as a whole; very little caution has hitherto been exercised in this matter. Against Egypt has been urged the allusion to "corn upon the mountains"; but this occurs in one of the eucharistic prayers, and these are certainly not composed by the writer of the present book. The anti-Jewish tone of the second part suggests the neighbourhood of Jews, from whom the Christians were to be sharply distinguished. This might point to Palestine, but the conditions might also be found in Egypt. All that we can safely say as to locality is that the community here represented seems to have been isolated, and out of touch with the larger centres of Christian life.

This last consideration helps us in discussing the question of date. For such an isolated community may have preserved primative customs for some time after they had generally disappeared. Certainly the stage of development is an early one, as is shown, *e.g.*, by the prominence of prophets, and the need that was felt for the vindication of the position of the bishops and deacons (there is no mention at all of presbyters); moreover, there is no reference to a canon of Scripture (though the written Gospel is expressly mentioned) or to a creed. On the other hand, the "apostles" of the second part are obviously not "the twelve apostles" of the title; and the prophets seem in some instances to have proved unworthy of their high position. The ministry of enthusiasm which they represent is about to give way to the ministry of office. Three of the Gospels have clearly been for some time in circulation; St Matthew's is used several times, and there are phrases which occur only in St Luke's, while St John's Gospel lies behind the eucharistic prayers which the writer has embodied in his work. There are no indications of any form of doctrinal heresy as needing rebuke; the warnings against false teaching are quite general. On the whole, it seems wisest not to place the complete work earlier than A.D. 130, and this judgment has the support of Harnack, who has given special attention to the matter.

A large literature has sprung up round the *Teaching* since 1884. Harnack's edition in *Texte u. Unters.* vol. ii. (1884), is indispensable to the student; and his discussions in *Altchristl. Litteratur* and *Chronologie* give clear summaries of his work. Dr C. Taylor in 1886 drew attention to some important parallels in Jewish literature; his edition contains an English translation. Prof. Rendel Harris published in 1887 a complete facsimile, and gathered a great store of patristic illustration. Text and translation will also be found in Lightfoot's *Apostolic Fathers* (ed. min.). Other references to the literature may be found by consulting Harnack's *Altchristl. Litteratur.* The relation of the information derived from the *Didaché* (in regard to apostle, prophet, baptism, and eucharist) to other evidence is discussed in the articles so named in the *Encyclopædia Biblica.* (J. A. R.)

Teano, a town of the province of Caserta, Campania, Italy, 14 miles north-west of Capua by rail, forming conjointly with Calvi an episcopal see. It stands at the foot of an extinct volcano, Rocca Monfina (3412 feet), and possesses numerous small remains of the ancient *Teanum Sidicinum*, one of the most important towns of Campania. The chief institutions are a cathedral, a technical school, and a mineral spring. Population (1881), 12,993; (1900), 14,500.

Technical Education.—The meaning, methods, and purpose of technical education are set forth in the article in vol. xxiii. of the ninth edition of this work. The organization of technical instruction in the United Kingdom is mainly the work of the years from 1890. The experience acquired during this period has been utilized in building up a system of technical education adapted to the different needs of various classes of workers, based on the general principles laid down in the article just mentioned, to which the reader is referred. A definition of technical instruction applicable to the varied teaching of the United Kingdom has been fixed by Act of Parliament. The term includes instruction in science, art, and technology, and also manual training; and by technology is understood the practical application of different kinds of knowledge to a particular trade, or industry, or employment. The following article will be limited to (1) a short statement of the successive legislative efforts which have led to the organization of technical education in the United Kingdom, and (2) a brief exposition of the changes in the conception of technical education due to the practice and experience of recent years.

Legislative enactments.

1. Since 1890 the progress of technical education has been very much helped by the "National Association for the Promotion of Technical Education," which was inaugurated at a meeting held on 1st July 1887. The general objects of the Association were, and still are, to promote and watch legislation, to spread information, and to discuss and assist in giving effect to the recommendations of Royal Commissions appointed to inquire into educational methods and organization. To its activity the development of technical education in England has been largely due. The first legislative effort to give effect to the recommendations of Royal Commission on Technical Instruction, whose report was published in 1884, was a Bill introduced into Parliament in July 1887. The purpose of this Bill was to enable school boards and local authorities to provide out of the rates technical schools, or to contribute to their support. A special provision of the Bill was that a poll might be demanded by fifty ratepayers before any action could be taken under the powers it conferred. Technical instruction was so defined as to include subjects aided or sanctioned by the Science and Art Department. The Bill was read a second time on 9th August 1887, but never reached the committee stage. In the following March a new Bill was introduced on behalf of the "National Association." It empowered school boards to provide technical instruction in schools under their management, and to contribute to the maintenance of higher technical institutes. The definition of technical instruction was widened so as to include the use of tools, commercial subjects, modern languages, and any subjects sanctioned by the Education and Science and Art Departments jointly. The Bill gave very extensive powers to school boards. It was withdrawn without a second reading, in view of the avowed intention of the Government to deal with the subject. On 17th May 1888 the Government Bill was introduced. It contained several new features which pointed in the direction of subsequent legislation. Whilst school boards were again empowered to provide technical instruction in their own schools, they were also required, under certain conditions, to aid in the supply of technical and manual training in voluntary schools. At the same time the control of secondary technical instruction

Bill of 1888.

was placed in the hands of a separate authority, viz., the "authority empowered to carry out the Public Libraries Acts." Additional rates, limited in each case to 1d. in the £, might be levied. The Bill bristled with difficulties. It aimed at placing voluntary schools, as regards technical instruction, under the control of school boards, but set up a new authority for the control of technical instruction higher than elementary. There was a growing belief, however, that school boards were not the most suitable bodies for the direction or control of technical education, which arose from the difficulty of devising means for securing equal advantages to both classes of elementary schools, and from the general unwillingness to extend school board authority beyond the limits of elementary instruction.

No reference was made to technical education in the Queen's Speech in opening the Parliamentary session of 1889, but the subject had been fully discussed during the recess. The difficulties in the way of legislation on the lines previously attempted were now clearly understood, and it was recognized that separate and distinct measures would have to be adopted for providing technical instruction in elementary schools and in schools of a higher grade. During the year 1889 three Bills were introduced by private members. Two only of these Bills were considered, the one dealing with elementary education, and enabling school boards to give technical teaching in schools under their management; the other enabling local authorities to establish or contribute to technical schools and classes. The former Bill was fully discussed, but in the absence of any practical settlement of the voluntary school difficulty, the Government withdrew its support, and the Bill was dropped. About this time the passing of another legislative measure helped very considerably towards the solution of the difficulty. The Local Government Bill, which became law in the year 1888, enacted that "a council shall be established in every administrative county . . . and be entrusted with the management of the administrative and financial business of that county." A number of new representative bodies known as county councils were thus created, with powers similar in character to those possessed by the old boroughs. To these newly constituted bodies were transferred all business previously conducted by the quarter sessions. The Act conferred similar powers on certain boroughs, according to their population, which were known as county boroughs. By utilizing these county municipal bodies for educational purposes, the necessity of entrusting technical instruction to school boards was avoided; and accordingly, on 24th July 1889, the Government introduced into the House of Commons a Bill conferring upon county and county borough councils, and also upon urban sanitary authorities, the power to levy a rate, not exceeding 1d. in the £, for the purpose of promoting technical and manual instruction in their district. This Bill met with serious opposition from school board authorities and their friends, who resented the limitations it imposed on their educational aspirations; but the Government was resolved to pass it, and after much obstruction it became law on 19th August 1889, having passed through all its stages in the House of Lords in a single sitting. The Bill marked an epoch in the history of education, being the first legislative enactment dealing with technical instruction in England.

Local Government Act, 1888.

The Act, which, with slight modification, is still operative, provides that:—

> The expression, "Technical Instruction," shall mean instruction in the principles of science and art applicable to industries, and in the application of special branches of science and art to specific industries or employments. It shall not include teaching the practice of any trade or industry or employment, but, save as aforesaid, shall include instruction in the branches of science and art with respect to which grants are for the time being made by the Department of Science and Art, and any other form of instruction (including modern languages and commercial and agricultural subjects), which may for the time being be sanctioned by that Department by a minute laid before Parliament, and made on the representation of a local authority that such a form of instruction is required by the circumstances of its district.

Although at first received with no great favour, the Act has proved useful, and is important as representing the outcome of a number of abortive attempts at legislation, occupying three years, and intended to give practical effect to some of the recommendations of the Royal Commission of 1884. The Act definitely settled the question as to the local authority for technical instruction, and decided it against the school board. It contained no provision, however, for the supply of technical instruction to children in either voluntary or board schools, and even expressly excluded from any share in its benefits all scholars receiving instruction in the obligatory or standard subjects. A way was soon found, however, of providing for technical instruction in elementary schools without any fresh Act of Parliament, and the difficulty of reconciling the interests of voluntary and board schools, which had impeded previous attempts at legislation, was thus avoided.

London School Board Joint-Committee.

Early in the year 1886 the School Board for London, finding that it was unable to expend on technical instruction any part of the school board rate, applied to the City and Guilds of London Institute for financial help. The application was favourably received, and in the following year a joint-committee was formed, consisting of representatives of the Board, of the Institute, and of the Drapers' Company. With the funds supplied by the Company and the Institute, the committee were enabled to try some interesting educational experiments. Six centres for workshop instruction were equipped, and children were received into the classes from voluntary and board schools. A scheme of instruction was prepared with the object of bringing into prominence the disciplinary character of the teaching, and of distinguishing it from the rule-of-thumb methods adopted in the workshop of commerce; and the experience of foreign schools, especially those in France, was utilized. The fears of trade unions lest the action of the school board would have the effect of increasing the number of trade carpenters were minimized, and the real value of manual training as a part of general education was for the first time illustrated. The experiment proved so successful that H.M. inspectors reported most favourably on the usefulness of the teaching, and on the value of the instruction in improving the general intelligence of the pupils, and particularly in rendering them more skilful and observant. Indeed, it was found that their progress in ordinary school studies was quickened by the practical training of the shop. As the result of these experiments the "use of tools" was recognized, in the Government Code of 1890, as a subject of school instruction on which grants were to be paid, and towards the cost of which the school board rate was applicable. Later, following further experiments by the joint-committee, laundry work and housewifery were included in the curriculum, and the problem of introducing so-called technical teaching into elementary schools was solved without any special legislation. Since 1890, manual training has formed a part of the elementary school system. The instruction includes the use of wood-working and metal-working tools, but stops short of teaching any particular trade, and is thus differentiated from the teaching given in the municipal schools of Paris. The new Code also provided for a more rational system of object-lessons and of rudimentary science teaching, encouraging practical exercises and experiments to be worked by the pupils themselves. The joint-committee having completed its work, ceased to exist in 1900.

The Act of 1889 and the Code of 1890 enabled local authorities and school boards to provide out of the rates technical instruction for the working classes. The rate available under the Act was limited to one penny in the pound, and very gradually, and with some hesitation, certain local authorities put the Act in force. The motive power required for promoting technical instruction, other than that in elementary schools, was, however, still wanting, and might have remained so for some time longer if it had not been for the accident that in the following year, during the discussion in Parliament of the question of compensation relating to public-houses, the residue of the beer and spirit duty was found to be unappropriated, and was allocated to county and county borough councils and made available for the purposes of technical education.

Local Taxation Act, 1890.

Technical instruction committees.

The Local Taxation (Customs and Excise) Act, which became law on the 18th August 1890, was "an Act for the distribution and application of certain duties of customs and excise," and it provided that the residue of the English share of these duties should be distributed between county and county borough funds, and made applicable "for the purposes of technical education within the meaning of the Technical Instruction Act, 1889." By the express terms of this Act, this disposition of the residue, which then amounted to £743,000 for England and Wales, was revocable by Parliament, and the allocation of the fund to education was left to the discretion of the local authorities. The grant accordingly was not generally regarded as permanent, and local authorities hesitated to commit themselves to any definite educational schemes. Indeed, it was seriously doubted whether such a windfall was likely to be made a permanent annual contribution from the State to the purposes of technical education. But gradually small sums were provisionally voted in aid of existing schools; and when the then Chancellor of the Exchequer declared that, if the money were found to be well and carefully expended, no future Chancellor would be able to divert it to any other purpose, local authorities began to consider how the money that had fallen into their hands might be best employed to meet local educational needs. Special committees were accordingly formed, consisting in many cases not only of members of the county or county borough council, but also of other persons versed in educational matters, to whom the preparation of schemes of instruction suitable to the several districts was referred. The committees so constituted, known as technical instruction committees, were established in all parts of the country, and to these bodies was delegated, subject to periodic reports to the council, the responsibility of dealing with the moneys at their disposal. The technical instruction committees proceeded in nearly all cases to elect as secretary a gentleman of scholarly attainments and educational experience, capable of advising as to the organization of schools and classes in accordance with the terms of the Act, and the special requirements of the district. The number of such organizing secretaries in England alone is seventy. As a result of the Acts of 1889 and 1890, local educational authorities, altogether distinct from school boards, have come into existence, each with a secretary acting as educational officer for the district. The creation of these educational authorities, with functions, however, limited to technical instruction, marks the most important step in the organization of education since the establishment of school boards.

Curriculum.

By special minutes of the Science and Art Department, new subjects were from time to time included under the term "technical," and the definition of technical education was gradually widened. Among the subjects first added to the list were those included in the "programme of technological examinations" of the City and Guilds of London Institute, and the teaching of technology, as distinct from science, was thus for the first time officially recognized and aided by grants from public funds. Later, commercial subjects and modern languages, the theory and practice of agriculture, and the arts and crafts underlying various cottage industries were accepted as branches of technical instruction; and whilst, on the one hand, the definition was so widened as to include nearly all that is comprised in the curriculum of a secondary school, the teaching of certain technological subjects approached so near to trade teaching that the provision excluding "the practice of any trade or industry or employment" from the teaching sanctioned by the Act appeared likely to be overlooked. Practical instruction in engineering, weaving, printing, photography, plumbing, carpentry, brickwork, bookbinding, and other subjects was encouraged by the City and Guilds Institute, acting as a central authority for education of a distinctly technological character; but notwithstanding the continued increase in the number of practical classes in different branches of technology, the teaching of technology as distinct from that of science and art has received no direct support, by means of grants in aid, from the State. Under the new conditions, however, of assessing the Government grant, introduced into the Directory of 1901–02, instruction in technology received some form of recognition.

Schemes for London.

The county of London remained for some time behind other counties in utilizing the provisions of the Technical Instruction Act of 1889, by devoting to educational purposes the funds placed at its disposal by the Local Taxation (Customs and Excise) Act, 1890. These funds, which in the first instance amounted to about £163,000, but now reach a total of nearly £200,000, were wholly employed for a period of two years in relief of the rates. The wants of London were not at first understood; and it was thought that sufficient funds for educational purposes might be obtained from other sources. A scheme for the utilization of a fairly large income arising from the City parochial charities had been under the consideration of the Charity Commissioners. It was first published in 1888, and, after some discussion and modification, was sanctioned by Parliament. According to this scheme, a capital sum of about £150,000, supplemented by a like amount obtained from the City companies and other sources, was made available for the building of technical and recreative institutions for the poorer classes of the working population of London, similar to the newly organized Polytechnic in Regent Street and the People's Palace in Mile End Road. The scheme created a central governing body for the general supervision of these institutions, and placed at its disposal an income of about £50,000 available for educational purposes, which, with the falling-in of leases, was certain to increase. Provision for the endowment of eight polytechnics and of other educational institutions was made in the scheme, and the Goldsmiths' Company undertook to erect and maintain from its corporate funds a ninth. Since then other similar but somewhat smaller institutions have been established.

Before the erection of these new institutions was completed, it was ascertained that the annual income at the

London board.

disposal of the trustees for the purposes of maintenance and equipment was altogether inadequate; and a committee of inquiry having been appointed by the London County Council, an exhaustive report on the educational needs of the metropolis was prepared, which led to the formation of a Technical Education Board, consisting of members of the County Council, who formed the majority of the board, and also of representatives of the City Parochial Trustees, of the City and Guilds Institute, of the School Board, and of other bodies; and to the board so constituted the council entrusted the spending of the funds available under the Local Taxation Act, 1890. The board held its first meeting on 28th April 1893. Since then, with the assistance of its organizing secretary, the board has arranged a comprehensive and varied scheme of scholarships, which, among other benefits, enables children from the elementary schools to continue their education in intermediate schools, and to pass on to the higher technical institutes and universities. It has supplemented by large grants the income of the polytechnic institutions; it has established or assisted in establishing new trade schools; it has provided laboratories, and aided in the teaching of practical science in a large number of secondary schools; it has encouraged the teaching of modern languages and commercial subjects; it has founded a school of economics, which has become a constituent part of the new University of London, and has utilized, in nearly all instances with the best possible results, the large annual income, now amounting to £180,000, allocated by the County Council to technical education.

Connexion with secondary education.

The close connexion between technical and secondary education was clearly indicated in the comprehensive definition of the former term given in the Act. But it soon became manifest that no great progress could be made in technical education unless further provision were made for secondary education and some improvement effected in the methods adopted in secondary schools. The cry of Matthew Arnold for the better organization of secondary education had, so far, met with no adequate response. There was still an insufficient supply of secondary schools, and a complete absence of advice or control by any central authority. The urgency of this need was recognized by the "National Association for the Promotion of Technical Education," which, at a meeting held in July 1889, resolved to alter its title by the addition of the words "and Secondary" after "Technical." This verbal alteration represented a widespread conviction that technical and secondary education are of necessity closely associated, and that future efforts should be directed towards the improvement and organization of secondary education and the union of different grades and branches of education under a single Government department. That the Technical Instruction Act would need to be followed by a Secondary Education Act was generally recognized. Accordingly, after much discussion, the Government in the year 1896 introduced into Parliament a comprehensive measure dealing with education as a whole and embodying the principal recommendation of the Royal Commission on Secondary Education. The Bill was well received, and, if the Government had persevered with it, would have passed into law, and the question would have been settled for a generation. It was wrecked owing to the difficulty of satisfying the aspirations of the smaller boroughs to be constituted as local education authorities. No further action was taken till 1898, when a new Bill was introduced by the Government, creating a Board of Education, and combining under one department the functions of the Education Department at Whitehall and of the Science and Art Department at South Kensington, with certain powers relating to the educational work of the Charity Commissioners. The Bill was fully discussed during the recess, and in a slightly altered form it became law in the early part of the year 1899, and came into operation in April 1900. The Board of Education called into existence by the Act was intended to become a central authority for elementary, secondary, and technological instruction. It is assisted in its work by a consultative committee of educational experts appointed by the president, whose special duty it is to prepare and keep a register of all qualified teachers. As now constituted, the board consists of the secretary, who is responsible to the president for the administration of both primary and secondary education, of two principal assistant secretaries, and of subordinate officers. There is an assistant secretary for secondary and another for technological instruction, both under the direction of the principal assistant secretary at the South Kensington branch. With a view of co-ordinating the technological instruction to be carried on by the board with that undertaken by the City and Guilds of London Institute and other bodies, a departmental committee was appointed in November 1900 on which those bodies were represented. As a result of the recommendations of this committee, arrangements were made for co-ordinating to some extent the work of the City and Guilds Institute with that of the Board of Education. In the regulations issued in 1902 for assessing the amount of State aid to be given by way of grants to technical schools, it was provided that the whole instruction given in any school, in technology as well as in science and art, should be considered; formal recognition was given to the certificates issued by the Institute, and the Examination Board of the Institute was strengthened by the addition of four members nominated by the Board of Education. The teaching of science and art, as applied to specific trades and industries, was thus brought under the direct supervision of the central educational authority.

Scotland.

The foregoing statements refer more particularly to England and Wales. In Scotland and in Ireland the organization of technical instruction has proceeded on different lines. A Technical Schools Act, applicable to Scotland only, was passed in 1887. This Act enabled school boards by means of the school funds to provide and maintain technical schools. The Act has proved to be practically inoperative. In Scotland, however, school boards have been entrusted with much larger powers, and possess greater influence, than in England. Many of the secondary schools of Scotland are under the direction and control of school board authorities. The residue of the beer and spirits duties, under the Local Taxation Act, applicable to Scotland was much less, even relatively to the population, than in England, and was, moreover, divided directly among so many different authorities as to be in most cases of little or no real value for educational purposes. Recently attempts have been made to combine the funds distributed among different neighbouring authorities, so as to bring them under the control of a single body for the benefit of a larger area. In the year 1896–97 the Education Department of Scotland was entirely separated from that of England, and there was a consequent transfer of functions and grants from the latter to the former. By the passing of the Local Taxation (Scotland) Act, 1898, the residue grant was relieved of certain charges, and additional funds thus became available for technical education. No grants for science or art instruction are made to Scottish schools from the English Board of Education; but several of the technical schools avail themselves of the examinations of the board, and also of those of the City and Guilds of London Institute. Among the equipped technical colleges in Scotland may be mentioned the Heriot-Watt College of Edinburgh, the Glasgow and West of Scotland Technical College, Glasgow, the Robert Gordon College, Aberdeen, and the Technical College, Dundee. These do not differ in any essential points from corresponding schools in England. The system of instruction is very similar, and among the subjects taught will be found most of those included in the Science and Art Directory and in the programme of the City and Guilds of London Institute. Special attention is given in some of these schools to the teaching of the principles and practice of the different branches of textile manufacture. Manual training forms an important part of the curriculum of primary and secondary schools, and the instructions to inspectors on science teaching issued by the Scottish Education Department show a just recognition by the department of the proper methods to be adopted in the teaching of science as a part of general education. Under the Scottish system, leaving certificates are awarded on the results of examinations held at the close of the ordinary school course. These examinations cause the minimum of interference with the ordinary school work. At the universities of Edinburgh, Glasgow, and Aberdeen the higher technical instruction in such subjects as engineering and naval architecture is well developed.

Ireland.

Ireland is still behind Great Britain as regards facilities for technical education. Although the Technical Instruction Act (1889) applies to Ireland as well as to England and Wales, very little use has hitherto been made of its provisions. Moreover, the Irish share of the funds available under the Local Taxation Act is definitely allocated to intermediate education. A committee known as the Recess Committee published in 1896 some valuable and important recommendations, which led to the passing of the Agriculture and Technical Instruction (Ireland) Act of 1899. The reports of two commissions, one on manual and practical instruction in primary schools, and the other on intermediate education, contain suggestions which will give encouragement to the practical teaching of technology and will help to promote a better system of instruction in Irish schools.

The work was successfully commenced under the direction of the newly-constituted Department of Agriculture and Technical Education consisting of an Agricultural Board, a Board of Technical Instruction, a Council of Agriculture, and a Consultative Committee of Education. The department has an endowment of £166,000 a year, which is distributed among the several branches. It has taken over the duties of several other administrative bodies, and the grant for science and art for Ireland, and the grant in aid of technical instruction in Ireland as defined by the Technical Instruction Act of 1889, hitherto administered from South Kensington, have been transferred to the new department. Among the industries for which the department is now occupied in organizing courses of instruction are engineering, textiles (particularly linen manufacture), shipbuilding, agriculture, and the fisheries. The operations of the department extend to all grades of schools, from the Royal College of Science, Dublin, organized as a Central Technical College, to the elementary and secondary schools which the department enters for the administration of the science and art grants to the evening technical classes conducted by local authorities. The first annual report of the department, published November 1901, showed that successful efforts had been made to improve science teaching as a part of general education, and to develop on correct lines manual training and technological instruction.

Changes in the conception of what technical education should be.

2. Experience has helped to establish certain principles as applicable to technical education. It is now generally admitted, that whilst the age at which the ordinary school training should cease, and technical or professional education should commence, must vary for different classes of workers, the teaching special to any industry or employment should supplement, and not form part of, general education. The subjects entering into the school curriculum may be, and in certain cases should be, selected with reference to their applicability to certain callings, but they should be so taught as to become instrumental in the formation of mental habits and the development of character, the mere knowledge or skill acquired being of secondary importance. In the teaching of science there has been, during the last few years, a marked change in method. Formerly the usefulness of the knowledge to be derived from the study of nature gave to physical science its chief claim to a place in the school curriculum, but it is now held that the real value of the study consists in the opportunities it affords of exercising the pupil in accurate observation, and of developing resourcefulness and powers of independent thought and reasoning. Whilst the opinion in favour of postponing as long as circumstances permit all specialized instruction has become of late years more pronounced, there has been a growing tendency, not only in England but also on the Continent and in the United States, to associate technical teaching more closely with workshop practice. The professional or trade teaching, which is supplementary to primary or secondary education, is more practical and less easily distinguishable by the ordinary observer from the training of the factory or workshop. This tendency is shown in all grades of technical education. The technical institutes established in London and in the large English manufacturing towns, attended mainly by evening students, are provided not only with expensive laboratory apparatus for the teaching of applied science, but also with tools and machines for the teaching of technology; and some of the departments of these schools are equipped so as to resemble a small factory. This is the case in the departments devoted to the teaching of mechanical and electrical engineering, weaving and spinning, watch and clock making, boot and shoe manufacture, and the different branches of the building and printing trades.

So far, however, no attempt has been made to teach the practice of any special trade. The teaching of technology is distinct from trade teaching. In all the technical institutes of London, and in most of those of other towns, none but persons actually engaged in the industry, the technology of which they are desirous of studying, are admitted to the workshop classes. The instruction given in such classes is very different as regards method, and also in its aims and objects, from the training of apprentices in the factory or trade shop. The tools and appliances are the same, but they are used rather as a help to the teachers in illustrating principles than as a means of enabling the student to acquire that dexterity and skill which constant practice can alone secure. With the general cessation of apprenticeship, as formerly understood, it is only in the school workshop that the young artisan has any opportunity of learning the use, and the principles underlying the use, of the instruments and appliances connected with his trade; and in those industries in which automatic machinery is gradually displacing hand labour he is altogether dependent upon school teaching for any knowledge he may wish to acquire of the processes involved in the particular manufacture, in some small section of which he is exclusively engaged. Modern technological teaching is essentially practical, but it is nevertheless different in kind from the mechanical and sectional practice of the factory of commerce; and except in some few, mainly artistic, crafts, there is no entrance to a trade through the door of the school workshop. In other countries, particularly in France, the case is different. The school, in many branches of industry, is accepted as a substitute for the shop, and the lad is so trained that he acquires in the school not only a knowledge of the principles of the trade, but sufficient dexterity and skill to enable him, on leaving school, to take his place among wage-earning operatives. It is only in day schools, in which the pupils spend the greater part of their time in workshop exercises, that trade teaching can be so developed. There are schools in England in which manual training in wood and metal work is carried beyond the limits of mere educational discipline; but even in those schools no special trades are taught, and the experience of recent years has only tended to emphasize the principle, that the education given in the ordinary day schools, whether primary or secondary, should be formative and general, rather than technical or professional.

Relations with practical trade.

Owing partly to climatic conditions, and partly to the fact that the hours of labour are somewhat shorter in England than abroad, evening schools of technology are likely to occupy a permanent place in the English system of technical education. In these schools all grades of workmen will continue to receive their special supplementary instruction; and it is from among the workmen so trained that foremen and works managers will generally be selected. Some intermediate teaching, however, is necessary between that of the elementary school and the technical class as a preparation for technological instruction. A knowledge of workshop arithmetic and geometrical drawing is indispensable, and it is in the evening continuation classes that such knowledge may be best acquired. These classes therefore supply the teaching which may be regarded as the connecting link between elementary and technological instruction.

By means of scholarships a large number of children from the elementary schools are now enabled to continue and complete their general education in day schools of a higher grade. Nearly every county has its scheme of scholarships, providing facilities for the further education of children who show special abilities and aptitudes. These scholarships are in many cases awarded on the results of examinations conducted by the Joint Scholarships Board, which consists of representatives of local educational authorities, of the associations of headmasters and headmistresses, of the universities, and other bodies. Pupils from the higher-grade schools enter industrial life at a later age than those from the elementary schools, and, by reason of the more advanced instruction they have received, are at once qualified to enter classes in technology. In these schools practical teaching is further developed, both in the laboratory and workshop, but as a part only of the ordinary school course; and it would be incorrect to describe such schools as *technical* in the strict sense of the term. The position of these higher-grade schools in the general educational scheme was the subject of an important action (*Rex* v. *Cockerton*, 1901) in which it was decided by the law courts that the school board was unable to apply the rates to the support of such schools. They were accordingly withdrawn from the sphere of elementary education, and will in future be treated as schools of a secondary type. The judgment on appeal was conclusive, that the school board rates can be employed only for the provision of elementary education for children, whether in the day or evening.

As regards secondary schools proper, in their relation to technical education, it is all important that the curriculum of such schools should be sufficiently varied to afford a sound liberal and preparatory training for the different branches of professional work. At least three types or departments of schools are needed—(*a*) the classical, (*b*) the mathematical, and (*c*) the modern language type; and each of these divisions might contain sub-departments. The first of these varieties would be available for the general training of students wishing to enter the legal, theological, or literary professions; the second for those preparing for engineering, manufacturing, or agricultural pursuits; and the third would be found best fitted as a preparation for a commercial calling. These schools would correspond to some extent to the three kinds of secondary schools found in Germany, and would be available for students preparing to enter one or other of the faculties of a modern university.

The demand for technical education, which originally led to the formation of the City and Guilds of London Institute, directed attention to the methods of teaching science, drawing, and other subjects, and to the necessity of including science in the curriculum of all grades of schools. The methods of science teaching have been greatly improved. Experimental work has become essential, and methods of investigation and research have been applied to the teaching of a number of subjects to which formerly they would have seemed inapplicable. A close connexion has thus been established between the workshop and the classroom, and practical instruction is now regarded as a necessary part of general education, and as no less disciplinary than the merely literary and oral teaching it has partly superseded. This change in the school curriculum, and in the methods of instruction, has narrowed the true significance of the term "technical" as applied to education. By the term "technical" as commonly used is now understood "technological" or "professional," and whilst technological instruction may supplement either primary or secondary education, it is necessarily distinct from either.

The conviction has been steadily gaining ground that success in manufacturing industry, in the higher walks of commerce, and in every pursuit requiring technical knowledge, depends very largely upon the thorough and complete training of those who are charged with the control of the different kinds of work in which the army of operatives are engaged. Intelligent and highly skilled workers are indispensable; but unless they are properly directed by efficient and expert officers they can effect but little. It is undoubtedly due to the careful training of the masters and leaders of industry that the Germans have achieved so large a measure of success in different technical pursuits. The recognition of this fact is slowly but surely influencing educational thought and action in Great Britain; but Germany is still far ahead in the facilities afforded for higher education, and in the advantage taken of the facilities that exist. The number of students in the universities of Germany exceeds 31,000, whilst in the technical high schools, which are of university rank, there are about 10,000. In England and in Wales there are not more than 13,000 students receiving an equally systematic training; and if we include Scotland the number does not exceed 18,000. Germany has relaxed none of her former efforts, but has been steadily occupied in the enlargement and improvement of her educational institutions. New schools have been erected, wherever and for whatever purpose they are needed, equipped with every modern appliance for scientific investigation and research. Each professional career has its corresponding high school or university department. The economy of a wise and

German example.

liberal expenditure on higher education is a recognized fact in German statecraft.

For those who are intended to occupy the highest posts in industrial life, a sound secondary education, supplemented by appropriate university training, is the best preparation. It is only in the university or tertiary grade of education that specialized or technological training for the higher industrial posts should commence. At this stage of education, general and professional teaching are more closely associated, and the names of the faculties of the new universities in the United Kingdom will in future indicate the several branches of professional work to which the different courses of university study are intended to lead. Of late there has been a marked development of distinctly technical instruction in connexion with the colleges of university rank. The error of restricting university studies to a certain limited range of subjects, which led in Germany to the establishment of technical high schools as institutions distinct from the universities, has been avoided. Engineering, in the broadest sense of the term, has been recognized as a branch of university education of the same order as medicine or law. Laboratories and workshops have for many years formed part of the equipment of the principal university colleges. In the statutes of the new University of London a separate faculty is assigned to engineering, and part of the work of the polytechnic institutes is correlated with that of the reconstituted University. In Germany a new Doctorate in Engineering has been created, to be conferred by the professors of the technical high schools. A survey of the field of education shows that whilst the difference between technical and general education is well marked in the primary and secondary stages, it is the function of the university to liberalize professional teaching, and to afford opportunities for specialized study and research in the higher branches of knowledge applicable to the practical work of industrial life. (P. M*.)

UNITED STATES.—The line between technical education and other forms of advanced training is not so clearly drawn in the United States as in most parts of Europe. There is not in the United States that sharp separation in *personnel* or in methods between the university, the military school, and the technical school which exists in the United Kingdom, and especially on the European Continent. The schools of law and medicine in many an American university approach more nearly in their requirements and their methods of instruction to the technical schools of Europe than to the traditional characteristics of a legal or medical faculty. The American universities include in their programmes courses in applied science which would be regarded in Europe as belonging exclusively to a polytechnic institute. Much of the training of engineers and chemical experts has been accomplished in colleges which were established for other purposes, rather than in distinctively technical schools. In this matter West Point set an honourable example. Its courses of instruction in military engineering gradually developed such a high degree of efficiency that they became an admirable means for training civil engineers also. What was true of West Point was equally true at a later date of Annapolis. In like manner the Sheffield Scientific School at Yale, and the Lawrence Scientific School at Harvard; both founded in 1847 as places for the teaching of theory, became by force of circumstances schools of practitioners also. Of a similar character were the School of Mines at Columbia and the scientific schools at Princeton and Dartmouth. The Morrill Act of 1861, for the encouragement of colleges of agriculture and the mechanic arts, caused a large number of other institutions whose work was collegiate rather than technical in its character, especially among the state universities, to establish scientific courses, sometimes of a high degree of merit, in order to secure the income to be obtained by compliance with its general provisions. These scientific schools, private or public, are something peculiar to America. They differ from the colleges of England, or the departments of philosophy in the universities of the Continent, in basing their course predominantly on the study of natural science. They differ on the other hand from the technological schools, in teaching theory rather than practice, in reducing shop work to a minimum—in short, in not endeavouring to anticipate the kind of things that the student will need to learn afterwards, but in teaching him the things which he otherwise would not learn at all.

Passing to the more distinctively technical schools of the country, which emphasize shop and field work and the more practical side of scientific training, we shall find it convenient to group them under four heads: first, schools of engineering and applied chemistry—technological schools in the old sense; second, schools of agriculture and forestry; third, schools of the arts of design; fourth, schools for the teaching of trades.

The earliest institution of the first group, and for more than a generation the only one of this distinctive character, was the Rensselaer Polytechnic Institute, established at Troy in 1824. The next, and in some respects the most important of all, was the Massachusetts Institute of Technology, established in 1861, but not actually placed in operation until 1865. In all branches of engineering, as well as in metallurgy and applied chemistry, and even in biological study, it has maintained a high rank. The Worcester Polytechnic was established at about the same time, and it was a little later that the Packer endowment formed the basis of an excellent technical school at South Bethlehem, Pa., known by the name of Lehigh University. The Stevens Institute of Technology at Hoboken was established in 1871. Among the many other foundations of a later date the Case School of Applied Science at Cleveland, and the Sibley College at Cornell, deserve special mention for the work which they have accomplished; nor should we omit to name institutes like those of Armour at Chicago, or Carnegie at Pittsburg.

The colleges of agriculture did not develop either so quickly or so independently as the colleges of engineering and applied chemistry. The technical training under this head in most of the states was given by adding special courses to institutions established for other purposes. Perhaps the most important practical effect of these agricultural courses has been the establishment of experiment stations, not so much for the training of experts as for giving to the world the results of expert work. Schools of forestry represent a more recent development, in which Cornell took the initiative, and which Yale has carried out to the highest degree of efficiency.

The courses of study in the two groups thus far described are intended to be collegiate in their grade; that is, those who desire to enter upon these courses are expected to have a knowledge of mathematics and natural science not inferior to that required in the classical colleges, and to present a more or less adequate equivalent in modern languages in place of the Greek or Latin requirement. In such circumstances, these institutions give degrees intended to be in a general way co-ordinate with the bachelorship of arts. In the two following groups there is no such general standard of requirement. In fact, each institution has arranged its demands to suit itself, so that there is no American *system* of technical education, but only a number of isolated institutions.

Of the schools of design in the United States, some are connected with universities, like the Yale School of the Fine Arts. Especially is this true of the architectural courses; for instance, at Cornell, Columbia, and Harvard. Others are connected with academies of design. But a much larger number were established by private endowment in the various cities, of which the Cooper Union in New York has probably the best-known history and the largest field of usefulness.

The fourth group, of trade schools, may be said to bear the same relation to the high school system of the country that the schools of engineering bear to the colleges or universities. Taking their pupils with comparatively small preliminary requirements, they give a surprisingly good training in the principles necessary for the intelligent exercise of various trades, for the simpler arts of design and construction, and for household economy. Most conspicuous in this group is the Pratt Institute of Brooklyn, founded in 1887. In the number of its pupils it equals the very largest universities of the country, and it has shown the utmost activity and success in developing the study of library management and other lines of work outside of the traditional conception of a trade school.

The movement to introduce manual training into the American high schools, which has been during the last few years extremely successful, is often regarded as the equivalent of the establishment of a system of technical education on the lower secondary grade. This idea is not justified. By those who have been most successful in its use, manual training is made to be what its name implies—a *training* for the hand, rather than a preparation for particular lines of industrial activity. In other words, they value it for the education which it gives to the powers of perception and muscular control, rather than for any specific results which it teaches the child to achieve. It is perhaps fair to say that the traditional high school, the manual training school, and the trade school may in the future bear the same relation to one another which is now held by the college, the scientific school, and the institute of technology.

The best summary of the work of various technological schools in America is found in the second volume of monographs on education in the United States, edited by Nicholas Murray Butler for the United States Educational Exhibit at the Paris Exposition of 1900. Especially valuable is the chapter on scientific, technical, and engineering education, by T. C. Mendenhall, president of the Technological Institute, Worcester, Mass. (A. T. H.)

Tecucĭ, chief town of the district of the same name, Rumania, picturesquely situated on the right bank of the river Berlad, 40 miles north-west of Galatz. The neighbourhood of Tecucĭ was the scene of a fierce battle in 1476 between Stephen the Great and the Turks. Population (1895), 11,000; (1900), 13,405.

Teddington, a parish and village in the Uxbridge parliamentary division of Middlesex, England, 12 miles from Hyde Park Corner (London), close to the Thames, with a station on the Kingston line in connexion with the North London and London and South-Western railways. Two bridges were erected in 1889, one for foot passengers only. Since 1894 Teddington has been governed by an urban district council. The parish church of St Alban's, still incomplete, has already cost nearly £30,000. The church of St Mary's was renovated in 1898. The National Physical Laboratory was opened in Bushey House here in March 1902. Population (1881), 6599; (1891), 10,052; (1901), 14,029.

Tegetthoff, Wilhelm von, BARON (1827–1871), Austrian admiral, son of Lieutenant-Colonel Karl von Tegetthoff, was born at Marburg, in Styria, on 23rd December 1827. After passing through the naval college at Venice, he first served afloat in 1845, and in 1848 was made an ensign. In 1849 he was present at the blockade of Venice, resulting in its surrender. In 1852 he was promoted to be a lieutenant, and during the Crimean war was employed on a sort of police duty at the Sulina mouth of the Danube, which brought him to the favourable notice of the Archduke Maximilian, who in 1854 had been appointed head of the navy with the style of rear-admiral. After some time in a semi-official scientific expedition in Egypt, Arabia, and the Red Sea down to the island of Socotra, Tegetthoff was promoted to the rank of captain of the third class, and in 1858 he commanded the corvette *Erzherzog Friedrich* on the coast of Morocco, then in a very disturbed state. The corvette returned to Trieste on the imminence of the war with France; but during 1859 the French fleet commanded the Adriatic in vastly superior force, against which the Austrians were powerless. After the peace Tegetthoff made a voyage to Brazil as aide-de-camp to Maximilian, and in 1860–63 commanded a large frigate in the Levant during the disturbances in Syria, and on the coast of Greece or in the Piræus at the time of the Greek revolution. In the end of 1863 he was sent to the North Sea as commodore in command of two frigates, with which, together with three small Prussian gunboats, he fought an action with the Danish squadron, and though without any decisive success, succeeded in raising the blockade of the mouths of the Elbe and Weser. The Austrian emperor answered Tegetthoff's telegraphic despatch by another promoting him to be rear-admiral, and conferring on him the Order of the Iron Crown. In 1865 he commanded a small squadron in the Mediterranean, and in the war of 1866 was placed in command of the whole effective force of the Austrian navy. With all his efforts, however, this was markedly inferior to the Italian force opposed to it, and when the two fleets met off Lissa on 20th July, the decisive victory of the Austrians was entirely due to the personal superiority of Tegetthoff and the officers whom he in great measure had trained. In numbers, in ships, and in armament the Italians were much the more powerful, but they had neither a capable chief nor efficient officers. Tegetthoff was immediately promoted, by telegraph, to the rank of vice-admiral, and among the many decorations conferred on him was one from his former commander, the unfortunate Maximilian, at this time emperor of Mexico, whose body was in the following year brought home by Tegetthoff. In March 1868 he was appointed head of the naval section of the War Office and commander-in-chief of the navy, which offices he held till his death at Vienna, after a very short illness, on 7th April 1871—in the words of the semi-official notice—"zu früh für Oesterreich."
(J. K. L.)

Tegucigalpa, capital of the republic of Honduras, Central America, situated in 14° 08′ N. and 87° 15′ W., at an altitude of 3200 feet above sea-level, on the eastern bank of the Choluteca river, about 75 miles in a direct line from the Pacific coast. It is the largest and finest city of the republic, with a population of about 18,000. Until 1880 the seat of government of the republic was alternately Comayagua and Tegucigalpa, but since that date the capital has remained in the latter city. It is tolerably well laid out, has some fine public buildings, good waterworks, and other modern improvements. The principal church, called the Parroquia, is, with the exception of the cathedral of Comayagua, the largest and handsomest church in the republic. The city is united to Comayaguela or Concepcion, on the other bank of the Choluteca, by a fine bridge. The latter town is administratively a part of Tegucigalpa. There are in the city a university, national institute, colleges, national library, high school for girls, school of arts and manufactures, a fine national printing office, and other public buildings.

Tehrán, or Teherán (the former the true Persian pronunciation, the latter due to Turkish influence), a province of Persia, with capital of same name (which is also the capital of the Persian empire). It pays a yearly revenue of about £100,000, and comprises the districts of Saújbulágh, Shahriár, Feshavíyeh, Shimrán, Kasrán, and Veramín. The first three, situated north-west, west, and south of the city of Tehrán, are very fertile, and supply the capital, principally with fruit, but also with grain. Shimrán, the district north of the city, and on the slopes of the Elburz (rising to an elevation of 12,600 feet) has 63 villages (one, Tajrísh, the seat of the governor, with a population of over 3000), which are much frequented during the summer months by the inhabitants of the city seeking relief from the great heat. One of the villages, Gulhek or Gulahek, but correctly Kulhek (with a guttural K, and meaning a small, reedy mere), situated 800 feet above the city of Tehrán and 6½ miles from it, was given in fief to the British Government by Fath Ali Shah about 1830 for the summer quarters of the British Legation. Zergendeh, a village adjoining Gulhek, is held in a similar manner by the Russian Government, and the Russian Legation stays there during the summer. Kasrán is a hilly district north-east of Tehrán, with numerous coal mines (inferior coal of the Jurassic period) and streams abounding with salmon trout. The Veramín district, south-east of Tehrán city, has 123 villages, and supplies the city and surrounding districts with wheat, barley, and rice. It is watered by the Jájrúd river, and is considered one of the most fertile districts of Persia.

Tehrán, or Teherán, the capital of Persia, about 70 miles due south of the central point of the southern shore of the Caspian Sea. It is situated on the immense gravel deposit which slopes down, with an average fall of about 115 feet per mile, from the foot of the Elburz, 8 or 9 miles north of the city, and extends for 16 miles to near Sháh-Abdul-Azím, 5½ miles south of it. In 1869 the Shah decided upon enlarging the city: the old embattled mud wall, flanked by a number of round towers, was demolished, the dry ditch filled up, and an enceinte, consisting of a ditch and fifty-eight unequal bastions, according to Vauban's first system, was constructed and completed in 1874. The city then took the shape of an irregular octagon, and its circumference (a line drawn through the salient angles of the bastions) measures 19,596 metres, or 12·18 miles. The area within the bastions is about 7½ square miles. There are twelve gates, which are closed from two hours after sunset to half-an-hour before sunrise. According to observations taken in 1895 by British officers in connexion with determining the longitude of Madras, the longitude of Tehrán (British Legation in the northern part of the city) is 51° 25′ 2·8″ E. The latitude of the old telegraph office is 35° 41′ 6·83″ N., and its elevation 3810 feet. The northern gates of the city are 282 feet above the southern ones. Tehrán has 6½ miles of tramways (single lines), and is connected with Sháh-Abdul-Azím by a single line of railway of one-metre gauge. To the countries mentioned in the ninth edition of this work as being represented at Tehrán by legations, Belgium and Italy have since then been added. The water supply is from about thirty underground canals (*kanats*) led from the slopes of the northern hills, and running 5 to 10 miles at considerable depths below the surface, and would be ample for the requirements of the population if it could be regularly and equally distributed; but the supply in the months of October and November is only about one-half of that during March, and much water is lost through open ditches and by leakage. The distribution therefore is irregular: in winter and early spring, when the gardens require very little water from the canals, the supply is too great, and in summer it is too little. It has been calculated that the mean water supply amounts to the enormous quantity of 921,000 gallons per hour all the year round, but that, after deducting the quantity wasted in distribution, irrigation of gardens, filling tanks and baths, watering streets, &c., there remain forty-two gallons per head daily during the month of April, seventeen during July, August, and September, and ten during October and November. Even the last quantity would suffice if evenly distributed, but as most of the canals are private property and independent of Government or municipal control, the distribution is unequal, and it frequently happens that when some parts of the city have water in abundance others have hardly any. Population about 250,000, including 500 Europeans, 4000 Armenians, a like number of Jews, 150 to 200 Zoroastrians, and a military garrison of 5000 to 6000. (A. H.-S.)

Teignmouth, seaport and market-town, Devonshire, England, in the Ashburton parliamentary division of the county, 14 miles south of Exeter by rail. In 1897 the harbour commissioners commenced improvements to the navigable channel at the entrance to the harbour. In 1901, 1224 vessels entered with 172,924 tons cargo, and 1212 vessels cleared with 171,744 tons. A western tower was added to the church of St Michael's, East Teignmouth, in 1889. Racing and cruising yachts are built here. Population (1881), 8496; (1891), 8292; (1901), 8636.

Telav, a district town of Russia, Transcaucasia, in the government and 63 miles E.N.E. of the town of Tiflis. It stands at an altitude of 2240 feet. It is a very old town, founded in 893, and until 1797 was the capital of Kahetia, and has several ruins of old forts. In the neighbourhood are the Ikaltoi monastery (6th century), the Shuanty monastery (16th century), and the famous Alaverd church, visited by many pilgrims. Wine is exported. In 1897 its population was 11,810, chiefly Armenians (9000) and Georgians (2000).

Telegony.—Telegony is the name now given to the hypothesis that offspring sometimes inherit characters from a previous mate of their dam. Until recent years the supposed inheritance of characters acquired by a dam from one or more of her former mates was usually designated by breeders "throwing back"; by physiologists, "infection of the germ," or simply "infection." The doctrine of "infection," like the somewhat allied doctrine of "maternal impressions," seems to be alike ancient and widespread. Evidence of the antiquity of the belief in "maternal impressions" we have in Jacob placing peeled rods before Laban's cattle to induce them to bring forth "ring-straked speckled and spotted" offspring; evidence of the antiquity of the "infection" doctrine we have, according to some writers, in the practice amongst the Israelites of requiring the childless widow to marry her deceased husband's brother, that he might "raise up seed to his brother." Whatever may have been the views of stockowners in the remote past, it is certain that during the Middle Ages the belief in "infection" was common amongst breeders, and that during the last two centuries it met with the general approval of naturalists, English breeders being especially satisfied of the fact that the offspring frequently inherited some of their characters from a former mate of the dam, while both English and Continental naturalists (apparently without putting the assertions of breeders to the test of experiment) accounted for the "throwing back" by saying the germ cells of the dam had been directly or indirectly "infected" by a former mate. It is noteworthy that Agassiz, Darwin, Carpenter, and Romanes were all more or less firm believers in the doctrine of infection, and that a few years ago, with the exception of Professor Weismann, all the leading biologists had either subscribed to the telegony doctrine or admitted that "infection of the germ" was well within the bounds of possibilities. Even Professor Weismann did not deny the possibility of the offspring throwing back to a previous mate. The widespread belief, he admitted, "may be justifiable and founded on fact," but he was careful to add that "only the confirmation of the tradition by methodical investigation, in this case by experiment, could raise telegony to the rank of a fact." In assuming this attitude Professor Weismann decidedly differed from Mr Herbert Spencer, who some years ago mentioned that he had evidence "enough to prove the fact of a previous sire asserting his influence on a subsequent progeny."

The importance of determining whether there is such a thing as telegony is sufficiently evident. If a mare or other female animal is liable to be "infected" by her first or by subsequent mates, telegony will rank as a cause of variation, and breeders will be justified in believing (1) that pure-bred females are liable to be "corrupted" when mated with sires of a different breed; and (2) that inferior or cross-bred females, if first mated with a high-class sire, will thereafter produce superior offspring, however inferior or cross-bred her subsequent mates. If, on the other hand, "infection of the germ" is impossible, telegony will not count as a factor in variation, and breeders will no longer be either justified in regarding mares and other female animals as liable to be "corrupted" by ill-assorted unions, or benefited by first having offspring to a high-class, or it may be more vigorous, mate. Though, according to breeders, evidence of telegony has been found in nearly all the different kinds of domestic mammals and birds, most stress has been laid on instances of "infection" in the horse and dog families.

Telegony in the Horse Family.—Beecher at the end of the 17th century pointed out that "when a mare has had a mule by an ass and afterwards a foal by a horse, there are evident marks on the foal of the mother having retained some ideas of her former paramour, the ass." That mares used in mule breeding are liable to be infected is still widely believed, but irrefragable evidence of the influence of the ass persisting, as Agassiz assumed, is conspicuous by its absence. Darwin says, "It is worth notice that farmers in south Brazil . . . are convinced that mares which have once borne mules when subsequently put to horses are extremely liable to produce colts striped like a mule" (*Animals and Plants*, vol. i. p. 436). Baron de Parana, on the other hand, says, "I have many relatives and friends who have large establishments for the rearing of mules, where they obtain from 400 to 1000 mules in a year. In all these establishments, after two or three crossings of the mare and ass, the breeders cause the mare to be put to a horse; yet a pure-bred foal has never been produced resembling either an ass or a mule."

The prevalence of the belief in telegony at the present day is largely due to a case of supposed infection reported to the Royal Society in 1820 by Lord Morton. A chestnut mare, after having a hybrid by a quagga, produced to a black Arabian horse three foals showing a number of stripes—in one more stripes were present than in the quagga hybrid. The more, however, the case so intimately associated with the name of Lord Morton is considered, the less convincing is the evidence it affords in favour of "infection." Stripes are frequently seen in high-caste Arab horses, and cross-bred colts out of Arab mares sometimes present far more distinct bars across the legs and other zebra-like markings than characterized the subsequent offspring of Lord Morton's seven-eighths Arabian mare. In the absence of control experiments there is therefore no reason for assuming Lord Morton's chestnut mare would have produced less striped offspring had she been mated with the black Arabian before giving birth to a quagga hybrid. To account for the stripes on the subsequent foals, it is only necessary (now that the principles of cross-breeding are better understood) to assume that in the cross-bred chestnut mare there lay latent the characteristics of the Kattiawar or other Indian breeds, in which stripes commonly occur. Darwin and others having regarded Lord Morton's mare as affording very strong evidence in support of the infection hypothesis, it was considered some years ago desirable to repeat Lord Morton's experiment as accurately as possible. The quagga having become extinct, a number of mares were put to a richly striped Burchell zebra, and subsequently bred with Arab, thorough-bred, and cross-bred sires. Other mares were used for control experiments. Thirty mares put to a Burchell zebra produced seventeen hybrids, and subsequently twenty pure-bred foals. The mares used for control experiments produced ten pure-bred foals. Unlike Lord Morton's quagga hybrids, all the zebra hybrids were richly, and sometimes very distinctly, striped, some of them having far more stripes than their zebra parent. Of the subsequent foals, three out of Highland mares presented indistinct markings at birth. But as equally distinct markings occurred on two pure-bred Highland foals out of mares which had never seen a zebra, it was impossible to ascribe the stripes on the foals born after zebra hybrids to infection of their respective dams. Further, the subsequent foals afforded no evidence of infection, either in the mane, tail, hoofs, or disposition. Of the pure-bred foals, *i.e.*, the foals by pure-bred sires out of mares which had never been mated with a zebra, two were striped at birth and one acquired stripes later—they were revealed as the foal's coat was shed. Moreover, while the faint markings on the foals born after hybrids completely disappeared with the foals' coat, the stripes on the three pure-bred colts persisted. One of the permanently striped colts, a bay, was out of a black Shetland mare by a black Shetland sire, one was by a dun Norwegian pony out of a roan-coloured Arab mare, while the third was by a Norwegian pony out of a half-bred bay Arab mare. It has been asserted by believers in telegony that evidence of infection may appear in the second though not present in the first generation. By way of testing this assumption, a bay filly, the half-sister of a richly striped hybrid, was put to a cross-bred Highland pony, and a Highland mare, while nursing her hybrid foal, was put to a colt the half-brother of a hybrid. The result was two fillies which in no single point either suggest a zebra or a zebra hybrid. Similar results having been obtained with horses and asses, there is no escape from the conclusion that the telegony tradition is not confirmed by such methodical investigations as were suggested some years ago by Professor Weismann. (See Cossar Ewart, *The Penycuik Experiments*, 1899.)

Telegony in Dogs.—Breeders of dogs are, if possible, more thoroughly convinced of the fact of telegony than breeders of horses. Nevertheless, Sir Everett Millais, a recognized authority, has boldly asserted that after nearly thirty years' experience, during which he made all sorts of experiments, he had never seen a case of telegony. Recent experiments support Millais's conclusion. Two of the purest breeds at the present day are the Scottish deerhound and the Dalmatian (spotted carriage-dog). A deerhound after having seven pups to a Dalmatian was put to a dog of her own breed. The result was five pups, which have grown into handsome hounds without the remotest suggestion of the previous Dalmatian mate of their dam. A similar result was obtained with a deerhound first mated with a retriever. Many accidental experiments on telegony are made annually with dogs. Two such experiments may be mentioned. A black-brindled Scottish terrier belonging to a famous breed had first a litter of pups to a curly-haired liver-and-white cocker-spaniel. The pups were spaniel-like in build, and of a brown-and-white colour. Subsequently this terrier had pups to a black-brindled terrier. All the pure-bred pups were typical terriers, and evidence of their dam having escaped infection, is the fact that three of them proved noted prize-winners. The subject of the second undesigned experiment was a wire-haired fox-terrier. In this case the first sire was a white Pomeranian, the second a cross-bred Irish terrier. Having had ample opportunity of being "corrupted," the fox-terrier was mated with a prize dog of her own strain. The result was three pups, all in make and markings pure terriers, and one of the three was regarded as an unusually good specimen of the breed.

Experiments with cats, rabbits, mice, with sheep and cattle, with fowls and pigeons, like the experiments with horses and dogs, fail to afford any evidence that offspring inherit any of their characters from previous mates of the dam; *i.e.*, they entirely fail to prove that a female animal is liable to be so influenced by her first mate that, however subsequently mated, the offspring will either in structure or disposition give some hint of the previous mate. In considering telegony it should perhaps be mentioned that some breeders not only believe the dam is liable to be "infected" by the sire, but also that the sire may acquire some of the characteristics of his mates. This belief seems to be especially prevalent amongst breeders of cattle; but how, for example, a long-horned Highland bull, used for crossing with black hornless Galloway cows, could subsequently get Galloway-like calves out of pure Highland heifers it is impossible to imagine.

In conclusion, it may be pointed out that it was only natural for breeders and physiologists in bygone days to account for some of their results by the "infection" hypothesis. Even now we know surprisingly little about the causes of variation, and not many years ago it was frequently asserted that there was no such thing as reversion or throwing back to an ancestor. But even were the laws of heredity and variation better understood, the fact remains that we know little of the origin of the majority of our domestic animals. On the other hand, from the experiments of Mendel and others, we now know that cross-bred animals and plants may present all the characters of one of their pure-bred parents, and we also know that the offspring of what are regarded as pure-bred parents sometimes revert to remote, it may be quite different, ancestors. The better we understand the laws of heredity and variation, and the more we learn of the history of the germ cells, the less need will there be to seek for explanations from telegony and other like doctrines. (J. C. E.)

TELEGRAPHY.

MANY improvements have been effected in the art of electric telegraphy since the article on TELEGRAPHY was written for the ninth edition of this Encyclopædia (see volume xxiii. p. 112). Considerable progress has been made towards an understanding of the nature of the physical operations accompanying the propagation of an electric current along a conductor, and much has been done in making practical applications of electrical discoveries in telegraphy. These will be briefly discussed under four headings: (i.) Theory, (ii.) Land Telegraphy, (iii.) Submarine Telegraphy, (iv.) Wireless Telegraphy.

I. THEORY.

The theory of the electric telegraph enunciated by W. Thomson (Lord Kelvin) in 1855, which has been of great importance in Atlantic and cable telegraphy generally, has now become merged in a wider theory of which it forms an extreme case. This wider theory is founded upon Maxwell's theory of electromagnetic radiation, and may be accordingly termed the radiational theory. The latest type of electric telegraphy, usually termed "wireless," which has been developed from Hertz's experimental researches, also comes under the wider theory. The principal difficulties are concerning the various functions of wires. The fundamental radiational part is comparatively easy. Electric telegraphy is done by means of electromagnetic waves through the ether differing in no essential respect from radiation from the sun. This involves a flux of energy through the ether, travelling at the enormous speed of 30 earth quadrants, or 3×10^{10} centimetres per second, which speed will be denoted here by v. The energy arriving at the earth's surface may be measured by its heating effect, but in transit it is measured by the product of the density of the energy into its speed, that is, by $2\mathrm{T}v$, if $2\mathrm{T}$ is the density. In Maxwell's theory of light it is half electric energy, say $\mathrm{U}=\frac{1}{2}c\mathrm{E}^2$, half magnetic energy, $\mathrm{T}=\frac{1}{2}\mu\mathrm{H}^2$. Here E and H are the intensities of the electric and magnetic forces, and μ c are etherial constants. It is a general property of elastic waves that, to be transmitted without reflection in transit, the two energies concerned should be equal. In this case, therefore, $\mu\mathrm{H}^2=c\mathrm{E}^2$, and $\mathrm{E}=(\mu/c)^{\frac{1}{2}}\mathrm{H}$. The ratio $(\mu/c)^{\frac{1}{2}}$ is the same as μv, as may be proved by adjusting the vectors $\mathbf{E}$ and $\mathbf{H}$ so that the two circuital laws of electromagnetics shall be simultaneously obeyed. To secure this result, $\mathrm{E}=\mu v\mathrm{H}$, and $\mathbf{E}$ and $\mathbf{H}$ must be perpendicular to one another and to the direction of propagation. If a watch indicates three o'clock, and the big hand stands for $\mathbf{E}$ and the small hand for $\mathbf{H}$, then the flux of energy is straight through the watch from front to back. These properties hold good in all parts of plane waves. It is convenient to think of a slab wave. Let the ether between two parallel planes be the seat of uniform $\mathbf{E}$ and uniform $\mathbf{H}$, related as above, and in the plane of the slab. This being the state of things at a given moment, electromagnetics asserts that the slab of $\mathbf{E}$ and $\mathbf{H}$ will move through the ether (when stationary) perpendicular to itself at speed v, unchanged, and carrying all its properties with it. It is not known what μ and c are separately, but $\mu cv^2=1$ connects them. Also the product μv is known in terms of resistance, being an impedance equivalent to 30 ohms; and cv is the equivalent conductance. The electric displacement is $\mathbf{D}=c\mathbf{E}$, and the magnetic induction is $\mathbf{B}=\mu\mathbf{H}$.

A little later the concrete forms of these equations will be wanted. If a condenser of permittance S has a charge Q under the voltage V, then $Q=SV$. This is the concrete form of $D=cE$ for a unit cube, for Q is the total displacement through the condenser, and V the line integral of **E**, which is therefore the voltivity, whilst c, corresponding to S, is the permitivity. The energy of the condenser is $\frac{1}{2}SV^2$. This is the space integral of $\frac{1}{2}cE^2$. Similarly, if P is the total induction through a coil of inductance L under the gaussage C, then $P=LC$. This is the concrete form of $B=\mu H$. So μ is the inductivity, and H the gaussivity, C being the line integral of **H**. The energy of the coil is $\frac{1}{2}LC^2$, which is the space integral of $\frac{1}{2}\mu H^2$. It is important to bear in mind these relations of the concrete and the specific, for they appear frequently in telegraphic theory.

There may be any number of slabs of the above kind, separated, or in contact, of any depths and any strengths. But if $E=\mu vH$ in all, they will all behave alike, independently of one another. This is expressed by

$$E=\mu vH=f(t-x/v), \tag{1}$$

where $f(t)$ expresses the state at the plane $x=0$. If **E** and **H** do not change in direction from one slab to another, the radiation is plane-polarized; the plane of polarization is the plane of **H**. But the direction of **E** (and with it that of **H**) may vary from slab to slab in any way we like. Then the radiation is circularly, or elliptically, or heterogeneously polarized, the last being, in the average, equivalent to no polarization. In all cases the behaviour of individual slabs is the same. The disturbance is vibratory in solar radiation, but in telegraphy this is not necessary. We may have waves in which E and H do not change at all. It is the progression through the ether that is the wave, not accidental vibration. There is, it may be noted, no change from electric to magnetic energy anywhere in this sort of radiation.

We can make an immediate application to telegraphy. The slab was above considered to extend indefinitely. But let the tubes of displacement be confined between a pair of parallel perfectly-conducting plates upon which they terminate perpendicularly. The tubes of induction are unchanged. One plate is positively, the other negatively, electrified to surface density D. In virtue of the perfect conductivity, this terminated plane slab will behave exactly like the complete one; that is, we may send any radiation we like along between the plates, unchanged in transit. This is a rudimentary case of distortionless telegraphy along a pair of conductors. But the plates need not be infinitely extended, nor need they be flat. They may become a pair of cylinders of any form of section. The three most important cases are: (1) a pair of parallel wires; (2) a wire suspended parallel to a flat conductor, the earth; (3) a wire inside a cylinder surrounding it. In all cases the displacement goes from one conductor to the other through the ether between them, leaving one and reaching the other perpendicularly, and its distribution is to be calculated as in two-dimensional electrostatics. In all cases the lines of **H** cut the lines of **E** perpendicularly. They therefore make complete circuits round one or other conductor. In all cases $E=\mu vH$.

If we consider only a unit tube of flux of energy (a beam) there is no difference from the radiational case first considered. The complications due to the varied distributions of **E** and **H** in their plane are avoided by expressing results in terms of the concrete V and C. The line integral of **E** in any wave plane from one conductor to the other is V, the line integral of **H** in a circuit of magnetic force is C. Then we have

$$V=LvC=F(t-x/v); \tag{2}$$

$$C=SvV; \qquad LSv^2=1; \qquad \tfrac{1}{2}SV^2=\tfrac{1}{2}LC^2. \tag{3}$$

The additional L and S are the inductance and permittance per unit depth of the wave, or per unit length of the conductors.

The use of conductors will now be seen partly. They serve to *guide* a wave along from place to place without loss, and with a limited amount of energy. Without them, the complete plane wave would be required. If not complete, it will spread out over all space. This is, in fact, what occurs with solar radiation. Although the small curvature makes the radiation practically plane waves, yet they are really expanding spherical waves. The energy is conserved, and therefore its density varies inversely as the square of the distance from the sun's centre, whilst E and H vary inversely as the distance. This is the attenuation.

The transition from plane to spherical waves is shown by the theory of waves along conical conductors. Let there be two coaxial conical conductors with a common apex O. Let the semi-vertical angles be θ_1 and θ_2. The displacement is to go from the inner cone to the outer symmetrically in spherical sheets centred at O. The induction as usual is to be perpendicular to the displacement, therefore in circles round the inner cone. As before, make $E=\mu vH$. Then the wave will run along between the cones at speed v, attenuating in transit like solar radiation. We may vary the angles of the two cones as we please. An important case is got by making one angle $\theta_1=0$, the other $\theta_2=\frac{1}{2}\pi$; this gives the case of a flat plane with a vertical wire projecting from it at O, and the waves are hemispherical. The displacement goes from the wire to the plane in quadrantal sectors. This gives "wireless" telegraphy, like that of Lodge and Marconi, though more perfect, having ideal conditions. Signals made at O will be sent out in hemispherical waves quite undistorted, though attenuating as they expand. They are guided by the wire and by the plane representing the surface of the sea. If the wire is of finite length reflected pulses are generated; the waves sent out then become vibratory, of a frequency and wave length determined by the length of the wire. If the angle of one cone is $\theta_1=0$, and of the other $\theta_2=\pi$, we get complete spherical waves upon a wire, generated at O. If the wire is of finite length the terminal reflections make it become a sort of Hertzian vibrator.

Comparing the case of the cylindrical wires with the so-called "wireless" case, though there is little difference in theory, there is great difference in practice. Using wires, we can send radiation anywhere we like in small quantities without loss. One wire and earth is enough, but two parallel wires are preferable, to avoid certain interferences. Were it not for the resistance of the wires, and a little disturbance and loss in turning corners (for the wires need not be straight), telegraphy with wires would be perfect, by any path to any distance. But in "wireless telegraphy," though no expensive connecting wires are required, which gives a remarkable freedom in certain ways, there is enormous loss, and enormous power is required to send workable signals across the Atlantic, since they are being sent simultaneously everywhere. But for this loss by expansion and by resistance, and possible unsettled interferences, there is no reason to limit the distance. The course of a wave round the earth can be easily followed graphically.

When a wave sent along wires comes to a sharp bend in the circuit, a new wave is generated at the bend. This, combined with the old wave, forms the wave after passing the bend. There is a rapid accommodation of the wave round the wire to the new direction. But if the bending is continuous, instead of abrupt, the accommodation goes on continuously also. The reason is that the electrification cannot leave the wires, so the wave in close proximity must accommodate itself to them. A part of the wave, however, really does go off into space with some loss of energy at a sharp corner by its own natural tendency to keep going, but the wire serves to guide the disturbance round the corner as a whole, by holding on to the tubes of displacement by their ends. This guidance is obviously a most important property of wires.

There is something similar in "wireless" telegraphy. Sea water, though transparent to light, has quite enough conductivity to make it behave as a conductor for Hertzian waves, and the same is true in a more imperfect manner of the earth. Hence the waves accommodate themselves to the surface of the sea, in the same way as waves follow wires. The irregularities make confusion, no doubt, but the main waves are pulled round by the curvature of the earth, and do not jump off. There is another consideration. There may possibly be a sufficiently conducting layer in the upper air. If so, the waves will, so to speak, catch on to it more or less. Then the guidance will be by the sea on one side and the upper layer on the other. But obstructions, on land especially, may not be conducting enough to make waves go round them fairly. Then waves will go partly through them.

The effects of the resistance of the guides are very complicated in general, and only elementary cases can be considered here. Considering the transmission of plane waves in the ether bounded by parallel cylinders; first imagine the ether to be electrically conducting. Then

$$-\frac{d\mathrm{H}}{dx}=k\mathrm{E}+c\frac{d\mathrm{E}}{dt}, \qquad \text{or} \qquad -\frac{d\mathrm{C}}{dx}=\mathrm{KV}+\mathrm{S}\frac{d\mathrm{V}}{dt}, \tag{4}$$

expresses the first circuital law, and

$$-\frac{d\mathrm{E}}{dx}=\mu\frac{d\mathrm{H}}{dt}, \qquad \text{or} \qquad -\frac{d\mathrm{V}}{dx}=\mathrm{L}\frac{d\mathrm{C}}{dt}, \tag{5}$$

expresses the second. The additional quantities here are k the conductivity, and K the conductance per unit length along the wires. The effect is to waste energy at the rate $k\mathrm{E}^2$ per unit volume, or KV^2 per unit length. It is wasted in heating the medium or matter in it, according to Joule's law. Two other effects occur, viz., attenuation of the wave in transit, and distortion, or change of shape, due to reflection in transit. The attenuation cannot be prevented, but the distortion can. For let the medium be conducting magnetically, so that $g\mathrm{H}^2$ is the waste per unit volume, and RC^2 the corresponding waste per unit length. This g is analogous to k, and R to K. Then instead of (5) above, we shall have

$$-\frac{d\mathrm{E}}{dx}=g\mathrm{H}+\mu\frac{d\mathrm{H}}{dt} \qquad \text{or} \qquad -\frac{d\mathrm{V}}{dx}=\mathrm{RC}+\mathrm{L}\frac{d\mathrm{C}}{dt}. \tag{6}$$

These are of the same form as (4). So, if there be no electric conductance, but only the new magnetic conductance, the wave of H will be distorted in the same way as that of E was before, and the wave of E in the same way as that of H was before, and there will be attenuation similarly. But if the two conductivities coexist, though the attenuations are additive the distortions are combative, and may therefore destroy one another. This occurs when $\mathrm{R/L}=\mathrm{K/S}$, or $g/\mu=k/c$. The solution expressing the transmission of a plane wave is now

$$\mathrm{E}=\mu v\mathrm{H}=\epsilon^{-gt/\mu}f(t-x/v), \tag{7}$$

or

$$\mathrm{V}=\mathrm{L}v\mathrm{C}=\epsilon^{-\mathrm{R}t/\mathrm{L}}\,\mathrm{F}(t-x/v). \tag{8}$$

The meaning is that signals are transmitted absolutely without distortion, every slab independently of the rest, but with attenuation in transit according to the time factor $\epsilon^{-\mathrm{R}t/\mathrm{L}}$.

This would be very curious, even if it could only be imagined to be done by means of the imaginary magnetic conductivity. What is even more remarkable, however, is that it can be closely imitated by means of the real electric resistance, not of the medium outside the wires, but of the wires themselves. Abolish g altogether, but keep in R, which is to mean the steady resistance of the conducting guides per unit length, previously taken as zero. Then

$$-\frac{d\mathrm{C}}{dx}=\mathrm{KV}+\mathrm{S}\frac{d\mathrm{V}}{dt}, \qquad \text{and} \qquad -\frac{d\mathrm{V}}{dx}=\mathrm{RC}+\mathrm{L}\frac{d\mathrm{C}}{dt} \tag{9}$$

are still the proper equations in certain circumstances, to be mentioned later. Thus equation (8) is still the result, *i.e.*, distortionless propagation along wires. The waste RC^2 is now in the wires, instead of outside. It equals the other waste KV^2. It follows that any ordinary telegraph circuit may be made approximately distortionless by adding a certain amount of leakance, or leakage conductance; for it has L, S, and R already, and a little K. Increase K until $\mathrm{K/S}=\mathrm{R/L}$. Then the distortion, which may be excessive at first, will gradually disappear, and the signals will be restored to their proper shape, but at the expense of increased attenuation. If K be increased further, distortion will come on again, of the other kind; for at first R was in excess, but now K is.

For example, if R is 1 ohm per kilom., and $\mathrm{L}v=600$ ohms, then

$$\frac{1}{600}=\frac{\mathrm{R}}{\mathrm{L}v}=\frac{\mathrm{K}}{\mathrm{S}v}=\mathrm{KL}v, \text{ so } \mathrm{K}^{-1}=360{,}000 \text{ ohms per kilom.}$$

This is the insulation resistance required. Also, the attenuation in the distance x is $\epsilon^{-\mathrm{R}x/\mathrm{L}v}$ or $\epsilon^{-x/600}$; that is, from 1 to ϵ^{-1} in 600 kilom. to ϵ^{-2} in 1200 kilom., and so on.

To understand the reason of the disappearance of the distortion: concentrate the resistance of the wire in detached lumps, with no resistance between them. Let each resistance be r. Similarly concentrate the leakance, each leak being k. Then, between the r's and k's there is natural unattenuated distortionless propagation; so we have only to examine what happens to a slab wave in passing by one of the r's, or one of the k's, to see the likeness and difference of their effects on V and C. First let a positive wave be passing r. Let V_1, V_2, V_3 be corresponding elements in the incident, reflected, and transmitted waves. Then the conditions are

$$\mathrm{V}_1+\mathrm{V}_2=\mathrm{V}_3+r\mathrm{C}_3, \qquad \mathrm{C}_1+\mathrm{C}_2=\mathrm{C}_3, \tag{10}$$

and, since $\mathrm{V}_1=\mathrm{L}v\mathrm{C}_1$, $\mathrm{V}_2=-\mathrm{L}v\mathrm{C}_2$, $\mathrm{V}_3=\mathrm{L}v\mathrm{C}_3$, we have the results

$$\frac{\mathrm{V}_3}{\mathrm{V}_1}=\frac{1}{1+r/2\mathrm{L}v}, \qquad \mathrm{V}_1=\mathrm{V}_2+\mathrm{V}_3. \tag{11}$$

The second of these equations shows that the electrification (and displacement) is conserved. The first shows the ratio of the transmitted to the incident wave. The incident element, on arriving at r, divides into two, both of the same sign as regards V; one V_3 goes forwards, the other V_2 backwards, increasing the electrification behind. Now suppose a slab wave passes by n resistances in succession in the distance x, such that $nr=\mathrm{R}x$, then the attenuation produced in the distance x is the n^{th} power of $\mathrm{V}_3/\mathrm{V}_1$, and in the limit, when n is made ∞, it becomes $\epsilon^{-\mathrm{R}x/2\mathrm{L}v}$. This is when there is no leakage.

Next consider the effect of a single leak. The conditions are

$$\mathrm{C}_1+\mathrm{C}_2=\mathrm{C}_3+k\mathrm{V}_3, \qquad \mathrm{V}_1+\mathrm{V}_2=\mathrm{V}_3, \tag{12}$$

and the results are

$$\frac{\mathrm{V}_3}{\mathrm{V}_1}=\frac{1}{1+k/2\mathrm{S}v}, \qquad \mathrm{C}_1=\mathrm{C}_2+\mathrm{C}_3. \tag{13}$$

Here the second result shows that the induction is conserved, instead of the displacement. A part of C_1 is thrown back and increases C behind the leak. The complete attenuation in the distance x, by similar reasoning to the above, is $\epsilon^{-\mathrm{K}x/2\mathrm{S}v}$, when there is leakage without resistance in the wires.

To compare the two cases; in the first, part of V_1 is reflected positively and part of C_1 negatively, in passing a resistance; and in the second, part of V_1 is reflected negatively and part of C_1 positively. The effects are opposite. So if the resistance and the leak coexist, there is partial cancellation of the reflection. This compensation becomes perfect when r and k are infinitely small and in the proper ratio. Then there is no reflection, though increased attenuation. So with R and K uniformly distributed there is no reflection in transit anywhere, provided $\mathrm{R/L}=\mathrm{K/S}$. The attenuation in the distance x is now $\epsilon^{-\mathrm{R}x/\mathrm{L}v}$.

If the circuit stops anywhere, what happens to the wave depends upon the electrical conditions at the terminus. If it is a short circuit, then the resultant $\mathrm{V}=0$ is imposed. This causes complete positive reflection of incident V, and negative of C. If insulated, then the resultant $\mathrm{C}=0$, and there is positive reflection of incident C and negative of V. A remarkable case is that of a terminal resistance, say R_1. Then

$$\mathrm{V}_1=\mathrm{L}v\mathrm{C}_1, \qquad \mathrm{V}_2=-\mathrm{L}v\mathrm{C}_2, \qquad \mathrm{V}_1+\mathrm{V}_2=\mathrm{R}_1(\mathrm{C}_1+\mathrm{C}_2) \tag{14}$$

are the conditions. So the reflected wave is given by

$$\frac{\mathrm{V}_2}{\mathrm{V}_1}=\frac{\mathrm{R}_1-\mathrm{L}v}{\mathrm{R}_1+\mathrm{L}v}. \tag{15}$$

V is reflected positively when $\mathrm{R}_1>\mathrm{L}v$, and negatively when $<\mathrm{L}v$. If $\mathrm{R}_1=\mathrm{L}v$, there is no reflection. The energy of the wave is absorbed by the resistance. So we attain not only perfect transmission, but also perfect reception of signals.

The above method of treating resistance and leakance by isolated resistances and leaks may be applied to find out what in general happens when there is either no leakage or else no resistance in a continuous circuit. Suppose, for example, there is no leakage. Given a charge anywhere, initially without current, how will it behave? If there were no resistance, it would immediately split into two; one with positive magnetic force would move to the right, the other with negative magnetic force would move to the left, both at speed v. Now this is also exactly what happens in a resisting circuit at the first mmoent, namely, the generation of a pair of oppositely travelling pure electromagnetic slab waves. But this state does not continue, because the resistance causes a continuous partial reflection of the two waves. This may be studied in detail by easy numerical operations when we concentrate the resistance of the circuit at a number of equidistant points. The result is as follows:—Let V_0 be the original state of V of depth a. Then at a certain time t the distribution consists first of two heads at distance $2vt$ apart. These are two pure electromagnetic waves, of depth a, travelling at speed v. They are the attenuated remains of the initial waves $\frac{1}{2}V_0 = V = LvC$, and $\frac{1}{2}V_0 = V = -LvC$. Between them is the rest of V_0, cast behind by reflection as the two waves progress. In time the heads attenuate to insignificance, and there is left the widespread diffused state of V, having a maximum at the centre. It then tends to obey the Fourier law of diffusion.

If, on the other hand, there is no resistance, then the effect of the leakance alters the nature of the disturbance between the heads. V is positive in the heads, which are nearly as before, but negative in the intervening space. Now in the former case the charge or integral of SV was conserved. Suppose Q was the original charge. Then $\frac{1}{2}Q\epsilon^{-Rt/2L}$ is the amount in each head, and the rest of Q is diffused between them. But in the second case the charge in each head is $\frac{1}{2}Q\epsilon^{-Kt/2S}$, and the total charge at the same moment is $Q\epsilon^{-Kt/S}$. So we know the amount of negative charge between the two heads.

If the initial state is a pure slab wave $V_0 = LvC_0$, it goes on moving as a pure wave, but attenuating, and casting a tail behind it, the tip of which travels backwards at speed v. The tail of V is everywhere positive, and the tail of C is everywhere negative at first and until the head has attenuated very considerably, when by diffusion in the tail itself and attenuation it becomes positive, first near the head and later all the way to the middle. The ultimate result is a widely diffused state of V symmetrical with respect to the origin, where V is a maximum and C zero, whilst elsewhere C is all positive on the right side and negative on the left, in accordance with the diffusion law.

It is now necessary to consider what R, the resistance, means in the above theory. The remarkable property of guidance has been noticed, and also that R in the wires acts oppositely to K outside in reflective power, so that they may neutralize. But there is another remarkable property of wires to be mentioned. They are conductors truly, but it is for conduction or guidance of the wave outside them, in effect, in all the above. Do they conduct the wave similarly inside? Not at all. So far from doing that, they obstruct it. If a plane wave strikes flush against a perfect conductor it is wholly reflected, and with any good conductor it is mostly reflected. When a wave is sent along a wire, a purely superficial conduction is first of all concerned. The boundary of the wire is exposed to magnetic force tangentially. Now, suppose the wire is really a conducting dielectric, like the medium outside it in cases before considered. Then the magnetic force impressed upon its boundary will send an electromagnetic wave inwards. This wave will be nearly of the same type as the plane wave in the medium outside, when there is electric conductivity there, if the conductor has a plane boundary. If it is a wire, the wave will be cylindrical, with complications accordingly. But there is no difference in principle. So the transit of the plane wave along the wire outside it causes the transmission perpendicularly into the wire of another wave, and just as the former suffers positive reflection of H and negative of E in transit, so does the secondary wave which, so to speak, leaks into the wire and converges to its axis.

But though there is no difference in principle, there is a very great difference in practice. The external conductivity is usually very small, and a wave can go a long way with little change. But the internal conductivity is relatively very large indeed. Hence if an impulsive wave enters the wire at its boundary, its "head," in the sense used above, attenuates to nothing almost at once, and the wave becomes of the diffusive kind. The magnetic induction therefore diffuses into the wire according to Fourier's law of diffusion. The time interval needed to effect any operation varies as the product μka^2, where μ is the inductivity, k the conductivity, and a the radius of the wire. This diffusion is nothing like the elastic wave outside from which it results. It is to be regarded, in the main, as a purely local phenomenon. The electric force in this transverse wave is axial, or parallel to the axis of the wire. Energy is wasted in the wire at the rate kE^2 per unit vol. The transverse wave has no direct action upon the main wave outside the wire from which it is derived, but its indirect action may in time become very great, namely, the distortion and attenuation of the main wave before considered.

Metals vary considerably in the facility with which they are penetrated. Iron and copper are typical examples. Although k is six times as great in copper as in iron, yet μ is 100 or 200 times as great (for small H) in iron as in copper. So iron is much more difficult to penetrate than copper; and it takes a far longer time to set up the state of steady current in iron if the wires are of the same size. When it is reached the steady current in iron is only one-sixth of that in copper, if the impressed voltage be the same. It follows that under the action of an alternating voltage the wave-train entering the iron will attenuate much faster than that entering the copper. In either case, increasing the frequency of alternation removes the current from the interior towards the boundary, shortening the wave-length. The tendency is towards skin conduction. The attenuation is so rapid in going inwards that only one wave-length in the wire itself need be considered. This may be confined within a mere skin. Then the interior might be all scooped out without making any sensible difference. With Hertzian waves a mere film may be sufficient. These waves (outside) may be of the order of a few metres long, and the derived wave inside of microscopic length. With telephonic waves, on the other hand, there is very good penetration in the usual copper wires, except at the higher frequencies. On the other hand, if the wires are iron there is bad penetration.

Wires have really no definite resistances as a whole when waves are sent along them. The resistance per unit length will vary according to the amount of penetration at the place. The least resistance is when there is complete penetration. It is then the steady resistance measured by the Christie balance. But if the impressed alternations are simply periodic, and the resultant alternating state is allowed to be assumed, then a definite meaning can be given to the "effective resistance" (Rayleigh). If it is called R′ it will be such that $R'\overline{C^2}$ is the average rate of generation of heat, $\overline{C^2}$ meaning the mean square of the current. The more the current is concentrated, the greater the resistance. Thus with Hertzian waves the resistance is largely multiplied (compared with the steady resistance), for it is the resistance of a thin skin. It is also easy to multiply the resistance three times or so with telephonic currents in iron wires, but in copper wires there is little increase.

In skin conduction the resistance depends upon the area of the surface of the conductor. The amount per unit area is the same for a round wire as for a plane boundary when the surface state is the same. But, as before mentioned, the displacement between a pair of parallel cylinders distributes itself (in electromagnetic waves) according to two-dimensional electrostatics, and the magnetic force lines are perpendicular to the displacement. It follows that in such very rapid alternations as lead to skin conduction, the skin current concentrates itself where the displacement is strongest, usually the parts of the two conductors which are nearest together.

The penetration of the magnetic force also increases the inductance L. This increase is a trifling matter in copper, but in iron, since it becomes magnetized, it is a large effect with good penetration, though insignificant when there is skin conduction.

The way the current "rises" in a wire under impressed surface action may be visualized by comparing it with water in a pipe, originally at rest, subjected to surface traction upon its boundary acting longitudinally. The traction will at first only drag along the outermost layer of water. But if the traction continues to act steadily, viscosity will gradually cause similar motion to penetrate inwards, and to any depth. On the other hand, if the traction alternates in direction, not too slowly, only the outer layer will be sensibly moved to and fro.

It may become possible to convert this analogy into something more than an analogy by regarding the surface traction as that exerted by the longitudinal electric force on electrification in the wire, and supposing that the interior electrification (half positive, half negative) is somehow controlled in its average motion by the diffusion law. It has always been difficult to reconcile metallic conduction with electrolytic. There is a slow drift of ions in electrolysis, carrying electric charges. But there is no sign of ionic electrolysis in metallic conductors. Again, regarding metals as polarizable, Maxwell's idea that conduction consisted in a breakdown of the electric displacement does not go far in explaining the nature of the intermolecular discharge. Yet the possibility of a convective explanation of metallic conduction in harmony with Maxwell's theory became obvious when it was established that a moving charge in that theory was magnetically the same thing as a "current element," both in itself and under external magnetic force. Only quite lately, however, has it been possible to carry out this notion even tentatively. This has come about by the experimental researches which appear to establish the individuality of electrons of astonishing smallness and mobility. It is now believed by many that the conduction current inside a wire consists of a slow drift of electrons. Naturally, in the present state of ignorance about atoms and molecules, the theory is in an experimental stage. But it does not come into the telegraphic theory sensibly, since the electronic drift is a local phenomenon. It is stationary compared with the wave outside a wire. It may be noted that it is not necessary to consider the electronic drift to be the cause of the electromagnetic wave which has the drift for an after effect.

The resistance of the sea to Hertzian waves in "wireless telegraphy" comes under the same principles, and may be calculated by the same formula as the skin resistance of wires. But this is only a rough beginning, for a reason to be seen presently. Going back to equations (9), consider that R originally meant magnetic conductance outside the wires. The theory was then an exact one; but when R means the resistance of the wires, the theory cannot be exact, because R is not in the right place. It is outside the wave. The theory is now only true, as regards R, for long waves. A long wave-length may be considered to be one which is a large multiple of the distance apart of the wires, though there is really no distinct limitation. Telegraphic and telephonic waves are long, of course. So may Hertzian waves be, though, on the other hand, as these waves may be made only a few centimetres in length, such waves might require serious correction in the theory. Even when they are many metres long and the wires only a few centimetres apart, although there may be little distortion in transit, the estimation of attenuation may be considerably upset. As for light-waves, obviously they are very much too short for the theory. The application of these remarks to waves over the sea is obvious. The waves in the air are too short for the influence of the resistance of the sea to operate on them in so simple a way as in the wire theory. The air itself also may be feebly conductive, generally or locally.

Understanding, then, confinement to long waves, equations (9) will apply when the circumstances allow R to be considered fairly constant. This may happen when the conductors are thin sheets of metal permitting very rapid penetration. It may also happen with wires, as when the frequency of the waves is not so great as to increase the resistance greatly; for example, in telephony along copper wires of low resistance. But a considerable extension of the use of equations (9) may be made. Let it be a simply periodic train of waves that is in question, and let R stand for the effective resistance, which becomes definite at a definite frequency. Also make the corresponding change in L, if desired. Then it is a consequence of the general theory of wires that equations (9) are still true in the circumstances. The fundamental solution is

$$V = V_0 \epsilon^{-Px} \sin (nt - Qx), \qquad (16)$$

due to $V_0 \sin nt$ impressed at $x = 0$, where P and Q are given by

$$P + Qi = \sqrt{(R + Lni)(K + Sni)}\,; \qquad (17)$$

that is

$$P \text{ or } Q = (\tfrac{1}{2})^{\frac{1}{2}} \left\{ (R^2 + L^2 n^2)^{\frac{1}{2}} (K^2 + S^2 n^2)^{\frac{1}{2}} \pm (RK - LSn^2) \right\}^{\frac{1}{2}}. \qquad (18)$$

Valuable information may be obtained from this equation, by varying the frequency and other constants.

In an extreme case when R and S are paramount,

$$P = Q = (\tfrac{1}{2} RSn)^{\frac{1}{2}}. \qquad (19)$$

This applies to signals received at the end of a long submarine cable, slowly worked. They start as electromagnetic waves, and degenerate to diffusive waves. This is the reason why Lord Kelvin's (W. Thomson's) theory of 1855 applies pretty closely to the reception of signals.

In contrast with this, $R/L = K/S$ produces distortionless transmission, with $P = R/Lv$, $Q = n/v$. This v is defined by $LSv^2 = 1$, and is usually smaller than v in ether. Again, if R/Ln and K/Sn are both small, we get approximately

$$P = \frac{R}{2Lv} + \frac{K}{2Sv}, \qquad Q = \frac{n}{v}. \qquad (20)$$

This is practically very important in telephony. We can have a near approach to distortionless transmission. It is easy to make K/Sn small, because it is naturally small. We may in fact put $K = 0$ in effect. So if R/Ln is small, there is little distortion in transit. Observe, too, that the attenuation in the distance x is only $\epsilon^{-Rx/2Lv}$ instead of $\epsilon^{-Rx/Lv}$, which is important. The proper leakage to remove the distortion entirely would cure the evil also when R/Ln is big; any value, in fact. Now in telephony we are not concerned with very low frequencies, but only with those beginning with the lowest tone of the human voice. If R/Ln is small for this, it is small for all higher tones, therefore first-rate telephony. Even if R/Ln is 1 for the lowest tone, it will be $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, &c., for the octaves. Then P and Q in (16) will each not vary much in the upper tones, and there can be good transmission.

There are other ways of approximating to the distortionless state than by leakage. In the first example given, p. 215, no leakage would be wanted, because there would be so little distortion in thousands of miles without the leakage. Other examples relating to telephony have been given. Considering the matter more generally, let there be a circuit in which R/L is far greater than K/S, K being small and to be kept small, preferably, to avoid attenuation by leakage. Then we may tend to equalize R/L and K/S in several ways. First, by reducing S. This is well known. It means with air wires, separating them as much as possible. With cables it means reducing the "specific inductive capacity" principally, by air or paper insulation. But this reduction of S is not nearly enough. Another way is to reduce R. This is well known, and is very important. It can be carried a long way. Cable companies have been much too economical in the matter of copper, in the past especially. A third way is to increase L. Inductance causes impedance in general. But this way is proper, and is powerful. If we can increase the L of a circuit, without any change at all in R, S, we can approximate to distortionless transmission as much as we please, and with as little attenuation as we please. That is, the effect of increasing L is advantageous in a double sense, for it lessens the attenuation and the distortion simultaneously. To illustrate, if it were possible for L to be zero on say 100 miles of cable of Atlantic type (which it is not), telephony would be very bad indeed or impossible, because there would be such a wide difference in the attenuation produced on tones of different frequencies. The formula (16) above may be used, with $L=0$, $K=0$. But even if L is increased only from 0 to the small value 2 (cm. per cm., B.A. abs. units), the formula will show a remarkable improvement; and if L is increased to 10, the results are excellent. What happens is simply this, that self-induction imparts momentum to the waves, and this carries them on. The formula will show that further increase in L will carry waves across the Atlantic with little loss. But the L needed is exceedingly great. Any increase of L does good, provided it be unaccompanied by increased resistance or other evils to destroy the benefit. It is therefore very important to know how to increase L, and to find out what can be made of the principle concerned in practice. Now there is some practice in it already. Telephone wires in air, for long distance telephony, should be, and are in some places, put up in such a way as to make L as large as possible, although some electricians have maintained that L should be as small as possible. The difference between $L=2$ and $L=20$ or 30, which is produced by separating wires, is enormous, and largely multiplies the distance over which telephonic waves can be carried.

But it is the improvement of signalling through cables that is most important, if it can be done. The most effective way of obtaining self-induction is by the use of iron, suitably arranged and divided; not iron for the guides, but outside or inside them. There is plenty of iron put round cables now, but it is for protection, and is not at all suitably arranged for the purpose required. It is not unlikely that a new type of cable can be designed in which iron can be brought into use to increase the self-induction largely and in a uniform manner. The writer invented a way of carrying out the principle other than uniformly, and recommended it for trial; viz., by the insertion of inductance coils in the main circuit at regular intervals, say one per mile, according to circumstances. The time constants of these coils should be as large as possible, so that the average inductance may be largely increased without a large increase in the average resistance per mile. The action of the coils is similar to that of small detached loads placed upon a string to give it inertia, and enable it to carry waves farther. If we wish to imitate a curve containing bends of various sizes by means of dots, it is obviously necessary to have several dots in every bend. So, in the substitution of detached inductances for uniform inductance, we need to have several coils in every bend of the electrical wave. It is easy to say that so many coils will be wanted in such a length, in telephony, for example, if we can fix upon the shortest wave-length, by using the known formula for the wave-length. One could do that without being considered to make a new discovery. But this does not answer the question how few the coils may be for telephony through a cable. Theoretically we want an infinite number, *i.e.*, uniform inductance. We must sacrifice something. The shortest telephonic wave-length necessary to be considered is a doubtful element, and there are unmentioned interferences to be allowed for. Hence experiment alone can decide how few the coils need be for telephony through a distance far exceeding that possible without the coils. Nothing particular has been done in Great Britain to carry out the writer's invention, but in America some progress has been made by Dr Pupin, who has described an experiment supporting its practicability; the length telephoned through was increased five times by inserting the coils.

The above radiational theory of telegraphy founded upon Maxwell's theory of light has been proved in all essential points and in various details by important experiments of Hughes, Lodge, Hertz, and others, to say nothing of long-distance telephony in America, or the more recent spherical telegraphy. But quite different views have been maintained by the electricians of the British Post Office, under the guidance of Sir W. H. Preece. It is only fair to put on record here his leading articles of faith. The information is derived from his papers. Self-induction is harmful to telephony, and is to be avoided and minimized. Nevertheless, experiments upon the Post Office wires showed that though self-induction is sensible in iron wire circuits, it is quite insensible in copper circuits. That is why copper wire is so successful, and iron wire a failure. Also the capacity of circuits (their permittance) is reckoned in a peculiar manner. What controls telephony is "the KR law." If K is the total capacity of a circuit in microfarads, and R its total resistance in ohms, the product KR fixes over what distance telephony can be carried on. It must not exceed 2000 because of the KR law, the speed of the current varying as the square of the length of the line. Finally, Sir W. H. Preece has a special invention aiming at Atlantic telephony. Imagine a round wire to be slit in two, and the halves to be slightly separated for insulation, say by a piece of paper. The two halves form the circuit, and it was supposed by the inventor that by the close approximation of the flat surfaces the electrostatic and electromagnetic inductions would neutralize one another.

For additional information the reader is referred to the following works:—Lord KELVIN. *Mathematical and Physical Papers*, vol. ii. Cambridge, 1884.—CLERK-MAXWELL. *Treatise on Electricity and Magnetism*, vol. ii. Oxford, 1881.—J. J. THOMSON. *Recent Researches in Electricity and Magnetism.*—OLIVER HEAVISIDE. *Electrical Papers.* London, 1892; and *Electromagnetic Theory.* London, 1893. (O. HE.)

II. LAND TELEGRAPHY.

The improvements introduced in land telegraphy within the last two decades of the 19th century related almost entirely to line construction and instrument design. No striking novelties were devised, and such inventions as could be claimed as new have not, so far, been developed to the extent necessary to make them practical successes. Nevertheless very real progress was made, though it was practically in the direction of the better adaptation of old principles to modern requirements. Almost all the general types of apparatus which were in use at the beginning of the period named are still employed, and have proved themselves capable of fully meeting modern necessities. In determining what are real improvements, it is especially necessary to consider what are the working conditions involved in practical telegraphy. Exaggerated importance has been attached to certain systems of rapid and multiple telegraphy, which, although they are capable under favourable conditions (seldom met with in practice) of *transmitting* a large amount of message work, are yet of little value, from the fact that the received and recorded signals cannot be handled and transcribed to commercial advantage at a correspondingly high speed. In illustration of this it may be stated that it is found in practice that more message work can be transmitted and dealt with by means of the "Wheatstone Automatic" apparatus when running at a moderate speed, than when running (as it is quite capable of doing) at a speed of from 400 to 600 words per minute. Methods therefore (among others) which claim to be able to transmit at speeds which have not hitherto been attained are not necessarily "improvements."

Over-ground lines.

In the aerial or overground system of land telegraphs the use of copper wire has become very general. The advantage of the high conducting power which copper possesses is of especial value in moist climates (like that of the United Kingdom), since the effect of leakage over the surface of the damp insulators is much less noticeable when the conducting power of the wire is high than when it is low, especially when the line is a long one. Copper is not yet universally employed, price being the governing factor in its employment; moreover, the conducting quality of the iron used for telegraphic purposes has of late years been very greatly improved.

In the British Postal Telegraph system five sizes of iron wire are in general use, weighing respectively 200, 400, 450, 600, and 800℔ per statute mile, and having electrical resistances (at 60° F.) of 26·64, 13·32, 11·84, 8·88, and 6·66 standard ohms per statute mile respectively. The sizes of copper wire employed have weights of 100, 150, 200, and 400 ℔ per statute mile, and have electrical resistances (at 60° F.) of 8·782, 5·855, 4·391, and 2·195 standard ohms respectively. Copper wire weighing 600 and 800 ℔ per mile has also been used to some extent. The copper is "hard drawn," and has a breaking strain as high as 28 tons per square inch; the test strain required for the iron wire is about 22½ tons. The particular sizes and descriptions of wires used are dependent upon the character of the "circuits," the longer and more important circuits requiring the heavier wire.

Practically one form of "insulator" is in general use on the postal lines, viz., the "Cordeaux screw"; but the "Varley double cup" (see *Ency. Brit.*, vol. xxiii. p. 114) is still employed, especially by the railway companies, and is a very serviceable pattern, though possessing the defect that the porcelain cup is not removable from the iron bolt on which it is mounted. The Cordeaux insulator (Fig. 1) is made in one piece. A coarse screw-thread is formed in the upper part of the inner cup, and this screws on to the end of the iron bolt by which it is supported. Between a shoulder, *a*, in the iron bolt and a shoulder in the porcelain cup *c* is placed an indiarubber ring, which forms a yielding washer and enables the cup to be screwed firmly to the bolt, while preventing the abrasion of the porcelain against the iron. The advantage of the arrangement is that the cup can at any time be readily removed from the bolt. At the termination of a line a large insulator (Fig. 2), mounted on a strong steel bolt having a broad base flange, is employed. Connexion is made into the office (or to the underground system, as is often the case) from the aerial wire by means of a copper conductor, insulated with gutta-percha, which passes through a "leading in" cup, whereby leakage is prevented between the wire and the pole. The insulators are planted on creosoted oak arms, 2½ inches square and varying in length from 24 to 48 inches, the 24 and 33 inch arms taking two, and the 48-inch four, insulators. The unequal lengths of the 24 and 33 inch arms are adopted for the purpose of allowing one wire to fall clear of that beneath it, in the case of an insulator breaking or the securing binder giving way. The poles are of red fir, creosoted, this method of preservation being the only one now used for this purpose in the United Kingdom. The number of poles varies from about 15 to 22 per mile of line; they are planted to a depth of from 2 to 4 feet in the ground. For protection from lightning each has an "earth wire" running from the top down to the base.

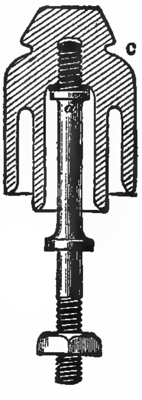

Fig. 1.—Cordeaux Insulator

Under-ground lines.

Gutta-percha-covered copper wires are largely used for the purpose of underground lines, the copper conductor weighing 40℔ per statute mile, and the gutta-percha covering 50℔ (90℔ total). The conductor has an electrical resistance (at 60° F.) of 22·66 standard ohms, and an electrostatic capacity of 0·270 microfarad, per statute mile. The insulated wires are enclosed in cast iron pipes which are buried at a depth of about 18 inches beneath the footways and contain sometimes as many as 70 wires. In London alone the buried wires exceed 20,000 miles in length. At every 400 yards along the line of pipes are placed "flush" boxes, *i.e.*, cast iron boxes with stone covers, which are flush with the surface of the ground; at these boxes the wires are jointed. Other flush boxes are also provided where there are no joints, but where the wires are drawn into the pipe in lengths of 400 yards, half being taken to either side of the box. *Paper* cables, *i.e.*, copper wires insulated with carefully dried paper of a special quality, are now very largely used. A number of the wires, each enveloped in a loose covering of well-dried paper, are loosely laid up together with a slight spiral "lay" in a bundle, and the whole is enclosed in a stout lead pipe. It is essential that the paper covering be loose, so as to ensure that each wire is enclosed in a coating not of paper only, but also of air; the wires in fact are really insulated from each other by the dry air, the loose paper acting merely as a separator to prevent them from coming into contact. The great advantage of this air insulation is that the electrostatic capacity of the wires is low (about one-third of that which would be obtained with gutta-percha insulation), which is of the utmost importance for high speed working or for long-distance telephonic communication. As many as 400 wires are enclosed in one lead pipe.

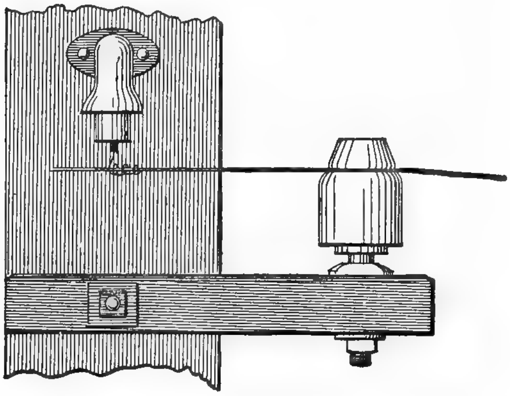

Fig. 2—Terminal Insulator.

Between London and Birmingham a paper cable 116 miles long and consisting of 72 copper conductors, each weighing 150℔ per statute mile, was laid in 1900. The conductors are enclosed in a lead pipe, 2¼ inches in outside diameter and ⅛ inch thick, which itself is enclosed in cast iron spigot-ended pipes, 3 inches in internal diameter, and buried 2 feet below the surface of the roadway. At intervals of 2 miles "test pillars" are placed for the purpose of enabling possible faults to be accurately located. Each conductor has a resistance (at 60° F.) of 5·74 ohms per statute mile, and an average electrostatic capacity per mile between adjacent wires of 0·06 microfarad, or between wire and earth of 0·1 microfarad; the insulation resistance of each wire is about 5000 megohms per mile.

The one disadvantage of paper cables is the fact that any injury to the lead covering which allows moisture to penetrate causes telegraphic interruption to the whole of the enclosed wires, whereas if the wires are each individually coated with gutta-percha, the presence of moisture can only affect those wires whose covering is defective. There is no reason for doubting, however, that, provided the lead covering remains intact, the paper insulation is imperishable; this is not the case with gutta-percha-covered wires.

Testing.

In order to maintain the system of telegraph lines in good working condition, daily tests are essential. In the British Postal Telegraph Department all the most important wires are tested every morning between 7.30 and 7.45 A.M., in sections of about 200 miles. The method adopted consists in looping the wires in pairs between two testing offices, A and B (Fig. 3); a current is sent from a battery, E, through one coil of a galvanometer, *g*, through a high resistance, *r*, through one of the wires, 1, and thence back from office B (at which the wires are looped), through wire 2, through another high resistance, *r*′, through a second coil on the galvanometer, *g*, and thence to earth. If the looped lines are both in good condition and free from leakage, the current sent out on line 1 will be exactly equal to the current received back on line 2; and as these currents will have equal but opposite effects on the galvanometer needle, no deflection of the latter will be produced. If, however, there is leakage, the current received on the galvanometer will be less than the current sent out, and the result will be a deflection of the needle proportional to the amount of leakage.

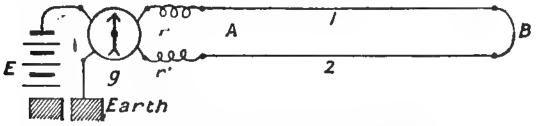

FIG. 3.—Method of testing circuits.

The galvanometer being so adjusted that a current of definite strength through one of the coils gives a definite deflection of the needle, the amount of leakage expressed in terms of the insulation resistance of the wires is given by the formula

$$\left.\begin{array}{r}\text{Total insulation}\\ \text{resistance of}\\ \text{looped lines}\end{array}\right\} = \frac{R}{2}\left(\frac{D}{d} - \frac{1}{2}\right);$$

in which R is the total resistance of the looped wires, including the resistance of the two coils of the galvanometer, of the battery, and of the two resistance coils *r* and *r*′ (inserted for the purpose of causing the leakage on the lines to have a maximum effect on the galvanometer deflections). In practice the resistances *r*, *r*′ are of 10,000 ohms each. The deflection observed on the galvanometer when the lines are leaky is *d*, while D is the deflection obtained through *one* coil of the galvanometer with all the other resistances in circuit; and assuming that no leakage exists on the lines, this deflection is calculated from the "constant" of the instrument, *i.e.*, from the known deflection obtained with a definite current. For the purpose of avoiding calculation, tables are provided showing the values of the total insulation according to the formula, corresponding to various values of *d*. If the insulation per mile, *i.e.*, the total insulation multiplied by the mileage of the wire loop is found to be less than 200,000 ohms, the wire is considered to be faulty. The climatic conditions in the British Islands are such that it is not possible to maintain, in unfavourable weather, a higher standard than that named, which is the insulation obtained when all the insulators are in perfect condition and only the normal leakage, due to moisture, is present.

Batteries.

There are three kinds of batteries in general use in the British Postal Telegraph Department, viz., the Daniell, the bichromate, and the Leclanché. The Daniell type consists of a teak trough divided into five cells by slate partitions coated with marine glue. In each cell is placed a porous chamber containing sulphate of copper crystals and a copper plate; the cell also contains a zinc plate immersed in a solution of sulphate of zinc. The electromotive force of each cell is 1·07 volts, and the resistance 3 ohms. The Fuller bichromate battery consists of an outer jar containing a bichromate of potash and sulphuric acid solution, in which a plate of hard carbon is immersed; in the jar there is also a porous pot containing dilute sulphuric acid and a small quantity (2 oz.) of mercury, in which stands a stout zinc rod. The electromotive force of each cell is 2.14 volts, and the resistance 4 ohms. The Leclanché is of the ordinary type, and each cell has an electromotive force of 1·64 volts and a resistance of 3 to 5 ohms (according to the size of the complete cell, of which there are three sizes in use). Dry cells, *i.e.*, cells containing no free liquid, but a chemical paste, are also largely employed; they have the advantage of great portability.

Universal battery working.

The adoption of improved forms of batteries, and, of recent years, the introduction of accumulators for telegraphic purposes, has resulted in the very general application of the principal of working a number of instruments off one set of batteries. The batteries must be of low resistance, otherwise great variation in the strengths of the currents passing out to the lines takes place when a number of instruments are being worked. In practice, when primary batteries are used for the purpose, not more than five or six circuits can be worked satisfactorily together, but by using accumulators as many as 300 can be grouped on one set of cells. So satisfactory has been the use of accumulators that they have entirely replaced ordinary batteries at large offices. The force of the set of accumulator cells provided is such as to give sufficient power for the longest circuit to be worked, the shorter circuits being brought up approximately to a level, as regards resistance, by the insertion of resistance coils in the circuit of the transmitting apparatus of each shorter line. A spare set of accumulators is provided for every group of instruments in case of the failure of the working set. For working "double current," two sets of accumulators are provided, one set to send the positive and the other set the negative currents; that is to say, when, for example, a double current Morse key is pressed down it sends, say, a positive current from one set, but when it is allowed to rise to its normal position then a negative current is transmitted from the second set of accumulators. It is not possible to work double current from one set alone, as in this case, if one key of a group of instruments is up and another is down, the battery would be short-circuited and no current would flow to line.

Instruments.

At small country towns or villages, where the message traffic is light, the Wheatstone "ABC" instrument is used. In this apparatus electric currents are generated by turning a handle (placed in front of the instrument), which is geared, in the instruments of the most recent pattern, to a Siemens shuttle armature placed between the two arms of a powerful horse-shoe permanent magnet. When one of a series of keys (each corresponding to a letter) arranged around a pointer is depressed, the motion of the pointer, which is geared to the shuttle armature, is arrested on coming opposite that particular key, and the transmission of the currents to line is stopped, though the armature itself can continue to rotate. The depression of a second key causes the first key to be raised. The currents actuate a ratchet-wheel mechanism at the receiving station, whereby the hand on a small dial is moved on letter by letter. A noticeable feature in the modern A B C indicator, as well as in all modern forms of telegraph instruments, is the adoption of "induced" magnets in the moving portion of the apparatus. A small permanent magnet is always liable to become demagnetized, or have its polarity reversed by the action of lightning. This liability is overcome by making the movable parts which require to be magnetic, of soft iron, and magnetizing them by the inducing action of a strong permanent magnet.

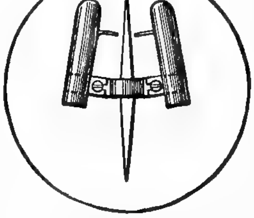

Fig. 4.—Single Needle with sounding arrangement.

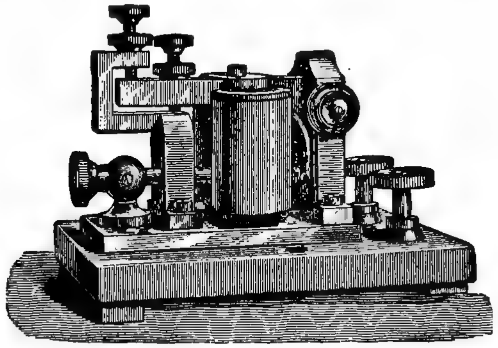

Fig. 5.—Modern "Sounder."

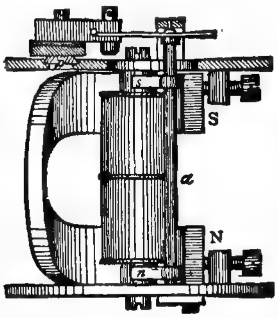

Fig. 6.—Post Office Standard Relay.

At offices where the work is heavier than can be dealt with by the A B C apparatus, the "Single Needle" instrument is very largely used; it has the advantage of slight liability to derangement, and of requiring very little adjustment. A fairly skilled operator can signal with it at the rate of 20 words per minute. The needle (in the modern pattern) is of soft iron, and is kept magnetized inductively by the action of two permanent steel magnets. The coils are wound with copper wire (covered with silk), 10 mils[1] in diameter, to a total resistance of 200 ohms. The actual current required to work the instrument is 3·3 milliamperes (equivalent approximately to the current given by 1 Daniell cell through 3300 ohms), but in practice a current of 10 milliamperes is allowed. A simple, but important, addition to enable the reading from the instrument to be effected by sound is shown in Fig. 4. In this arrangement the needle strikes against small tubes formed of tin-plate. Fig. 5 shows the modern pattern of "Sounder" as used by the British Post Office. The magnet is wound to a resistance of 40 ohms (or 900 ohms when worked from accumulators), and the instrument is worked with a current of 400 milliamperes (25 milliamperes with accumulators). Direct, or single, current working is employed only for very short lines; for long lines, relays are invariably used. Fig. 6 shows the most modern pattern of relay used by the British Post Office, known as the "Post Office Standard Relay." In this instrument there are two soft iron tongues, *n*, *s*, fixed upon and at right angles to an axle *a*, which works on pivots at its ends. These tongues are magnetized by the inducing action of a strong horse-shoe permanent magnet, S N, which is made in a curved shape for the sake of compactness. The tongue plays between the poles of two straight electromagnets. The coils of the electromagnets are differentially wound with silk-covered wire, 4 mils in diameter, to a total resistance of 400 ohms. This differential winding enables the instrument to be used for "duplex" working, but the connexions of the wires to the terminal screws are such that the relay can be used for ordinary single working. Although the relay is a "polarized" one, so that it can be used for "double current" working, it is equally suitable for "single current" purposes, as the tongue can be given a bias over to the "spacing" side, *i.e.*, to the side on which no current passes through the local circuit. The standard relay will work single current with a current of 3 milliamperes, though in practice about 10 would be used. Worked double current—that is, with the tongue set neutral, having no bias either to the spacing or marking side—the relay will give good signals with 1½ milliampere of current, though in practice 10 milliamperes are provided. The lightness of the moving parts enables great rapidity of action to be obtained, which for automatic fast speed working is very essential. When a local instrument such as a sounder (Fig. 5) is worked from a relay, the dying away of the magnetism in the iron cores of the electromagnet, when the relay tongue moves from the marking to the spacing side, *i.e.*, when the local battery is cut off, sets up an induced current of high tension, which causes a spark to jump across the contact points of the relay, and by oxidizing them makes it necessary for them to be frequently cleaned. In order to avoid this sparking, every local instrument in the British Postal Telegraph Department has a "spark" coil connected across the terminals of the electromagnet. The spark coil has a resistance about ten times as great as that of the electromagnet it shunts, and the wire of which it is composed is double wound so as to have no retarding effect on the induced current, which circulates through the spark coil instead of jumping in the form of a spark across the contact points. The device is a most effectual one, and a very important improvement.

"Single current" working by means of a non-polarized relay, although general in America, is not adopted in England. In the latter country, when such working is resorted to, a polarized relay with a bias is used, but on all important lines worked by sounders, the "Double Current" system is employed. In this the tongue of the relay is kept over to the spacing side by means of a current flowing in one direction, but on the depression of the signalling key the current is reversed, moving the relay tongue over to the marking side. The relay tongue being perfectly free to move, can be actuated by a comparatively weak current, and, moreover, requires but little

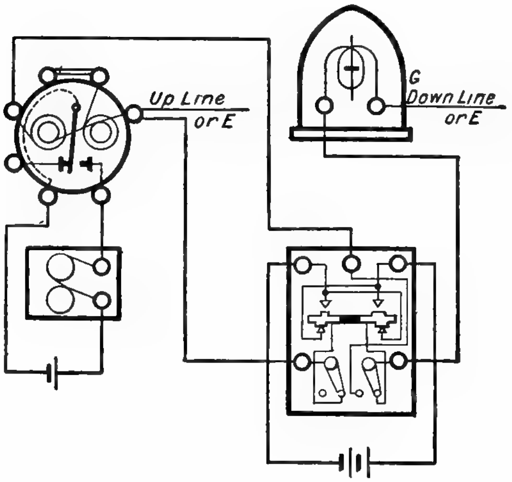

Fig. 7.—Connexions for Double Current working.

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[1] 1 mil = $\frac{1}{1000}$ inch.

adjustment. Normally a switch attached to the key cuts the battery off, and connects the line direct through the receiving relay; this switch is turned to "send" when transmission commences, and is moved back to "receive" when it ceases: this movement is done quite mechanically by the telegraphist, and as it is practically never forgotten, automatic devices to effect the turning are wholly unnecessary. Fig. 7 shows the general arrangement of the connexions for double current working; the galvanometer G is used for the purpose of indicating whether a station is calling, in case the relay sticks or is out of adjustment.

Multiplex system.

The "Multiplex" system devised by Delaney, which has been adopted to a limited extent in Great Britain, enables a large amount of work to be done on one wire. The general arrangement of the apparatus is shown by Fig. 8. Arms *a* and *b*, one at each station A and B, are connected to the line wire, and are made to rotate simultaneously over metallic segments, 1, 2, 3, 4, and 1′, 2′, 3′, 4′, at the two stations, so that when the arm *a* is on segment 1 at A, then *b* is on segment 1′ at B, and so on. At each station sets of telegraph apparatus are connected to the segments, so that when the arms are kept rotating the set connected to 1 becomes periodically connected to the set connected to 1′, the set connected to 2 to the set connected to 2′, and so on. In practice the number of segments actually employed is much greater than that indicated on the figure, and the segments are arranged in a number of groups, as shown by Fig. 9, all the segments 1 being connected together, all the segments 2, all the segments 3, and all the segments 4. To each group is connected a set of apparatus; hence during a complete revolution of the arms a pair of instruments (at station A and station B) will be in communication four times, and the intervals during which any particular set of instruments at the two stations are not in connexion with each other become much smaller than in the case of Fig. 8. In practice this subdivision of the segments is so far extended that the intervals of disconnexion become extremely small, and each set of apparatus works as if it were alone connected to the line. As many as 162 segments in eight groups are practically used. The arm which moves round over the segments rotates at the rate of three revolutions per second, and is kept in motion by means of an iron toothed wheel, the rim of which is set in close proximity to the poles of an electromagnet. Through this electromagnet pass impulses of current regulated in frequency by a tuning-fork contact breaker; these impulses, acting on the teeth of the iron wheel, by a series of pulls keep it in uniform rotation. If the rates of vibration of the two tuning-forks at the two stations could be maintained precisely the same, the two arms would rotate in synchronism, but as this uniform vibration cannot be exactly preserved for any length of time, a means is provided whereby the rate of vibration of either of the forks can be slowed down, so as to retard the rate of rotation of one or other of the arms. This is effected by means of "correcting" segments, of which there are six sets containing three each. Should the rotating arms fail to pass over these correcting segments at their synchronous positions, correcting currents pass to a relay which cuts off momentarily the current actuating the tuning-fork, thereby altering the rate of vibration of the latter until the arms once more run together uniformly. The actual number of sets of apparatus it is possible to work multiplex depends upon the length of the line, for if the latter is long, retardation-effects modify the working conditions. Thus between London and Manchester only four sets of apparatus can be worked, but between London and Birmingham, a shorter distance, six sets (the maximum for which the system is adapted) may be used.

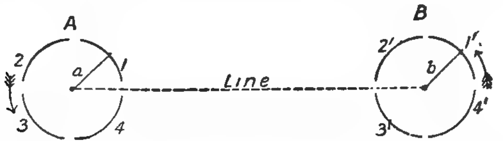

Fig. 8.—Multiplex working.

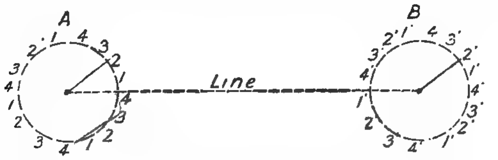

Fig. 9.—Grouping of Segments in Multiplex System.

Wheatstone automatic system.

The Wheatstone automatic apparatus, as described in *Ency. Brit.*, vol. xxiii. p. 120, although in general principle unaltered, has undergone several important modifications which well illustrate the result of experience. In the older form of instrument (*ibid.*, p. 120, Fig. 18) the automatic contacts were made through the medium of the crank-levers A B and the pins *p p* on the rocking-bar E; in the most recent arrangement, Fig. 10, the crank-levers A A′ and the pins P P′ on the rocking-bar Y are used solely for the purpose of regulating the automatic contacts, which are wholly made by the rocking-lever L. This arrangement in fact corresponds to the double current key of the "Double Current" system, the key action being regulated by the movements of the levers A and A′, which, as in the older arrangement, are controlled by the vertical rods S M, which pass through the perforations in the paper slip. It is found that this modified arrangement gives great certainty of action, a point of great importance with the mechanism running at a very high speed. Although it is quite possible to obtain good signals at a rate corresponding to 600 letters per minute, in practice it is found that such a high speed is not advisable, as it is difficult or impossible for even the most skilled operators properly to handle and transcribe from the "slip" on which the signals are recorded.

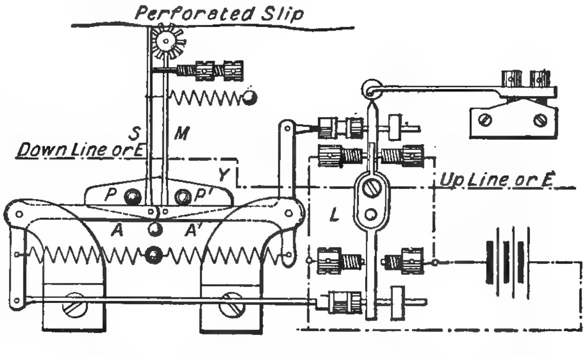

Fig. 10.—Wheatstone Automatic Transmitter.

Pollak-Virag system.

In the Pollak-Virag system the sending is automatically carried out by means of a paper ribbon resembling in many respects that used for the Wheatstone apparatus. The ribbon carries two series of perforations, one (on one side of the ribbon) representing the dashes of the Morse alphabet, and the other series (on the other side) representing the dots. The reception is effected by means of a telephone disc which is connected by a multiplying movement to a small mirror. This mirror directs a light-ray upon sensitized paper, and imprints a line which alternately rises and falls in waves; the waves above a central line represent the dashes, and those below, the dots. The perforated ribbon is prepared by an apparatus which closely resembles that used for perforating Wheatstone ribbon. It is inserted in an automatic transmitter, of which the essential sending parts are extremely simple. The slip passes over a metal cylinder and beneath two metal brushes, so placed as to correspond exactly in position with the two lines of perforations. In this way the passage of a perforation allows one or other of the brushes to fall and come in contact with the metal cylinder beneath. The brush which corresponds to the upper series of perforations is joined to the positive pole of the battery, while the brush which corresponds to the lower series of perforations is connected with the negative pole. The metal cylinder is joined to the line. The battery is joined to earth or to a return line. It will thus happen that when a perforation of the upper series, corresponding to the dashes of the Morse alphabet, passes under the brush of the transmitter, the brush comes in contact with the metal cylinder and joins the positive pole of the battery to line, while if a perforation of the lower, or dot, series passes, the corresponding brush will come into contact with the cylinder, and the negative pole of the battery will be joined to line. By this arrangement (which, however, is not novel) currents of differing direction are sent into the receiving apparatus. Through an aerial line 650 kilometres long the system has worked at a speed of over 1600 words per minute with a battery power of 20 volts only (see *Electrical Review*, 16th and 23rd March 1900).

Squier and Crehore system.

In Squier and Crehore's "Synchronograph" system "sine waves" of current, instead of sharp "makes and breaks," or sharp reversals, are employed for transmitting signals, the waves being produced by an alternating-current dynamo, and regulated by means of a perforated paper ribbon, as in the Wheatstone automatic system. The arrangement has been found under certain conditions to give better results than those obtained with sharp reversals, but the apparatus for the purpose is (as at present arranged) too bulky for general use, and cannot yet be considered practicable (see *Electrical Review*, 7th May 1897).

Type printing telegraphs.

The Hughes apparatus has remained substantially unaltered in general arrangement. It is still exclusively used in England for working the circuits to the Continent, but in many of the instruments the driving is effected by a small electromotor instead of by a weight.

Several new and interesting features have been introduced in the Rowland multiple method of telegraphic working. The transmitter consists of a mechanical keyboard provided with a series of levers, which effect certain combinations of positive and negative currents for each letter. These currents are furnished by an alternator which transmits sine currents over the line and operates a motor at the distant end of the line, both machines running in synchronism. At the receiving end of the circuit a shaft is coupled to the motor; this is provided with gearing which rotates four combining commutators and four type wheels, which print the letters on the band of paper. There are four transmitters and four receivers, which are operated independently by means of an adaptation of the multiplex system of working, and each circuit is provided with a number of segments set apart for its own use. Each transmitter is therefore able to transmit a separate series of positive and negative currents in different combinations; these are distributed, by suitably arranged distributors and relays at the receiving end of the line, into their respective receivers. The function of the "combiner" in each receiving instrument is so to group the received combination of positive and negative currents that they operate polarized relays in such a manner that the position of the tongues corresponds with the operation of the levers on the transmitter. Since each letter is represented by a specific combination of positive and negative currents, it is possible, by means of the combinations, to close a local circuit at any given interval, and so cause the paper to be pressed against the periphery of the type wheel at the time when the letter required is opposite. The paper is also caused to advance automatically for each letter, start a fresh line, and also to commence a fresh form at the completion of each message.

Repeaters.

On long circuits worked by the Wheatstone fast-speed apparatus, and especially on those in which a submarine cable is included, it is found necessary to introduce "repeaters" half way, in order to enable a high speed to be maintained. The speed at which a circuit can be worked depends upon what is known as the "KR" of the line, *i.e.*, the product of the total capacity and the total resistance, both the capacity and the resistance having a retarding effect on the signals. By dividing a line into two halves the working speed will be dependent upon the KR of the longest half, and as *both* K and R are directly proportional to the length of the line, the KR product for the half of a circuit is but one quarter that of the whole length of the circuit, and the retardation is correspondingly small. Thus the speed on a line at which the repeater is situated exactly midway will be four times that of the line worked direct. Repeaters (or translators, as they are sometimes termed) are in Great Britian only used on fast-speed circuits; they are in no case found necessary on circuits worked by hand, or at "key speed" as it is called.

AUTHORITIES.—PREECE and SIVEWRIGHT'S *Telegraphy*; HOUSTON and KENNELLY'S *Electric Telegraphy* (American); MONTILLOT'S *Telegraphie* (French); KEMPE'S *Handbook of Electrical Testing*. (H. R. K.)

III. SUBMARINE TELEGRAPHY.

Development of cable enterprise.

The system of submarine cables originated in the middle of last century by Great Britain has continued to develop in her hands until the world has been covered with a veritable network of cables, which has hitherto done much to prevent the decline of her commercial supremacy, the possession of so comprehensive a system of rapid communication radiating in all directions having assisted in keeping London the centre of the world's trade. During the last few years, however, other maritime nations in Europe have begun to realize the importance of submarine cable enterprise in this respect, and France and Germany have made some progress towards freeing themselves from the British monopoly. Both are now connected to America by cables which are owned in their respective countries, though their manufacture and submergence was effected by an English company. This spread of the cable system has naturally followed trade routes, and thus, with the exception of the cables to America, their trend has been eastwards as far as Australia and Japan; and now the circuit of the globe by British-owned cables is on the eve of completion, as the long-projected Pacific cable, connecting Vancouver with Australia, in course of manufacture, will be laid before the close of 1902.

In 1887 Sir C. Bright stated in his Presidential Address to the Society of Telegraph Engineers that 107,000 miles of submarine cable had been, up to that time, manufactured and laid, and that the capital invested therein was estimated at about £37,000,000, while in 1897, as stated by

Sir H. Mance (Presidential Address to the Institution of Electrical Engineers), 1300 cables were in existence, of an aggregate total of 162,000 nautical miles, varying in length from a quarter of a mile to 2600 miles, and representing a total capital of £40,000,000 sterling, 75 per cent. of which had been provided by England. It was undoubtedly Sir J. Pender who contributed most, from a business point of view, to the development of this colossal industry, and to his unfailing faith in their ultimate realization may be ascribed the completion of the first successful Atlantic cables. At the present day (1902) the total length of submarine cable laid in the world amounts to about 200,000 miles, 20,000 being the property of Government administrations. Nearly the whole of these cables have been manufactured on the Thames, for it is only within the last few years that in Italy at Spezia, in France at Calais, and in Germany at Nordenham, works of sufficient magnitude to turn out long submarine cables have been established, and even this has only been effected by the aid of more or less financial support from the respective Governments.

Manufacture.

The principles underlying the design of a submarine cable are so well established, that of recent years there has been little alteration except in the direction of improvement in materials and in the application of more rigorous tests. To secure immunity from the ravages of submarine boring animals, *e.g.*, *teredo navalis*, it has been found necessary, for depths not exceeding 300 fathoms, to protect the core with a thin layer of brass tape, while the subjection of the core to a hydraulic pressure of four tons to the square inch and an electric pressure of 5000 volts from an alternating-current transformer has been adopted, by one manufacturer at least, to secure the detection of masked faults which might develop themselves after submergence. The deep-sea portion is sheathed with tempered galvanized steel wires, offering a breaking strain of rather over eighty tons per square inch, with an elongation of at least 5 per cent., the separate wires being first covered with a firm coating of tape and compound, or compound alone. The open type of sheathing, where each wire was served with manila, adopted in the early transatlantic cables, has been abandoned. The costly experiment of inserting in one of the Atlantic cables 300 miles of the light cable proposed by Captain Trot and Mr. Hamilton had very unfortunate results, and may be deemed to have decided once and for ever against the use of any such type.

The cost of the cable before laying depends on the dimensions of its core, the gutta-percha, which still forms the only trustworthy insulator, constituting the principal item of the expense; for an Atlantic cable of the most recent construction the cost may be taken at £250 to £300 per nautical mile.

Cable laying.

The use, during the laying of the cable, of the measuring wire for determining the ship's speed has been further improved by Messrs Siemens Brothers and Co., so that a continuous indication and record of the actual slack paid out is secured. The instrument by which this is effected, termed a "Slack Indicator" (Fig. 11), consists of a long screw spindle, coupled by suitable gearing with the cable drum, and thus rotating at the speed of the outgoing cable; on this screw works a nut which forms the centre of a thin circular disc, the edge of which is pressed against the surface of a right circular cone, the line of contact, as the nut moves along the screw, being parallel to the axis of the latter. This cone is driven by gearing from the wire drum, so that it rotates at the speed of the outgoing wire, the direction of rotation being such as to cause the nut to travel towards the smaller end of the cone. If both nut and screw are rotating at the same speed, the position of the former will remain fixed; and as the nut is driven by friction from the surface of the cone, this equality of speed will obtain only when the product of the diameter (d) of the cone at that position multiplied into its speed of rotation (n) equals the product of the diameter (a) of the disc multiplied into the speed of rotation (N) of the screw, or $N/n = d/a$, and thus the ratio of cable paid out to that of wire paid out is continuously given by a pointer controlled by the disc, for any difference in speed between nut and screw will cause the nut to move along the screw until the diameter of the cone is reached which fulfils the above conditions for equality in speed. In Fig. 11 the edge of the disc serves as the pointer and the scale gives the percentage of slack, or $(N-n)/n$. The wire being paid out without slack measures the actual distance and speed over the ground, and the engineer in charge is relieved of all anxiety in estimating the depth from the scattered soundings of the preliminary survey, or in calculating the retarding strain required to produce the specified slack, since the brakesman merely has to follow the indications of the instrument and regulate the strain so as to keep the pointer at the figure required—an easy task, seeing that the ratio of speed of wire and cable is not affected by the motion of the ship, whatever be the state of the sea, whereas the strain will in heavy weather be varying 50 per cent. or more on each side of the mean value. Further, the preliminary survey over the proposed route, necessary for deciding the length and types of cable required, can afford merely an approximation to the depth in which the cable actually lies, since accidents of wind and weather, or lack of observations for determining the position, cause deviations, often of considerable importance, from the proposed route. From the continuous records of slack and strain combined with the weight of the cable it is a simple matter to calculate and plot the depths along the whole route of the cable as actually laid. The above diagram (Fig. 12) is compiled from the actual records obtained during the laying of the Canso-Fayal section of the Commercial Cable Company's system, and shows by the full line the actual strain recorded which secured the even distribution of 8 per cent. of slack, and by the dotted line the strain that would have been

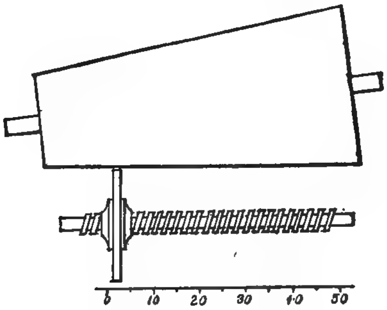

Fig. 11.—Slack Indicator.

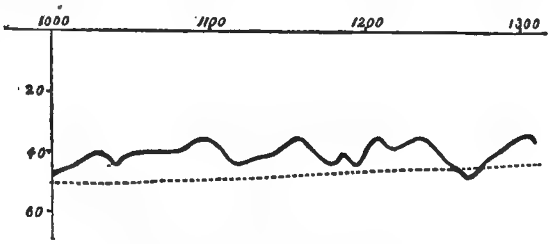

Fig. 12.—Records of strain and depths.

applied if the soundings taken during the preliminary survey had been the only source available, although the conditions of sea and weather favoured close adherence to the proposed route. The ordinates of the curve give the strain in cwts., and the abscissæ the distance in miles measured from the Canso end; as the strain is proportional to the depth, 18 cwts. corresponding to 1000 fathoms, the black line represents to an exaggerated scale the contour of the sea bed.

Repairing.

Owing to the experience gained with many thousands of miles of cable in all depths and under varying conditions of weather and climate, the risk, and consequently the cost, of laying has been greatly reduced. But the cost of effecting a repair still remains a very uncertain quantity, success being dependent on quiet conditions of sea and weather. The *modus operandi* is briefly as follows:—The position of the fracture is determined by electrical tests from both ends, with more or less accuracy, depending on the nature of the fracture, but with a probable error not exceeding a few miles. The steamer on reaching the given position lowers one, or perhaps two, mark buoys, mooring them by mushroom anchor, chain, and rope. Using these buoys to guide the direction of tow, a grapnel, a species of five-pronged anchor, attached to a strong compound rope formed of strands of steel and manila, is lowered to the bottom and dragged at a slow speed, as it were ploughing a furrow in the sea bottom, in a line at right angles to the cable route, until the behaviour of the dynamometer shows that the cable is hooked. The ship is then stopped, and the cable gradually hove up towards the surface; but in deep water, unless it has been caught near a loose end, the cable will break on the grapnel before it reaches the surface, as the catenary strain on the bight will be greater than it will stand. Another buoy is put down marking this position, fixing at the same time the actual line of the cable. Grappling will be recommenced so as to hook the cable near enough to the end to allow of its being hove to the surface. When this has been done an electrical test is applied, and if the original fracture is between ship and shore the heaving in of cable will continue until the end comes on board. Another buoy is then lowered to mark this spot, and the cable on the other side of the fracture grappled for, brought to the surface, and, if communication is found perfect with the shore, buoyed with sufficient chain and rope attached to allow of the cable itself reaching the bottom. The ship now returns to the position of original attack, and by similar operations brings on board the end which secures communication with the other shore. The gap between the two ends has now to be closed by splicing on new cable and paying out until the buoyed end is reached, which is then hove up and brought on board. After the "final splice," as it is termed, between these ends has been made, the bight, made fast to a slip rope, is lowered overboard, the slip rope cut, and the cable allowed to sink by its own weight to its resting place on the sea bed. The repair being thus completed, the various mark buoys are picked up, and the ship returns to her usual station.

The grappling of the cable and raising it to the surface from a depth of 2000 fathoms seldom occupy less than twenty-four hours, and since any extra strain due to the pitching of the vessel must be avoided, it is clear that the state of the sea and weather is the predominating factor in the time necessary for effecting the long series of operations which, under the most favourable circumstances, are required for a repair. In addition, the intervention of very heavy weather may mar all the work already accomplished, and require the whole series of operations to be undertaken *de novo*. As to cost, one transatlantic cable repair cost £75,000; the repair of the Aden–Bombay cable, broken in a depth of 1900 fathoms, was effected with the expenditure of 176 miles of new cable, and after a lapse of 251 days, 103 being spent in actual work, which for the remainder of the time was interrupted by the monsoon; a repair of the Lisbon–Porthcurnow cable, broken in the Bay of Biscay in 2700 fathoms, 11 years after the cable was laid, took 215 days, with an expenditure of 300 miles of cable. All interruptions are not so costly, for in shallower waters, with favourable conditions of weather, a repair may be only a matter of a few hours, and it is in such waters that the majority of breaks occur, but still a large reserve fund must be laid aside for this purpose. As an ordinary instance, it has been stated that the cost of repairing the Direct United States cable up to 1900 from its submergence in 1874 averages £8000 per annum. Nearly all the cable companies possess their own steamers, of sufficient dimensions and specially equipped for making ordinary repairs; but for exceptional cases, where a considerable quantity of new cable may have to be inserted, it may be necessary to charter the services of one of the larger vessels owned by a cable-manufacturing company, at a certain sum per day, which may well reach £200 to £300. This fleet of cable ships now numbers over forty, ranging in size from vessels of 300 tons to 10,000 tons carrying capacity.

Life.

The life of a cable is usually considered to continue until it is no longer capable of being lifted for repair, but in some cases the duration and frequency of interruptions as affecting public convenience, with the loss of revenue and cost of repairs, must together decide the question of either making very extensive renewals or even abandoning the whole cable. The possibility of repair is affected by so many circumstances due to the environment of the cable, that not even an approximate term of years has yet been authoritatively fixed. It is a well-ascertained fact that the insulator, gutta-percha, is, when kept under water, practically imperishable, so that it is only the original strength of the sheathing wires and the deterioration allowable in them that have to be considered. Cables have frequently been picked up showing after many years of submergence no appreciable deterioration in this respect, while in other cases ends have been picked up which in the course of twelve years had been corroded to needle points, the result probably of metalliferous deposits in the locality. It is scarcely possible from the preliminary survey, with soundings several miles apart, to obtain more than a general idea as to the average depth along the route, while the nature of the constituents of the sea bed can only be revealed by a few small specimens brought up at isolated spots, though fortunately the globigerine ooze which covers the bottom at all the greater ocean depths forms an ideal bed for the cable. The experience gained in the earlier days of ocean telegraphy, from the failure and abandonment of nearly 50 per cent. of the deep-sea cables within the first twelve years, placed the probable life of a cable as low as fifteen years, but the weeding out of unserviceable types of construction, and the general improvement in materials, have by degrees extended that first estimate, until now the limit may be safely placed at not less than forty years. In depths beyond the reach of wave motion, and apart from suspension across a submarine gully, which will sooner or later result in a rupture of the cable, the most frequent cause of interruption is seismic or other shifting of the ocean bed, while in shallower waters and near the shore the dragging of anchors or fishing trawls has been mostly responsible. Since by international agreement the wilful damage of a cable has been constituted a criminal offence, and the cable companies have avoided crossing the fishing banks, or have adopted the wise policy of refunding the value of anchors lost on their cables, the number of such fractures has greatly diminished.

Trans-mission of signals.

The theory of the transmission of signals on any electrical circuit has been mathematically developed, at great length, by O. Heaviside (*Electrical Papers*, London, 1892), who starting from Maxwell's fundamental equations of the propagation of electrical waves (see ELECTRICITY, *Ency. Brit.*, vol. viii.) shows that if the term involving the self-induction of the circuit be introduced, the "KR" formula, *i.e.*, that the speed of signalling on a cable is inversely proportional to the product of its resistance into its capacity, enunciated by Sir W. Thomson (Lord Kelvin), does not completely determine the solution of the problem. Assuming certain relations between the values of resistance, capacity, inductance, and insulation per unit length, it is shown than an ideal distortionless circuit is the result, such that the curve connecting current and time at the receiving end is an exact copy in attenuated form of that originated at the sending end. The theory of the effect of terminal apparatus by their introduction of extra resistance, &c., into the circuit has also been fully discussed by the same author, as well as the effect of departure from the values required for the ideal circuit. Various proposals have been made for carrying out these theoretical conclusions in the realm of practical cable work, but in no case with any such probability of success as to warrant the costly experiment of laying an actual cable embodying such qualities; in fact, the increase of capacity and attenuation of current resulting from the materials proposed, or connexions introduced, while the voltage applied must be kept within finite limits, would be such as to reduce the current far below that required to give legible signals on any receiving instruments hitherto in use. In actual practice, therefore, the KR formula still governs the size of the core of a submarine cable, and to arrive at the best results for a given first cost, the tendency in the latest instances of important cables has been to increase the weight of the conductor and diminish that of the dielectric, so as to allow the latter merely the thickness required by mechanical considerations in manufacture. Thus in the two transatlantic cables laid in 1894 by Messrs Siemens Brothers and Co. and the Telegraph Construction and Maintenance Co. respectively, the core of the former consisted of 500 ℔ copper and 320 ℔ gutta-percha per nautical mile (2029 yards), while of the latter the amounts were 650 ℔ and 400 ℔ respectively; in the similarly situated cable laid in 1866 the figures were 300 ℔ copper and 400 ℔ gutta-percha. Natural gutta-percha is still the only insulator possessing the requisite qualities for durability, and though its price is increasing year by year at a rapid rate, no other material has been found to replace it with any satisfactory result.

The mirror instrument has been completely ousted by the siphon recorder, various minor improvements to which have recently been introduced, principally in the adoption of permanent steel magnets to form the field in which the suspended coil moves, and in the substitution of mechanical vibration of the siphon in place of electrification of the ink, so as to eliminate the effect of atmospheric conditions which frequently caused discontinuity in the flow of ink. As the earth is used for completing the electric circuit, the signals received on such sensitive instruments as these are liable to be disturbed by the return currents of other systems in their immediate neighbourhood, which also use the earth as return, when such are of the magnitude generated by the working of electric tramways or similar undertakings, and to obviate this it is necessary to form the "earth" for the cable a few miles out at sea and make connexion thereto by an insulated return wire, which is enclosed in the same sheathing as the core of the main cable.

The heavier cores, with the consequent advance in speed of working attainable, have necessitated the introduction of automatic sending, the instruments adopted being in general a modification of the Wheatstone transmitter adapted to the form of cable signals, while the regularity of transmission thus secured has caused its introduction even on circuits where the speed cannot exceed that of the ordinary operator's hand signalling. The actual speed or rate of signalling depends to a great extent on the experience and ability of the operators, but an average value furnished by the results of various recent cables (see *Report Pacific Cable Committee*, London, 1899) is given by the formula, $S=120/(KR)$, where S is the number of words per minute, R the total resistance of the conductor in ohms, and K the total capacity in farads. About 50 per cent. increase may be obtained by the use of automatic curb sending. The speed of a cable is given in words per minute, the conventional number of five letters per word being understood, though in actual practice, owing to the extensive use of special codes, the number of letters per word is really between eight and nine; and this forms a considerable factor in lowering the earning capacity of a cable.

A relay capable of working at the end of a long cable has long been a desideratum. The difficulty experienced is that of securing a good electrical contact under the very slight pressure obtainable from an instrument excited by attenuated arrival-currents. In an instrument invented by Mr S. G. Brown (Brit. Pat. 1434 of 1899) it is sought to overcome this difficulty by causing the point of a contact-arm, representing the siphon in the ordinary form of recorder, to traverse the cylindrical surface of a rapidly rotating drum. This surface is divided into two parallel halves by a short insulating space on which the arm normally rests, so that two separate conducting surfaces are provided, with either one of which the arm will make contact in its excursions in one direction or the other from the central position, the direction and duration of contact being governed by the motion of the suspended coil. The great reduction in friction and in electrical resistance of the contact thus effected between the recurved end of the arm and the rotating surface secures the transmission of signals at such a high rate of speed that the combination of this relay with a special form of curb sender allows of the re-transmission of signals into a second cable at a speed not less than that of the siphon recorder worked in the usual way. The special form of curb sender mentioned, termed the "Interpolator," has been devised so as to secure the correct re-transmission of any given number of consecutive elements of a letter which are of the same sign, for when signals are received at the end of a long cable the relay arm will not return to its zero position between consecutive elements of the same sign, but will remain on the respective contact surface during the whole time occupied by such consecutive elements. The instrument consists of two cams, the form of which regulates the components of the curbed signal, one cam being for the dot element and the other for the dash element, which by their sequence give the letter signals; these cams, by means of clutches controlled by the relay, are mechanically rotated by clockwork, the speed of rotation being approximately adjusted to the rate of transmission of a single element, so that the requisite number of consecutive elements is transmitted corresponding to the duration of contact of the relay arm with the side controlling that particular element. By a modification of this apparatus the message, instead of being immediately re-transmitted into the second cable, can be punched on a paper slip, which can be inserted in the usual way into an automatic transmitter, so as to send either cable or Morse signals. Fig 13 shows the effect of the interpolator in dissecting the consecutive elements of any letter combination. Another instrument (see Brit. Pat. No. 18,261 of 1898) is what may be termed a magnifier, since signals so small as to be almost unreadable on direct record are rendered perfectly legible. The recorder coil is connected mechanically to a second similar coil, which is suspended between the poles of a laminated magnet, so that the motions of the two are similar. This magnet is excited by an alternating current, and the current induced in the second coil is after rectification sent through an ordinary siphon recorder. As the direction and intensity of this induced current are a function of the position of the second recoil in its field, and as this position is determined by its mechanical connexion with the recorder coil, it is evident that, by a suitable choice of the electrical elements of the second coil and its alternating field, the indications on the siphon recorder can be magnified to any reasonable extent. (See Fig. 13.)

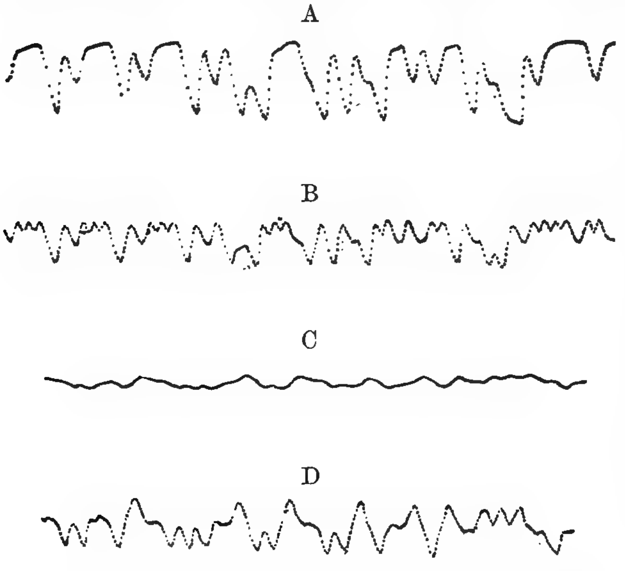

Fig. 13.—Taylor and Dearlove's Interpolator with Brown's Improvements.

A, slip as received on recorder, using ordinary relays for translating on to second cable; B, slip as received on recorder, when interpolator is used at intermediate station, for sending on to second cable; C (four cells through a line, KR=3·6), signals with recorder under ordinary conditions; D, all conditions the same as in C, but magnifying relay inserted between the end of the line and the recorder.

For further information the reader is referred to the following works:—E. Wunschendorff. *Traité de Télégraphie Sous-marine.* Paris, 1888.—C. Bright. *Submarine Telegraphs.* London, 1898.—O. Heaviside. *Electro-magnetic Theory.* London, 1893.—H. D. Wilkinson. *Submarine Cable Laying and Repairing.* London, 1896. (F. JA.)

IV. Wireless Telegraphy.

The suggestion that it might be possible to effect electric telegraphy between places not connected by a continuous metallic conductor was made very early in the development of the art of employing the electric current for telegraphic purposes. Hence it may be said that the so-called wireless telegraphy and telegraphy with wires originated contemporaneously. The earliest practical attempts to establish electric telegraphy (see Telegraphy, *Ency. Brit.*, vol. xxiii. p. 112) showed the necessity for a complete conducting circuit. Steinheil of Munich, acting on a suggestion given by Gauss, made in 1838 the important discovery that half of the circuit might be formed of the conducting earth, and so discovered the use of the *earth return*, since then an essential feature of nearly every telegraphic circuit. Encouraged by this success, he even made the further suggestion that the remaining metallic portion of the circuit might perhaps some day be abolished and a system of wireless telegraphy established.

Morse.

Morse showed, by experiments made in 1842 on a canal at Washington, that it was possible to interrupt the metallic electric circuit in two places and yet retain power of electric communication. (See Fahie, *History of Wireless Telegraphy*, p. 10.) His plan, which has been imitated by numerous other experimentalists, was as follows:—On each side of the canal, at a considerable distance apart, metal plates *e*, *e* (Fig. 14) were sunk in the water; the pair on one side were connected by a battery B, and the pair on the other by a galvanometer or telegraphic receiver R. Under these circumstances a small portion of the current from the battery is shunted through the galvanometer circuit, and can be used to make electric signals. Morse and Gale, who assisted him, found, however, that the distance of the plates up and down the canal must be at least three or four times the width of the canal to obtain successful results. Numerous investigators followed in Morse's footsteps. James Bowman Lindsay of Dundee between 1845 and 1854 reinvented and even patented Morse's method, and practically put the plan into operation for experimental purposes across the river Tay. J. W. Wilkins in 1849, and H. Highton in experiments described in 1872, also revived the same suggestion for wireless telegraphy.

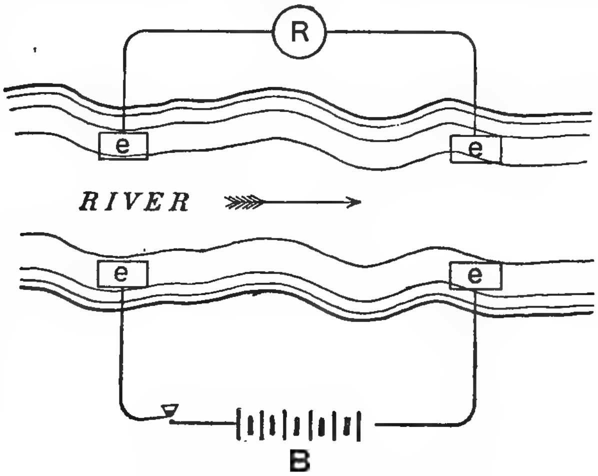

Fig 14.—Morse's Conduction Method.

Trowbridge.

The invention of the magneto-telephone put into the hands of electricians a new instrument of extraordinary sensitiveness for the detection of feeble interrupted, or alternating, currents, and by its aid Professor J. Trowbridge in 1880, in the United States, made a very elaborate investigation of the propagation of electric currents through the earth, either soil or water. (See "The Earth as a Conductor of Electricity," *Amer. Acad. Arts and Sci.*, 1880.) He found, as others have done, that if a battery, dynamo, or induction coil has its terminals connected to the earth at two distant places, a system of electric currents flows between these points through the crust of the earth. If the current is interrupted or alternating, and if a telephone receiver has its terminals connected to a separate metallic circuit joined by earth plates at two other places to the earth, not on the same equipotential surface of the first circuit, sounds will be heard in the telephone due to a current passing through it. Hence, by inserting a break-and-make key in the circuit of the battery, coil, or dynamo, the uniform noise or hum in the telephone can be cut up into periods of long and short noises, which can be made to yield the signals of the Morse alphabet. In this manner Trowbridge showed that signalling might be carried on over considerable distances by electric conduction through the earth or water between places not metallically connected. He even placed again in view the idea, which Lindsay had originally put out in another form, that it might be possible to signal in this manner by conduction currents through the Atlantic Ocean from the United States to Europe. He and others also suggested the applicability of the method to the inter-communication of ships at sea. He proposed that one ship should be provided with the means of making an interrupted current in a circuit formed partly of an insulated metallic wire connected with the sea at both ends by plates, and partly of the unlimited ocean. Such an arrangement would distribute a system of flow lines of current through the sea, and these might be detected by any other ships furnished with two plates dipping into the sea at stem and stern, and connected by a wire having a telephone in its circuit, provided that the two plates were not placed on the same equipotential surface of the original current flow lines. Experiments of this kind were actually tried by Graham Bell in 1882, with boats on the Potomac river, and signals were detected at a distance of a mile and a half.

At a later date, 1891, Trowbridge discussed another method of effecting communication at a distance, viz., by means of magnetic induction between two separate and completely insulated circuits. If a primary circuit, consisting of a large coil of wire P (Fig. 15), has in circuit a battery B and an interrupter I, and at some distance and parallel to this primary circuit is placed a secondary circuit S, having a telephone T included in it, the interruptions or reversals of the current in the primary circuit will give rise to a varying magnetic field round that circuit which will induce secondary currents in the other circuit and affect the telephone receiver. Willoughby Smith found that it was not necessary even to connect the telephone to a secondary circuit, but that it would be affected and give out sounds merely by being held in the variable magnetic field of a primary circuit. By the use of a key in the battery circuit as well as an interrupter or current reverser, signals can be given by breaking up the continuous hum in the telephone into long and short periods. This method of communication by *magnetic induction* through space establishes, therefore, a second method of wireless telegraphy which is quite independent of and different from that due to *conduction* through earth or water.

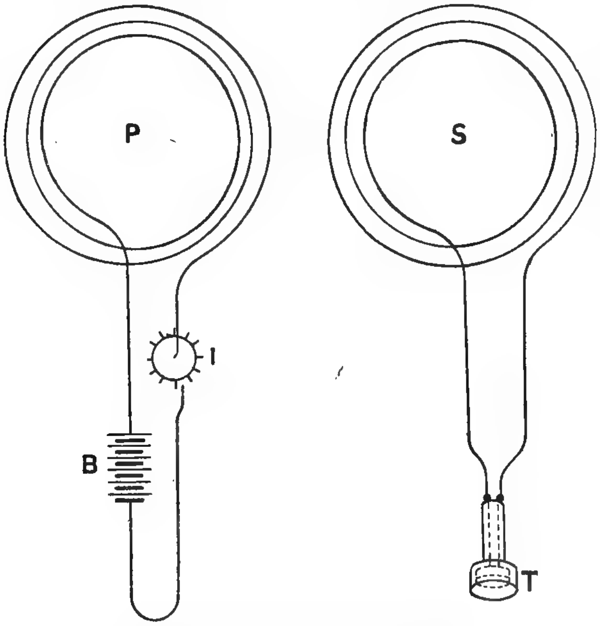

Fig. 15.—Magneto-Induction Method.

Preece.

Sir W. H. Preece, who took up the subject about the same time as Prof. Trowbridge, obtained improved practical results by combining together methods of induction and conduction. His first publication of results was in 1882 (*Brit. Assoc. Report*), when he drew attention to the considerable distance over which inductive effects occurred between parallel wires forming portions of telephonic and telegraphic circuits. Following on this he made an interesting experiment, using Morse's method, to connect the Isle of Wight telegraphically with the mainland, by conduction across the Solent in two places, during a temporary failure of the submarine cable in 1882 in that channel. In subsequent years numerous experiments were carried out by him in various parts of Great Britain, in some cases with circuits earthed at both ends, and in other cases with completely insulated circuits, which showed that conductive effects could be detected at distances of many miles, and also that inductive effects could take place even between circuits separated by solid earth and by considerable distances. Mr A. W. Heaviside in 1887 succeeded in communicating by telephonic speech between the surface of the earth and the subterranean galleries of the Broomhill collieries, 350 feet deep, by laying above and below ground two complete metallic circuits, each about 2¼ miles in length and parallel to each other. At a later date other experimentalists found, however, that an equal thickness of sea-water interposed between a primary and secondary circuit completely prevented similar inductive intercommunication. In 1885 Preece and Heaviside proved by experiments made at Newcastle that if two completely insulated circuits of square form, each side being 440 yards, were placed a quarter of a mile apart, telephonic speech was conveyed from one to the other by induction, and signals could be perceived even when they were separated by 1000 yards. The method of induction between an insulated primary and secondary circuits laid out flat on the surface of the earth proves to be of limited application, and in his later experiments Preece returned to a method which unites both conduction and induction as the means of affecting one circuit by a current in another. In 1892, on the Bristol Channel, he established communication between Lavernock Point and an island called Flat Holme in that channel by placing at these positions insulated single-wire circuits, earthed at both ends and laid as far as possible parallel to each other, the distance between them being 3·3 miles. The shore wire was 1267 yards long, and that on the island 600 yards. An interrupted current having a frequency of about 400 was used in the primary circuit, and a telephone was employed as a receiver in the secondary circuit. Other experiments in inductive telegraphy were made by Preece, aided by the officials of the British Postal Telegraph Service, in Glamorganshire in 1887; at Lock Ness in Scotland in 1892; on Conway Sands in 1893; and at Frodsham, on the Dee, in 1894. (See *Proc. Inst. Elec. Eng.*, vol. xxvii. p. 869.) In 1899 experiments were made at Menai Straits to put the lighthouse at the Skerries into communication with the coastguard station at Cemlyn. A wire 750 yards in length was erected along the Skerries, and on the mainland one of 3½ miles long, starting from a point opposite the Skerries, to Cemlyn. Each line terminated in an earth plate placed in the sea. The average perpendicular distance between the two lines, which are roughly parallel, is 2·8 miles. Telephonic speech between these two circuits was found possible and good, the communication between the circuits taking place partly by induction, and no doubt partly by conduction. On the question of how far the effects are due to conduction between the earth plates, and how far to true electromagnetic induction, authorities differ, some being of opinion that the two effects are in operation together. A similar installation of inductive telephony, in which telephone currents in one line were made to create others in a nearly parallel and distant line, was established in 1899 between Rathlin Island on the north coast of Ireland and the mainland. The shortest distance between the two places is 4 miles. By stretching on the island and mainland parallel wire circuits earthed at each end, good telephonic communication over an average distance of 6½ miles was established between these independent circuits.

Willoughby Smith.

The difficulty of connecting lightships and isolated lighthouses to the mainland by submarine cables, owing to the destructive action of the tides and waves on rocky coasts on the shore ends, led many inventors to look for a way out of the difficulty by the adoption of some form of inductive or conductive telegraphy not necessitating a continuous cable. Mr Willoughby S. Smith and Mr W. P. Granville put into practice between Alum Bay in the Isle of Wight and the Needles lighthouse a method which depends upon conduction through sea-water. (See *Proc. Inst. Elec. Eng.*, vol. xxvii. p. 938.) It may be explained as follows:—Suppose a battery on shore to have one pole earthed and the other connected to an insulated submarine cable, the distant end of which was also earthed; if now a galvanometer is inserted anywhere in the cable, a current will be found flowing through the cable and returning by various paths through the sea. If we suppose the cable interrupted at any place, and both sides of the gap earthed by connexion to plates, then the same conditions will still hold. Communication was established by this method in the year 1895 with the lighthouse on the Fastnet.[1] A cable is carried out from the mainland at Crookhaven for seven miles, and the outer end earthed by connexion with a copper mushroom anchor. Another earthed cable starts from a similar anchor about 100 feet away near the shore line of the Fastnet rock, crosses the rock, and is again earthed in the sea at the distant end. If a battery on the mainland is connected through a key with the shore end of the main cable, and a speaking galvanometer is in circuit with the short cable crossing the Fastnet rock, then closing or opening the battery connexion will create a deflection of the galvanometer. A very ingenious call-bell arrangement was devised, capable of responding only to regularly reversed battery currents, but not to stray "earth currents," and very good signalling was established between the mainland and the rock. Owing to the rough seas sweeping over the Fastnet, the conditions are such that any ordinary submarine cable would be broken by the wearing action of the waves at the rock boundary in a very short time. Another worker in this department of research was Mr C. A. Stevenson, who in 1892 advocated the use of the inductive system pure and simple for communication between the mainland and isolated lighthouses or islands. He proposed to employ two large flat coils of wire laid horizontally on the ground, that on the mainland having in circuit a battery, interrupter, and key, and that on the island a telephone. His proposals had special reference to the necessity for connecting a lighthouse on Muckle Flugga, in the Shetlands, and the mainland, but were not carried into effect. Professor E. Rathenau of Berlin made many experiments in 1894 in which, by means of a conductive system of wireless telegraphy, he signalled through three miles of water.

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[1] See Fahie, *History of Wireless Telegraphy*, p. 170; also 5th Report (1897) of the Royal Commission on Electrical Communication with Lightships and Lighthouses.

Lodge.

Sir O. J. Lodge in 1898 theoretically examined the inductive system of space telegraphy. (See *Proc. Inst. Elec. Eng.*, vol. xxvii. p. 799.) He advocated and put in practice experimentally a system by which the primary and secondary circuits were "tuned" or syntonized by including condensers in the circuits. He proved that when so syntonized the circuits are inductively respondent to each other with a much less power expenditure in the primary circuit than without the syntony. He also devised a "call" or arrangement for actuating an ordinary electric bell by the accumulated effect of the properly tuned inductive impulses falling on the secondary circuit. A very ingenious call-bell or annunciator for use with inductive or conductive systems of wireless telegraphy was invented and described in 1898 by Mr S. Evershed, and has been practically adopted at Lavernock and Flat Holme. (*Id.*, vol. xxvii. p. 852.)

Edison.

In addition to the systems of wireless or space telegraphy depending upon conduction through earth or water, and the inductive system based upon the power of a magnetic field created round one circuit to induce, when varied, a secondary current in another circuit, there have been certain attempts to utilize what may best be described as electrostatic induction. In 1885 Mr Edison, in conjunction with Messrs Gilliland, Phelps, and W. Smith, worked out a system of communicating between railway stations and moving trains. At each signalling station was erected an insulated metallic surface facing and near to the ordinary telegraph wires. On one or more of the carriages of the trains were placed also insulated metallic sheets, which were in connexion through a telephone and the secondary circuit of an induction coil with the earth or rails. In the primary circuit of the induction coil was an arrangement for rapidly intermitting the current and a key for short-circuiting this primary circuit. The telephone used was Edison's chalk cylinder or electromotograph type of telephone. Hence, when the coil at one fixed station was in action it generated high frequency alternating currents, which were propagated across the air gap between the ordinary telegraph wires and the metallic surfaces attached to one secondary terminal of the induction coil, and conveyed along the ordinary telegraph wires between station and moving train. Thus, in the case of one station and one moving railway carriage, there is a circuit consisting partly of the earth, partly of the ordinary telegraph wires at the side of the track, and partly of the circuits of the telephone receiver at one place and the secondary of the induction coil at the other, two air gaps existing in this circuit. The electromotive force of the coil is, however, great enough to create in these air gaps displacement currents which are of magnitude sufficient to be equivalent to the conduction current required to actuate a telephone. This current may be taken to be of the order of two or three micro-amperes. The signals were sent by cutting up the continuous hum in the telephone into long and short periods in accordance with the Morse code by manipulating the key in the primary circuit. The system was put into practical operation in 1887 on the Lehigh Valley railroad in the United States, and worked well, but was abandoned because it apparently fulfilled no real public want. Edison also patented (U.S. Patent No. 465971, 14th May 1885) a plan for establishing at distant places two insulated elevated plates. One of these was to be connected to the earth through a telephone receiver, and the other through the secondary circuit of an induction coil in the primary circuit of which was a key. The idea was that variations of the primary current would create electromotive force in the secondary circuit which would act through the air condenser formed by the two plates. The results, however, did not come up to expectation.

A very similar system of wireless telegraphy was patented by Professor A. E. Dolbear in 1886 (U.S. Patent No. 350299), in which he proposed to employ two batteries at two places to affect the potential of the earth at those places. At the sending station one battery was to have its positive pole connected to the earth and its negative pole to an insulated condenser. In circuit with this battery was placed the secondary circuit of an induction coil, the primary circuit of which contained a telephone transmitter or microphone interrupter. At the receiving station a telephone receiver was placed in series with another insulated battery, the negative terminal of which was to be in connexion with the earth. It is, however, perfectly certain that the method proposed could not effect the transmission of speech or signals between stations separated by any distance. Many other more or less imperfect devices—such as those of Mahlon Loomis, put forward in 1872 and 1877, and Kitsee in 1895—for wireless telegraphy were not within the region of practically realizable schemes.

Space Telegraphy by Hertzian Waves.—Up to 1895 or 1896 the suggestions for wireless telegraphy which had been publicly announced or tried can thus be classified under three or four divisions, based respectively upon electrical conduction through the soil or sea, magnetic induction through space, combinations of the two foregoing, and lastly, electrostatic induction. But a more suitable system for long distance working has been developed out of the modern researches on the production of electric waves. Before the classical researches of Hertz in 1886 and 1887, many observers had noticed curious effects due to electric sparks produced at a distance which were commonly ascribed to ordinary electrostatic or electro-magnetic induction. Thus Joseph Henry (*Scientific Writings*, vol. i. p. 203) noticed that a single electric spark about an inch long thrown on to a circuit of wire in an upper room could magnetize steel needles included in a parallel circuit of wire placed in a cellar 30 feet below with two floors intervening. Some curious distance phenomena connected with electric sparks were observed in 1875 by Edison (who referred them to a supposed new "etheric force"), and confirmed by Beard, S. P. Thompson, E. J. Houston, and others.[1] Professor D. E. Hughes made some remarkable observations and experiments in or between the years 1879 and 1886. He discovered a fact subsequently rediscovered by others, that a tube of metallic filings, loosely packed, was sensitive to electric sparks made in its vicinity, its electrical resistance being reduced, and he was able to detect effects on such a tube connected to a battery and telephone at a distance of 500 yards.[2]

These distance effects were not understood at the time, or else were referred simply to ordinary induction. Hertz, however, made known in 1887 the experimental proofs that the discharge of a condenser produces an electric spark which under proper conditions creates an effect propagated out into space as an *electric wave*. He employed as a detector of this wave a simple, nearly closed circuit of wire called a Hertz resonator, but it was subsequently discovered that the metallic microphone of D. E. Hughes was a far more sensitive detector. The peculiar action of electric sparks and waves in reducing the resistance of discontinuous conductors was rediscovered and investigated by Calzecchi Onesti,[3] and by Branly,[4] Dawson Turner,[5] Lodge,[6] and many others. Lodge particularly studied the action of electric waves in reducing the resistance of the contact between two metallic surfaces such as a plate and a point, or two balls, and named the device a "coherer." He constructed one form of his coherer of a glass tube a few inches long filled with iron borings or brass filings, having contact plates or pins at the end. When such a tube is inserted in series with a single voltaic cell and galvanometer it is found that the resistance of the tube is nearly infinite, provided the filings are not too tightly squeezed. On creating an electric spark or wave in the neighbourhood of the tube the resistance suddenly falls to a few ohms and the cell sends a current through it. By shaking or tapping the tube the original high resistance is restored. In 1894 he exhibited at Oxford apparatus of this kind in which the tapping back of the tube of filings was effected automatically. He ascribed the reduction of resistance of the mass to a welding or cohering action taking place between the metallic particles, hence the name coherer. But it has since been discovered that it is not universally true that the action of an electric wave is to reduce the resistance of a tube of powdered metal (see below).

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[1] See *Telegraphic Journal of London*, vol. iv. pp. 29, 46, 61; *Proc. Phys. Soc. Lond.*, vol. ii. p. 103.

[2] See Fahie, *History of Wireless Telegraphy*, p. 289; also an important letter by Professor D. E. Hughes himself in the *Electrician* of London, vol. xliii. p. 40.

[3] *Nuovo Cimento*, series iii. vol. xvii.

[4] *Comptes Rendus*, vols. cxi., cxii.; see also the *Electrician*, vol. xl. pp. 87, 91, 166, 235, 333, and 397; vol. xli. p. 487; vol. xlii. pp. 46 and 527; and vol. xliii. p. 277.

[5] *Report Brit. Assoc.*, 1892.

[6] Lodge, *Signalling through Space without Wires*, 3rd ed., p. 73, 1899.

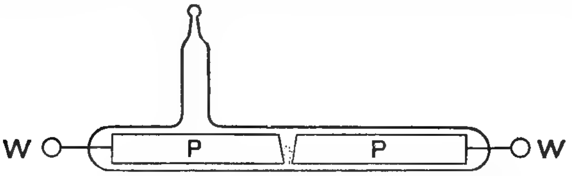

Fig. 16.—Marconi Form of Coherer.

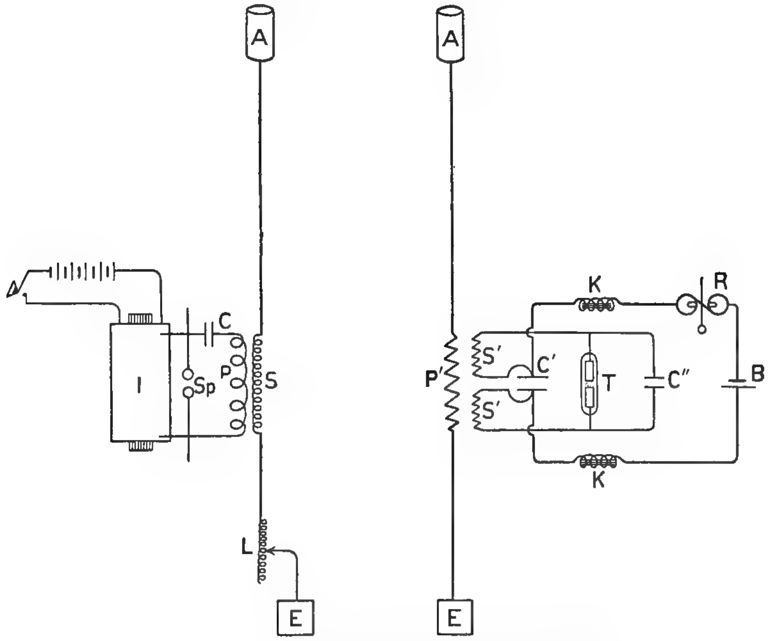

Fig. 17.—Transmitter and Receiver, later Marconi System.

Marconi.

Between 1894 and 1896 G. Marconi gave great attention to the improvement of devices for the detection of electric waves. He made his sensitive tube, or improved coherer, as follows:—A glass tube having an internal diameter of about 4 millimetres has sealed into it two silver plugs PP by means of platinum wires WW (Fig. 16); the opposed faces of these plugs are perfectly smooth, and are placed within a millimetre of each other. The interspace is filled with a very small quantity of nickel and silver filings, about 95 per cent. nickel and 5 per cent. silver, sufficient to fill loosely about half the cavity between the plugs, which fit tightly into the tube. The tube is then exhausted of its air, and attached to a bone or glass rod as a holder. Marconi employed this device as a very sensitive relay to set in operation ordinary telegraphic apparatus. The arrangements of his receiver as subsequently modified are as follows:—The plugs of the sensitive tube T (Fig. 17) are joined to the terminals of the secondary circuit S′S′ of a small transformer, called a "jigger," which has its secondary circuit cut in the centre and a small condenser C′ inserted. The terminals of the condenser are also connected to a relay R and single voltaic cell B through two coils of high inductance KK; the relay actuates a Morse printer or other telegraphic receiver through a local battery in the ordinary manner. One terminal of the primary circuit P′ of the jigger is connected to the earth E, and the other to an elevated conductor A or nearly vertical wire otherwise insulated. The great improvement introduced by Marconi was the employment of this vertical *air-wire*, *aerial*, *antenna*, or *elevated conductor*, as it is variously called, in combination with the earth connexion at both the receiving and transmitting stations; this aerial being used as a Hertz oscillator or radiator, and also as an electric wave absorber. A simple coherer, however sensitive, is not affected by an oscillatory spark at any very great distance, the reason being that the coherer is a small object and offers little surface to be acted upon by the electric wave, and therefore gathers up little wave energy. Minchin is said to have used collecting wires in connexion with photo-electric cells used as electric wave detectors (*Electrician*, vol. xxxix. pp. 832, 869). In 1895 it occurred to Popoff, a Russian physicist (see *Proc. Physico-Chemical Society of Russia*, vol. xxviii. p. 18), to connect a coherer to a lightning conductor, and using in connexion with it a relay, automatic tapper after the manner of Lodge, and Morse printer, he obtained records on the telegraphic tape due to atmospheric electric discharges at a distance. This, however, was not telegraphy, and there does not appear to be any evidence that any communication by Hertz waves of the nature of intelligible signals was achieved until Marconi in 1896 employed an aerial or air-wire, or elevated conductor, in connexion with the one secondary terminal of the transmitting induction coil, in the primary circuit of which he placed a signalling key, and *also* with one terminal of the receiving coherer, the other ends of both appliances being connected to the earth.[1] This use of an aerial at each place made all the difference between mere laboratory experiments and telegraphy in any proper sense of the word. It was soon found that the distance at which the effects of the oscillatory spark could be perceived by the aid of the coherer was closely connected with the height of this air-wire or aerial connected to the spark balls and coherer. Marconi then adopted the plan of erecting tall masts at the two stations between which wireless telegraphy was to be accomplished, and suspending from the top of each an aerial in the form of a long insulated copper wire. The operation of the receiver is as follows:—When electric waves created by a distant oscillatory spark, or rapid train of oscillatory sparks, the magnetic flux component of which is parallel to the earth's surface, fall on the aerial they set up in the primary circuit of the receiving induction coil or jigger electrical oscillations which induce other oscillations in the secondary circuit. These secondary oscillations break down the resistance of the tube and render it conductive; the single cell then sends a current through the coherer and causes the relay to operate, thus working the telegraphic instrument—generally a Morse printer—connected to the relay work. The receiver has a tapper or electromagnetic hammer in connexion with it which is set in operation by the current passing through the Morse printer; hence when the local battery actuates the printer the same current is used to administer small regulated taps or shocks to the tube, which bring it back to a non-conductive condition. By suitably adjusting the strength of these taps matters can be arranged so that a short train of oscillations causes a *dot* to be registered on the Morse tape, while a longer train registers a *dash*. In certain cases another condenser C″ (Fig. 17) is joined in across the terminals of the sensitive tube.

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[1] Captain H. B. Jackson, R.N., has stated (*Proc. Roy. Soc.*, May 1902) that in 1895 he began systematic experiments with Hertz waves for the purposes of navy signalling.

The transmitter used with the arrangement consists (Fig. 17) in one form, of a large induction sparking coil I, the secondary of which is connected to an adjustable spark ball discharger Sp. To the two spark balls are connected the terminals of a circuit consisting of a condenser C or series of Leyden jars arranged either in parallel or in series, and the primary circuit P of another air-core induction coil consisting of very few turns. The secondary circuits of this last induction coil have one terminal connected to the earth E, and the other to an elevated and insulated conductor A. In the original Marconi system the transmitter consisted solely of the induction coil I, generally a 10-inch spark coil, having one secondary terminal connected to the earth and the other to an elevated conductor A, often 150 feet long (Fig. 18). Similarly at the receiving end the terminal of the coherer T was connected directly to the aerial A, while the other was put to earth, the tube being also in circuit with a relay R and a cell B through impedance with KK. Subsequently, however, it was found by F. Braun and by Marconi that a greatly increased distance could be covered in signalling by the use of the second interposed induction coil PS and condenser C placed between the primary coil and the circuit of the elevated conductor (Fig. 17). In this last arrangement the oscillations are induced in the aerial by others in a circuit of larger capacity and therefore greater energy-storing power. Further, Marconi discovered that by suitably bringing into resonance, or tuning, the four circuits composing the primary and secondary of the receiving jigger, and this last-mentioned oscillation transformer or induction coil, the primary of which takes the discharge of the condenser, the receiver so tuned could be prevented from responding to irregular waves sent out from other non-resonant exciters. On these principles he elaborated between 1896 and 1900 a system of electric wave or spark telegraphy (German, *Funken Telegraphie*), in which each receiver was tuned to a particular wave frequency and responded only to that one frequency, or to a not very high harmonic.

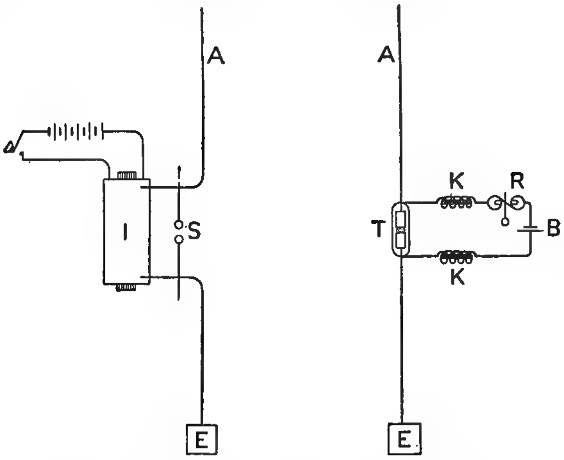

FIG. 18.—Transmitter and Receiver, original Marconi System.

At one time Marconi experimented with simple Hertz transmitters or wave producers placed in the focus of parabolic mirrors, and by this means was able to effect signalling up to a distance of a couple of miles. In some of the early experiments a Rhigi transmitter was employed, sparks being taken between brass balls immersed in oil, but he afterwards found that the wave production was more energetic if an ordinary 10-inch spark coil was used to produce sparks between brass balls in air 1 inch in diameter, placed 1 centimetre apart. Each of these sparks is a series of oscillatory discharges taking place between the earth and the elevated insulated conductor, or of electrical oscillations induced in the aerial, and each oscillation creates an electro-magnetic impulse or electric wave, or train of waves, which is propagated out into space over the surface of the sea or earth and affects the distant coherer. Owing to the high radiative power of the vertical wire, each oscillatory discharge gives rise only to a very brief train of electric waves, perhaps only a single impulse, but these impulses follow each other at a rate depending upon the vibration rate of the contact breaker of the induction coil. When the waves reach the receiver they act, as above explained, in setting the telegraphic printer in operation.

Marconi made his earliest demonstrations in Italy, and followed with others in England between Lavernock and Flat Holme, and Lavernock and Bream Down, near Bristol, in May 1897. Early in 1898 permanent stations were established between Alum Bay and Bournemouth, a distance of 4½ miles, where successful results were obtained. Later the Bournemouth station was removed to Poole Harbour, and the Alum Bay station to Niton in the Isle of Wight, the distance being thus increased to 30 miles. In December 1898 communication was established by the Marconi method between the East Goodwin lightship and the South Foreland lighthouse; and this installation was maintained for upwards of a year, during which it was the means of saving both life and property. In March 1899 communication was effected by his system between England (South Foreland lighthouse) and France (Wimereux, near Boulogne), a distance of 30 miles. He kept up the communication for six months, in all weathers, and found that ordinary commercial messages could be transmitted at the rate of 15 to 20 words a minute. In January 1901 he established communication by his system between the Lizard in Cornwall and Niton in the Isle of Wight, a distance of 200 miles. A full account of the development of his system was given by him in an article published in the *Fortnightly Review* for June 1902. Wireless telegraphy by electric waves, though by no means in every case with apparatus made by Marconi, has been largely adopted by the British and other navies and in the mercantile marine, and has proved to be of great utility in ordinary marine signalling between ship and ship and ship and shore.

Marconi's syntonic system.

The method of Hertzian wave telegraphy described above labours under the disadvantage that several transmitters and receivers in the same region affect each other equally. A transmitter consisting of a simple aerial or insulated conductor connected as described to the secondary terminal of an induction coil, the other terminal of which is earthed (see Fig. 5), affects within a certain radius all simple coherers or other receivers alike. Great attention has therefore been directed to the consideration of syntonic receivers and transmitters which can be "tuned," so that the tuned pair alone affect each other, but do not affect, and are not influenced by, other similar apparatus not tuned to sympathy with them. The improvements which have been made depend upon the fact that every circuit possessing inductance and capacity has a natural free time-period of electrical vibration. Thus if a condenser of capacity C is joined in series with a coil of inductance L, and a sudden impulsive electromotive force is applied to the circuit and then withdrawn, an electrical oscillation or rapidly alternating electric current will be created in the circuit, the frequency of which is equal to $1/2\pi\sqrt{LC}$.

Circuits are, however, broadly divided into good and bad radiators. In the first, an electrical oscillation when set up gives rise to the production of an electric wave or very short wave train in the surrounding ether (see

ELECTRICITY: *Electric Waves*, vol. xxviii.), and the oscillations are rapidly damped out. In the second the oscillations persist in the circuit, and do not give rise to radiated wave energy to anything like the same extent. Examples of radiative circuits are the ordinary Hertz radiator or a simple Marconi vertical insulated wire. Instances of non-radiative circuits are a Hertz resonator, or a coil and Leyden jar connected in series with a small spark gap in one place. There can be no effective syntony or tuning between very radiative circuits. Thus in the case of the Marconi simple vertical wire or transmitter the effect sent out at each spark can hardly be called a train of electric waves, but is merely a single impulse, or at most one or two vibrations. The energy stored up in the aerial is radiated, as it were, in one explosion. On the other hand, non-radiative circuits, though susceptible of being tuned, and able to affect each other by electromagnetic induction at small distances, cannot send out wave energy enough to affect each other at great distances. Marconi has, however, ingeniously combined the two forms of circuit (see British Patent Spec. No. 7777 of 1900), and by connecting a condenser placed in series with the primary coil of an oscillation transformer to the spark gap of an induction coil, and one terminal of the secondary circuit of the oscillation transformer to an aerial, the other terminal being connected to the earth, has made a transmitter capable of sending out trains of electric waves of definite wave length, provided that the two circuits of the oscillation transformer are tuned together. In other words, he associates a pair of syntonic circuits inductively, one being a good radiator and the other a persistent oscillator (Fig. 17). In the same way, at the receiving end he constructs a compound receiver consisting of an aerial wire earthed through the primary of an oscillation transformer, which is in syntony with a secondary circuit consisting of a coil and condenser. A receiving circuit of this kind responds only to its proper transmitter, and not to any simple Hertz wave producer. Using this device, Marconi was able in September 1900 to show the simultaneous sending and reception of two different Hertz wave telegraphic messages on the same aerial; and in 1900 and 1901 he elaborated a number of different forms of transmitters or radiating circuits, and a complete system of independent Hertz wave telegraphy, so arranged that syntonized receivers and transmitters alone responded, and were not affected by ordinary non-tuned apparatus (see *Journal Society of Arts*, vol. xlix. p. 505).

Slaby-Arco system.

Other workers in the same field have been Sir O. J. Lodge, who in conjunction with Dr A. Muirhead patented various devices for syntonic Hertz wave telegraphy (British Patent Spec. No. 18644 of 1897), and Slaby in Germany, who in co-operation with Count von Arco worked out a similar system. The Slaby-Arco arrangement consists at the transmitting end of an inductance coil elevated above the ground; one end of this coil is connected to the earth by a wire and the other end to a condenser, the opposite terminal of which is connected to one secondary terminal of an induction coil, the other terminal of this induction coil being earthed. The Slaby-Arco receiving arrangement in one form consists of an aerial wire which may be earthed, and from the lower end of which proceeds a straight or loosely coiled wire of the same length as the aerial. The coherer, or detector, is inserted between the earth and the outer end of this last wire (see Fig. 20). The vertical aerial wire responds to electromagnetic waves having a wave length of four times its own length, and the outer end of the attached bottom wire experiences variations of potential similar to that of the top of the aerial wire. By this arrangement a receiving circuit is made having a selective power, and an exhibition of duplex wireless telegraphy was given with it in December 1900 by Slaby, which, however, did not anticipate Marconi's work. Other workers who have given attention to syntonic wireless telegraphy are Blondel, Ducretet, and Tissot in France, Popoff in Russia, and Braun in Germany. Braun suggested the employment of an oscillation transformer for inducing the oscillations in the aerial, but did not appreciate at first the importance of having the transformer circuits in tune with each other.

The essential difference between a tuned or syntonic receiver and one not tuned may be likened to the effects of surface waves on water when acting on various forms of floating bodies. A cork floating on the surface is caused to bob up and down by surface waves of any period. If, however, a heavy log of wood be tethered to the bottom of the sea by a spiral spring the arrangement would have a definite natural period of vibration, and would only be set in oscillation by surface waves of like periodicity. Similarly a simple coherer attached in series with an aerial and the earth is affected by any electric wave of any kind; but if the arrangements devised by Marconi are made, the receiver becomes insensitive to electric waves of any frequency except those to which it is tuned.

The true function of the various elements in Marconi's system of electric wave telegraphy can hardly yet be said to have been determined. The earth connexion at both receiving and sending end is essential for long-distance work. Signals may be sent over a few miles with apparatus insulated at both ends, but for telegraphy over any distance, such as 100 or 200 miles or more, a good earth connexion is essential. The signals are better transmitted over water, especially sea-water, than over land, and over moist land than dry land. Coupled with the fact of the known opacity of water for short electric waves, this seems to point to a greater absorption of energy by dry earth than by water. As regards the effect of rotundity of the earth, in which the popular mind has professed to see a reason for a limitation of long-distance work, there is no evidence yet that it is effective. Although no accurate measurements have yet been made of the wave length usual in practice, theory points out that the fundamental wave length will probably be about four times the length of the aerial or antenna employed. Hence, with 200-feet masts the wave length is nearly one-sixth of a mile. Diffraction effects must therefore be present in any moderate terrestrial distances, and the earth curvature is not an effective screen even for distances of 1000 miles or so. The importance of the earth connexion may arise from the wave being thus compelled to expend itself wholly in the space between the receiver and transmitter.

There is some evidence that the function of the aerial in receiving is not the same as in sending. In sending it acts as a capacity. What is then required is means for storing up a sufficient quantity of electric energy which can be discharged as an electric wave or wave train. Accordingly, metallic cylinders or surfaces only slightly elevated can be used as transmitters. In the reception of effects a certain height of aerial is essential. The function of the aerial may then be, as suggested by J. A. Fleming, to integrate the electric force distributed through space into electromotive force, and for this purpose a length of metallic conductor is necessary. Marconi has enunciated the law that, other things being equal, two similar aerials will respond at distances varying as the square of their height. When the principal of tuning or resonance is made use of it is remarkable how small an initial expenditure of energy will, with the proper aerial, affect a receiver at very great distances. Thus, with masts 150 feet high, Marconi has worked between the Isle of Wight and Cornwall, a distance of 200 miles, the spark energy in this case being a 7-millimetre spark, equivalent to about 20,000 volts, charging a capacity of about 1/100 of a microfarad. Each discharge therefore represents the dissipation of energy equal to 2 joules or about 1½ foot-pounds. Probably only a portion of this is really employed in wave-making, yet the effects can be detected everywhere on the circumference of a circle 200 miles in radius described on an ocean surface. This sensibility can, however, only be obtained by the most careful syntonization of the transmitter and receiver, but when syntony and large wave-making energy are combined electric wave wireless telegraphy over very long distances can be accomplished.

Long-distance wireless telegraphy.

In creating powerful electric waves for communication over long distances it is necessary to employ an alternating current transformer (see TRANSFORMERS) supplied with alternating currents from a low frequency alternator D driven by an engine (Fig. 19). The transformer T_1 has its secondary or high-pressure terminals connected to spark balls S_1, which are also connected by a circuit consisting of a large glass plate condenser C_1 and the primary circuit of an air-core transformer T_2 called an oscillation transformer. The secondary circuit of this last is either connected in between an aerial A and the earth E, or it may be again in turn connected to a second pair of spark balls S_2, and these again to a second condenser C_2, oscillation transformer T_2, and the aerial A. In order to produce electric oscillations in the system, the first or alternating current transformer must charge the condenser connected to its secondary terminals, but must not produce a permanent electric arc between the balls. Various devices have been suggested for extinguishing the arc and yet allowing the condenser oscillatory discharge to take place. Tesla effected this purpose by placing the spark balls transversely in a powerful magnetic field. Elihu Thomson blows on the spark balls with a powerful jet of air. D'Arsonval causes the spark balls to revolve rapidly, and the draught of air acts in the same manner. J. A. Fleming devised a method which has practical advantages in both preventing the arc and permitting the oscillatory currents to be controlled so as to make electric wave signals. He inserts in the primary circuit of the alternating current transformers one or more choking or impedance coils R_1, R_2 (Fig. 19), called "chokers," which are capable, one or all, of being short-circuited by keys K_1, K_2. The impedance of the primary or alternator circuit is so adjusted that when both the chokers are in circuit the current flowing is not sufficient to charge the condensers; but when one choker is short-circuited the impedance is reduced so that the condenser is charged, but the alternating arc is not formed. In addition it is necessary to adjust the frequency so that it has the value of the normal time period of the circuit formed of the condenser and transformer secondary circuit, and thus it is possible to obtain condenser oscillatory discharges free from any admixture with alternating current arc. In this manner the condenser discharge can be started or stopped at pleasure, and long and short discharges made in accordance with the signals of the Morse alphabet by manipulating the short-circuiting key of one of the choking coils (see British Patent Specs. Nos. 18865, 20576, and 22126 of 1900, and 3481 of 1901). Another method suggested by Fleming by which the necessary control can be obtained for signalling is to construct the alternator with a field-magnet entirely of laminated iron, and then to open and close the exciting circuit by a suitable key. This then controls the condenser discharges and the production of the waves.

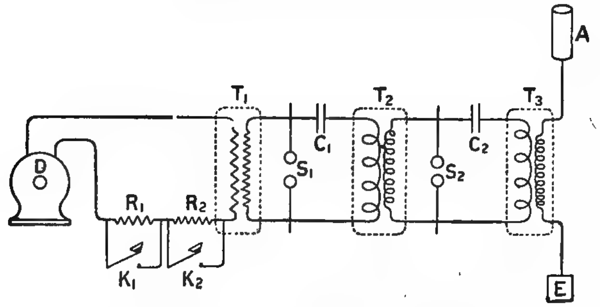

FIG. 19.—Alternate Current Transformer System. (Fleming.)

Trans-atlantic wireless telegraphy.

Availing himself of a suitable transformer plant for the production of powerful trains of electric waves, Marconi was able to produce and receive signals across the Atlantic Ocean between Cornwall in England and St Johns in Newfoundland on 12th December 1901. A station was erected at Poldhu near Mullion in Cornwall, in which was established an alternating current transformer plant. The general design and engineering arrangements for this first "æther wave power station" were made by the writer of this article. Condenser discharges were employed to create powerful electric oscillations in an aerial consisting of about 50 wires 150 feet long upheld in a fan form between two masts, the lower end of the aerial being connected through an oscillation transformer with the earth. Subsequently this aerial was enlarged, and now consists of 400 wires, upheld by four wooden towers each 215 feet high. At St Johns in Newfoundland Marconi elevated a wire 400 feet long by means of a kite, and, using a receiving jigger and various very sensitive electric wave detectors in connexion with a telephone and battery, was able to hear sounds corresponding to condenser discharges in Cornwall repeated rapidly three times (three dots) making the letter S in the Morse alphabet. These S signals were repeated regularly at intervals in accordance with a pre-arranged programme, so as to leave no doubt that they were really due to electric waves generated at the Cornwall station and propagated across the Atlantic Ocean a distance of 1800 miles. This experiment proved that the rotundity of the earth, amounting to an elevation of 110 miles in the 2000 miles, did not altogether intercept the electric waves. In a repetition of this experiment at the end of February 1902, Mr Marconi, on board the s.s. *Philadelphia*, received wireless messages printed down on the ordinary Morse tape at a distance of 1557 miles from the sending station at Poldhu, in Cornwall, England. He also received the letter S at a distance of 2099 miles from the same place. In the course of this voyage he noticed that the signals were better received during the night than the daytime, and that legible messages were received only 700 miles by day, but 1500 by night.

Limitations and improvements.

So long as a receiver consisting of metallic filings is used as a detector of electric waves, it has to be tapped and reset between each signal automatically in the manner suggested by Lodge and Popoff. This limits the rate at which the coherer can be worked in receiving signals on the Morse alphabet system. Attempts have therefore been made to obtain a self-adjusting receiver which shall work more rapidly. D. E. Hughes found in 1879 that a loose or microphonic contact of two metals was reduced in electrical resistance when an electric spark was made near it, and he discovered (see *Electrician*, 5th May 1899) that a carbon-steel microphonic contact is self-setting and requires no tapping back to cause it to regain its original resistance. It has since been found that an exceedingly sensitive electric wave detector which is self-recovering can be made by including a globule of mercury between an iron and a carbon rod placed as plugs in a glass tube. This microphonic receiver in connexion with a telephone and battery forms a very sensitive receiver for wireless telegraphy, and in one form, the invention of which has been claimed by Lieut. Solari, this receiver was used by Marconi in the first transatlantic wireless transmission (see *L'Elettricista*, May 1902, p. 118; also the *Electrician*, vol. xlix. p. 477, 1902, where the inventor is, however, stated to be P. Castelli, a petty officer in the Italian navy). Schäfer has devised a receiver, which he calls an "anti-coherer," by depositing silver upon glass and then scratching the deposit across with a diamond. If the gap is about 30 mm. long, then the resistance between the two sides is not infinite, but about 40 ohms. If electric waves fall on this receiver its resistance increases about threefold, and falls again when the waves cease. This receiver can therefore be used in connexion with a telephone and battery and interrupter to receive Morse signals by ear. Neugschwender (*Wied. Ann.*, vol. lxviii. p. 92) found that if a similar cut across a deposit of silver upon glass was breathed upon the film of moisture transmitted a small current electrolytically, but the impact of electric waves stopped this current. In one case the impact of waves on a cut 20 mm. long and 0·5 mm.

wide caused the resistance to rise from 50 ohms to 90,000. J. C. Bose (*Proc. Roy. Soc.*, vol. lxv. p. 171) found that a receiver made of fragments of potassium in kerosene increased in resistance when electric waves fell on it, and spontaneously recovered its former conductivity when the waves ceased. Up to the present time (1902), however, no one has succeeded in making a practical self-restoring electric wave detector for wireless telegraphy which can be used in conjunction with a relay to work a Morse printer, except the self-tapping metallic filings coherer as employed by Lodge, Marconi, Slaby, and others.

The actions taking place in the filings coherer when submitted to electric radiation have been studied by many physicists. Blondel and Dobkevitch (*Comptes Rendus*, 23rd April 1900) have stated that when such a tube is submitted to gradually increasing E.M.F. there is a certain critical voltage at which it passes suddenly from a non-conducting to a conducting condition. But W. H. Eccles (*Electrician*, vol. xlvii. p. 682) has denied this, and states from an extensive experience that a degree of coherence is produced by any E.M.F., and that its detection is merely a question of delicacy of instrument. A considerable amount of knowledge and skill is required to make a properly sensitive metallic filings coherer (Ger. *Fritter*). The general experience is that tubes made exclusively with non-oxidizable metals, *e.g.*, gold, silver, or platinum filings, are too sensitive, while those made exclusively with very oxidizable metals, *e.g.*, iron, copper, &c., are too insensitive and uncertain for telegraphic work. Marconi has obtained his best results with receivers in which nickel mixed with a small percentage of silver filings is used in a good vacuum between silver terminals. Even then to work well the tube must not have currents exceeding one-tenth of a milliampere sent through it, and the tapping back must be very gentle. So far all that can be said is that the making of a good metallic filings coherer tube is a matter of skill rather than science. M. Blondel and also Sir O. J. Lodge have designed forms of sealed tube with a pocket to hold a store of filings so that the working mass can be changed, but experience is wanting to show how far this is an advantage in practice.

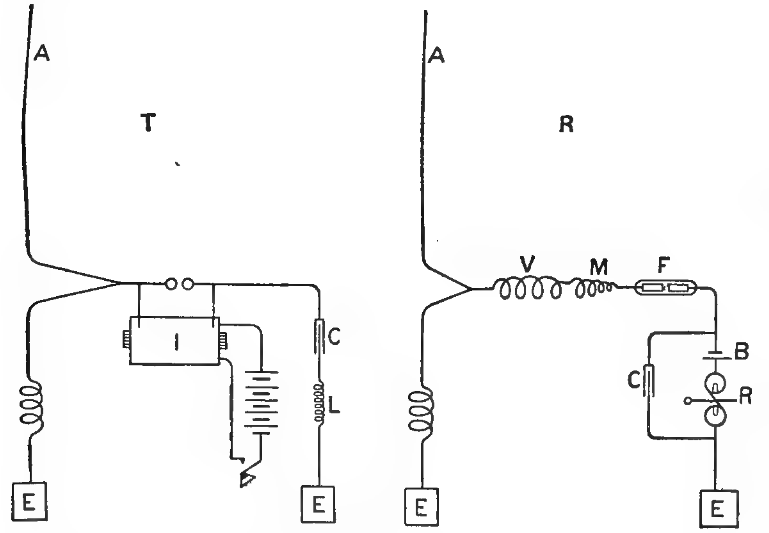

Fig. 20.—Slaby-Arco System.

The mode in which the sensitive tube should be connected to the aerial and the form of the latter have been the subject of much investigation. Slaby has contended that the coherer should not be connected between the aerial and the earth, because the latter place is a point of zero potential, and the amplitude of potential variation due to oscillations in the aerial is small near the base of the latter. He has therefore, in conjunction with Count Von Arco, devised arrangements for which he claims an advantage. At the transmitting end the aerial A (Fig. 20), which may consist of a lightning conductor, has a loop at its lower end connected with one secondary terminal of the induction coil. One secondary spark ball of the induction coil I is connected to this loop, and the other to a condenser C in series with an earthed inductance coil L. At the receiving end a similar lightning conductor A has its loop connected to a very open spiral wire V, the length of which is equal to the height of the aerial, and the outer end of this coil is connected through another coil M, called a *multiplicator*, to the coherer F. The coherer is earthed through a condenser C, which is shunted by a relay R and one dry cell B; according to Slaby, the receiver and transmitter can be so "tuned" that the receiver does not respond to electric waves of any length, but only to those proceeding from the proper transmitter. In a demonstration given in December 1900 he exhibited the apparatus in action, and showed that two receivers tuned to different wave lengths could be connected to the same lightning rod, and that each would only respond to its own proper transmitter (see *Electrical Review*, London, 28th December 1900; or *Engineering*, 8th February 1901). The difficulty, however, has hitherto been to prevent even a so-called "tuned" receiver from responding to any electric wave if the latter is sufficiently vigorous.

In 1896 E. Rutherford (see *Proc. Roy. Soc.*, vol. lx. p. 184, June 1896) described "A Magnetic Detector of Electric Waves and some of its Applications." This detector consisted of a bundle of very fine steel wires which were surrounded by a coil of wire. The steel was magnetized, and it was found that when the above coil was placed in series with a receiving circuit the oscillations set up in the latter demagnetized the steel. The effect was produced at distances of half a mile. More recently Marconi (see *Proc. Roy. Soc.*, 12th June 1902) discovered that if a bundle of iron wires is carried slowly through a magnetic cycle by being rotated in a magnetic field so as to magnetize it first in one direction and then in the other, it becomes very sensitive to the magnetizing action of electric oscillations. When a bundle of iron wires is thus carried through a cycle of magnetic operations the magnetization lags behind the magnetizing force in consequence of *hysteresis* (see Magnetism, vol. xxx.). If this bundle of iron wires is surrounded by two coils of insulated wire, one of which is in circuit with a telephone and the other is in inductive connexion with an aerial wire, then when an electric oscillation is set up in the aerial by an arriving electric wave these oscillations cause the magnetization of the iron core suddenly to come up into step with its external magnetizing force. This gives rise to a secondary current, and this is heard as a "tick" in the telephone. Marconi has in this manner constructed an improved magnetic detector of electric waves which is exceedingly sensitive and more certain than the coherer, with which it has nothing in common. This receiver, from its constant resistance, admits of being employed with great advantage in a syntonic system of wireless telegraphy. In July 1902, using this receiver, he received "wireless" messages on board the Italian flagship *Carlo Alberto* sent out from Poldhu, the vessel being then in Cronstadt harbour and the signals crossing England, the North Sea, Denmark, and the Baltic.

Marconi has described several interesting forms of transmitter and syntonic receiver arrangements (see *Journ. Soc. Arts*, London, vol. xlix. p. 506). One of these, the transmitter, consists of two concentric metal cylinders or a length of concentric cable. The inner cylinder is connected to earth and to one spark ball of an induction coil. The outer cylinder is connected to the other spark ball through an inductance. The improvement thus effected consists in giving the aerial a larger capacity, and enabling it to store up more electric energy. The radiation thus consists of a greater train of waves. The ordinary simple or plain insulated aerial used as a transmitter on Marconi's first plan has a very small capacity. Measurements show that a single aerial consisting of a 7/20 copper wire 200 feet in length, suspended vertically, has a capacity of 0·0004 microfarad, whilst 25 such wires arranged 3 inches apart, parallel to each other, have a capacity of 0·0016 microfarad. There is a limit to the length of oscillatory spark which can be obtained on such a single wire aerial with an ordinary 10-inch induction coil, usually employed, which may perhaps be taken at 2 centimetres, representing a potential of about 60,000 volts. Hence, for a single aerial as above, the stored-up energy before discharge amounts to $\frac{1}{2} \times \cdot 0004 \times (60{,}000)^2 = 0\cdot 72$ joule, or about 1½ foot-pound. Not all this energy, however, is available for wave making, as some is dissipated as heat. Moreover, this small amount of energy is almost all discharged in the first half vibration, so that no true train of waves is radiated, but merely an impulse given to the ether. Large capacity as well as large surface in the aerial is essential for the achievement of long-distance wireless telegraphy, especially if the latter is to be syntonic. This can only be accomplished by storing up a large amount of energy in a condenser and releasing it into a non-radiative circuit which is inductively connected with the radiative circuit. The radiative and storage power of the combination can be adjusted so as to radiate a considerable train of energetic electric waves.

Authorities.—J. J. Fahie. *A History of Wireless Telegraphy.* London, 1899.—O. J. Lodge. *Signalling through Space without Wires*, 3rd ed., London, 1899; "Improvements in Magnetic Space Telegraphy," *Proc. Inst. Elec. Eng.*, vol. xxvii. p. 799.—W. H. Preece. "Signalling through Space without Wires," *Proc. Royal Institution*, London, June 1897; "Aetheric

Telegraphy," *Proc. Inst. Elec. Eng.*, Dec. 1898.—G. Marconi. "Wireless Telegraphy," *Proc. Inst. Elec. Eng.*, London, 1899, vol. xxviii. p. 273; "Syntonic Wireless Telegraphy," *Journ. Soc. Arts*, 1901, vol. xlix. p. 505; "Wireless Telegraphy," *Proc. Roy. Inst. of Great Britain*, 1900, vol. xvi. part ii. p. 247; "The Progress of Space Telegraphy," *Proc. Roy. Inst. of Great Britain*, June 1902; or *Electrician*, 1902, vol. xlix. p. 388.—S. P. Thompson. "Telegraphy across Space," *Journ. Soc. Arts*, 1898, vol. xlvi. p. 453.—A. Slaby. *Die Funken Telegraphie*, Berlin, 1897; "Abgestimmte und Mehrfache Funken Telegraphie," *Elek. Zeitschr.*, December 1901.—J. A. Fleming. "Electric Oscillations and Electric Waves," Cantor Lectures, Society of Arts, 1900 and 1901.—A. Turpain. *Les Applications pratiques des Ondes Electriques*. Paris, 1902.—H. B. Jackson, R.N., F.R.S. "On Some Phenomena affecting the Transmission of Electric Waves over the Surface of the Sea and Earth," *Proc. Roy. Soc.*, May 1902.—A. Blondel and G. Ferrie. *État actuel et progrès de la telegraphie sans fils par ondes Hertziennes*, Paris, 1901; "Congrès International d'Électricité," *Rapports et Procès verbaux*, Paris, 1900, p. 321. (J. A. F.)

Telephone.—The electric speaking telephone was invented by Alexander Graham Bell, who first proposed to transmit speech electrically by the employment of electric undulations similar in form to the sound waves which characterize the words spoken. The apparatus constructed by him for the purpose of putting this conception into a practical form was the so-called magneto-telephone, in which a thin iron diaphragm is placed opposite a pole-piece constituting the end of a permanent magnet, around which pole-piece is wound a coil of insulated wire. The iron disc is enclosed in a suitable box, and the instrument is furnished with a mouth-piece. The transmitter and the receiver are alike. On speaking into the transmitter the air waves produced by the voice act to set the iron diaphragm into a corresponding condition of vibration. This, by its inductive action upon the magnet and coil, generates an undulatory current in the line which copies, as it were, the characteristics of the sound waves. The passage of this undulatory current through the coil of the receiving instrument varies the strength of the pole of its magnet and thus attracts the iron diaphragm more or less strongly, so that this enters into vibration and acquires motion of a character corresponding to and determined by the undulatory current. These vibrations of the receiver diaphragm produce air-waves which are necessarily similar in all their characteristics to those produced by the voice at the transmitter. Hence the sound heard at the receiver is a reproduction of that spoken into the transmitter.

Microphone.—The magneto-receiver has been universally used in practical telephony. But the magneto-transmitter was soon superseded by the microphone-transmitter, originally invented by Émile Berliner, which produces much louder effects. In this instrument an application is made of the principle that the transition resistance, as it has been called, which exists at the surface of contact of two separate conductors or electrodes, through which a current is passing, is varied in magnitude with changes in the pressure between them, becoming less as the pressure is greater. This change is particularly marked when one or both of the electrodes are of carbon. The form of microphone which until recently has been the standard type in the United States and to a large extent in other countries is the Blake transmitter, in which the electrodes are of platinum and hard carbon respectively. These are suspended from springs, and press lightly against one another. The platinum electrode is small, approximately ellipsoidal in shape, and rests in contact with the diaphragm. The carbon electrode is of large mass, and has spun around it a button of brass, still further increasing its inertia. When the diaphragm is set into vibration by the voice, its motions are communicated to the platinum "hammer electrode." This presses more or less closely against the "anvil electrode" of carbon, which on account of its large mass does not readily enter into motion; and there is thus brought about a variation in the transition resistance existing at the surface of contact of the two electrodes. The electrodes being in circuit with a battery and the receiving instrument, undulations will be produced in this circuit in consequence of the variation in transition resistance referred to, and these undulations will be of the same character as the sound waves which actuate the transmitter, and will thus cause a reproduction of speech at the receiver. Ordinarily the battery and microphone are put in circuit with the primary of an induction coil, in the secondary of which are placed the line and the receiver, in order to give better conditions for overcoming the necessarily large line resistance.

Another type of microphone which has been used in Europe much more than in the United States is the multiple-contact instrument. In this several microphonic joints are employed. Thus, in the Crossley transmitter four hard carbon pencils are arranged in a lozenge-shaped figure, the ends of each pencil resting loosely in a small carbon block. These blocks are fastened to a diaphragm of wood. The circuit connexions are such that two adjacent sides of the lozenge are in parallel and two in series. In the Ader transmitter as many as twelve carbon pencils are employed, arranged in a series of two groups with six pencils in parallel in each group. These are supported at their ends in parallel carbon bars, which are carried by a nearly horizontal wooden diaphragm. Such multiple-electrode transmitters give a loud although somewhat harsh sound, and will bear being spoken to very strongly without breaking the circuit.

A type of transmitter which has come to be invaluable in connexion with long-distance telephony, and which is superseding all other forms, is the granular carbon transmitter. The earliest instrument of this kind was the Hunnings transmitter. This was constructed of a shallow box placed in a vertical position, with metallic front and back and insulating sides. The front face was of thin metal, and served as a diaphragm. The box was filled nearly but not quite full of granulated hard carbon. The current from the battery used passed from the diaphragm through the granulated carbon to the metallic back of the box. When spoken to, the diaphragm vibrated, and thus set the carbon granules into vigorous vibration. The vast number of microphonic contacts present give rise to very strong electrical undulations, and hence to a loud sound.

The chief difficulty with this transmitter, and with various others of later date based upon it, has been the frequent packing of the carbon granules, which renders the instrument inoperative. The difficulty was first satisfactorily overcome in the long-distance transmitter, invented by A. C. White in the laboratory of the American Bell Telephone Company, and commonly known as the "solid back transmitter."

The microphonic portion of the transmitter is contained in a thin cylindrical box or case of brass, the inner curved surface of which is covered with an insulating layer of paper. The case is firmly fixed to a "bridge" with its back or bottom in a vertical position. To the brass bottom of the case is attached a thin disc of polished hard carbon which is slightly less in diameter than the brass bottom, so that the carbon disc almost entirely covers this brass back, leaving only a slight annular space around its edge. The front or cover of the case is a similar button of hard polished carbon, also slightly smaller in diameter than the cylindrical wall of the box. It is attached to a brass disc, which is fastened to the centre of the diaphragm by means of a rivet, and is capable of moving to and fro like a plunger when the diaphragm vibrates. A washer of thin flexible mica concentric with the carbon button is carried by the brass disc, and projecting over the edge of this, is held firmly against the rim of the cylindrical wall of the case by an annular brass collar, which is screwed upon the outer curved surface of this wall. The box is thus entirely closed at the front, while the front carbon disc, which constitutes an electrode, is perfectly free to follow the motions of the diaphragm. The space enclosed between the front and rear faces of the box is filled about three-quarters full of finely granulated hard carbon, which therefore lies in contact with the front and rear carbon discs of the apparatus, and also fills up the space lying between the lower edge of these discs and the curved surface of the case. The current from the battery passes from one of the carbon discs to the other through the particles of granulated carbon which fill the space between them.

The discs and granules constitute a very powerful microphone. The motions impressed upon the carbon granules are very vigorous, and this together with the particular arrangement of the parts of the instrument is effectual in obviating the difficulty from packing which attended the use of earlier forms of granulated carbon transmitters. For long-distance telephony this instrument is used exclusively by the American Bell Telephone Company, and it is rapidly displacing all other forms of transmitter for local work.

On long lines there is frequently used with this transmitter a more sensitive form of magneto-receiver than the usual one. The magnet of this is of horse-shoe type, with the two legs parallel and close together. The pole-pieces are very small and of elongated cross-section. The diaphragm is also somewhat less rigid than that of the ordinary instrument. The whole is enclosed in a rubber case resembling the usual one.

Circuit Arrangements.—In the early days of telephony, when circuits were not long, and before electricity had come to be used extensively for purposes of lighting and power distribution, grounded circuits like those used in telegraphy were almost exclusively employed. They were, however, subject to serious disturbances from the induction caused by currents in neighbouring telegraph and electric light wires, from leakage, and from the varying potential of the earth due to natural or artificial causes. The introduction of electric street railways caused an enormous increase in disturbances of this class. It was early recognized that a complete metallic circuit would obviate troubles from varying potential of the earth, and that if the outgoing and incoming branches of this circuit were parallel, and kept by transposition, spiralling, or otherwise at equal distances from the disturbing wire, induction effects would likewise be removed. The greater cost of such all-metallic circuits and certain incidental complications of the switchboards then employed at the central stations were objections to the general introduction of such a system. It has, however, proved to be a necessity with long-distance lines, and is very largely used for local service. It has also been found, as was suggested by the writer prior to its observance in practice, that to secure freedom from inductive disturbance the line must be "balanced," that is, the two branches must be substantially alike in their electric constitution. If, for example, one branch possesses a considerably greater capacity than the other, the line will be subject to disturbance. An all-metallic line which, being balanced, is free from inductive disturbance may become noisy if placed in continuous circuit with a grounded line which is itself silent from the absence of disturbing causes. For this reason, in connecting all-wire long-distance circuits with local grounded circuits, the connexion is not made directly, but translation is secured by means of an induction coil known as a "repeating coil." This has a ring-shaped core of an oval form, being in fact a closed circuit transformer, with the primary and secondary coils wound one upon each of the longer sides of the core. One of these coils is connected in circuit with the long-distance lines, and the other with the local grounded circuit.

Ordinary galvanized iron or steel telegraph wire is still used upon short lines for local service. But for long-distance telephony it is unsatisfactory, on account of its high impedance. The introduction in 1883 of the hard-drawn copper-wire of high conductivity, invented in 1877 by Mr T. B. Doolittle, was of the greatest importance in rendering the use of long lines practicable, and it is universally employed for such service. The gauge generally used is No. 12 standard gauge (104 mils), having a resistance of 5·2 ohms per mile. The New York–Chicago line, 950 miles in length, built in 1892, uses wire 165 mils in diameter (No. 8, Birmingham), weighing 435 ℔ per mile, and with a resistance of 2·05 ohms per mile.

The rapid increase in the use of the telephone and the constant multiplication of electric service wires have caused the use of underground cables to be imperative in cities. These are generally laid in conduits made up of iron pipes with manholes at intervals to allow of the drawing in of the cable. Their high electrostatic capacity is, of course, objectionable, as it greatly limits the range of clear articulation. In the systems of cable that were first used, the wires, usually with a cotton insulation, were drawn into lead tubes, and the tubes filled with paraffin or other similar compound, which kept the wires from the injurious effects of any moisture that might penetrate the lead tube. This form of cable has been superseded by a type with paper insulation. The separate wires are surrounded only with a loose covering of soft paper, which furnishes abundant insulation. About them is moulded a lead tube, which is carefully made so as to be free from "pinholes," thus avoiding any penetration of water. The dielectric of the cable is practically air, and the specific inductive capacity is therefore extremely low, from which follows a corresponding increase of the range of communication. Such a cable is very compact, a tube 2⅝ inches in diameter containing 800 or more wires.

As no practical process of telephonic relaying has been devised, it is extremely important that the character of the line should be such as to favour the preservation of the strength and form of the telephonic current. The latter element is the more important, since upon it clearness depends, while an extremely minute current is capable of giving audible speech. At one time it was believed by many that the same law held for the telephonic transmission of speech as for the transmission of ordinary slow telegraphic signals, viz., that the limiting range of intelligible conversation was inversely as the product of the resistance of the line by its capacity—forgetful of the fact that in the deduction of this law the only variables are supposed to be the two mentioned. This is practically true in cable signalling, but with the rapidly-varying electric undulations of the telephone, inductance plays an all-important part.

As long-distance telephone lines came to be extended it was soon found that conversation could be carried on over a much greater distance than would be inferred from the "KR law," as it was called. Furthermore, O. Heaviside showed mathematically that uniformly-distributed inductance in a telephone line is a distinct aid in preserving the strength of the electric undulations, thus preventing "attenuation" of the articulating current. Indistinctness of speech upon long telephone lines results from the distortion of the electric waves, which is due to the unequal attenuation of the undulations corresponding to the various partial tones of speech, the attenuation being greater as the frequency is higher. Hence the effect of high inductance in reducing attenuation is likewise to produce a distortionless circuit, as was also pointed out by Heaviside. (See TELEGRAPHY: *Theory.*) It has not proved feasible in practice to construct a uniform conductor of high inductance, but Professor M. I. Pupin has shown that it is practically possible to diminish the attenuation of a current by the use of a non-uniform "loaded" conductor with inductance coils separated by definite intervals, which must be less than half the length of the shortest component wave to be transmitted.

Speech has been habitually transmitted for business purposes over a distance of 1542·3 miles, viz., over the lines of the Long Distance Telephone Company, from Omaha to Boston. Conversation has been carried on over 2200 miles of No. 8 line.

Exchanges.

Switchboard.—In commercial telephony switchboards are an evident necessity as a means of putting into connexion subscribers who are desirous of communicating with one another. Where the number of wires entering the station is small the problem is a very simple one, since all that is necessary for the operator to do upon receiving a signal from the subscriber calling is to connect his wire in closed-circuit with the wire running to the person with whom he wishes to speak, of course at the same time opening both circuits at the station, where they were previously closed, since this condition would otherwise short-circuit the speaking current. A flexible cord, terminating in plugs which are slipped into "spring-jacks" as they are called, serves to accomplish the desired result. The spring-jack is a form of switch with two contact springs which press against each other, and close the circuit with the wires of which they are connected. When the plug is inserted this circuit is opened and a connexion is made with that circuit to which the wire running from the plug is joined. The plugs at the ends of the cords are inserted into those spring-jacks which are respectively in connexion with the wires of the calling and the called subscriber, thus putting these into communication with each other. The operator at the exchange by the use of a key can throw her own telephone into the circuit, and ascertain whether conversation is established and continued. A simple system of annunciator ("calling drops") actuated by the calling current of the magneto-bell shows the operator who it is that is calling, so that she may make inquiry as to the person with whom he wishes to speak. A separate drop-magnet ("clearing-out drop") is so arranged as to be inserted into the circuit at the same time that communication is established between the two subscribers. When the conversation is finished a ring upon the call-bell ("ring off") causes the drop to fall, and the operator thus notified of the fact removes the plugs and discontinues the connexion. This form of switchboard, usually called the "standard board," has proved satisfactory for small exchanges of from fifty up to five hundred subscribers. For the larger boards two operators are required.

In a more extensive exchange a number of operators are necessary to attend to calls. Several single switchboards like that described may be employed, each devoted to a certain section of the subscribers, and placed in care of an operator. In these circumstances, when, as frequently will be the case, the person calling desires to be put in communication with a subscriber who belongs to another section, connexions must be established in the office between the two sections, which necessitates additional switchboard arrangements and also increases the time required to put subscribers in communication with one another.

This difficulty is obviated by the use of the "multiple-switchboard," which is divided into a series of panels, each containing a set of spring-jacks connected with every subscriber's line, so that all subscribers can be reached from any section. A certain moderate number of incoming lines also terminate in each section of the multiple-switchboard, and are placed in the care of the operator assigned to that section. Hence this operator, when signalled in the usual manner, can put any one of these subscribers in connexion with any other subscriber whatever, without the necessity of calling upon another operator to make connexions. The objection to such a switchboard is the complicated wiring, because of the multiplication of spring-jacks that is required. Thus the 6000-wire switchboard in New York has 44 panels, and consequently $44 \times 6000 = 264,000$ jacks. Besides this, additional multiplication of wires arises from the necessity of providing for the "busy test," as with a multiple-switchboard it is impossible for any one operator to know that the line of the person called for is not already occupied. Hence special test-wires have to be arranged to meet this difficulty. Notwithstanding these objections, this form of switchboard has proved the most satisfactory that has been devised.

Party Lines.—An important improvement has been introduced into local telephone service by the use of the bridging bell of J. J. Carty, whereby a number of subscribers can be placed upon a single circuit or "party line," as it is called. The former practice was to place the calling apparatus in series. This was found to be objectionable on account of the effect of the large impedance introduced by the electro-magnets of the call-bells, so that not more than two or three persons could be placed upon a single circuit without seriously impairing conversation. The bells as now used are placed in bridges in parallel circuit between the go-and-return wires, or between the wire and the earth, according as a metallic or a grounded circuit is employed. The electro-magnets of the call-bells are so wound as to possess very high inductance. For this reason, although they are constantly in circuit, bridging across the lines, they will not interfere with telephonic transmission through the receiver at any station, since the rapidly-varying telephonic currents will be prevented from traversing the bell-magnets on account of the "throttling" action of these, while they freely traverse the receiver, which is of low inductance. Hence there is no sensible loss of the telephonic current through the several bridging bells. The armatures of the generators of the several call-bells are out of circuit except when one is operating to transmit a call, when it is automatically thrown in. On the other hand, the frequency of the alternating current produced by the call-bell is so low that these undulations easily traverse the electro-magnets of all the bells, their throttling action not being sufficient to prevent this. The current furnished by the rotating armature of the generator of the call-bell is of sufficient strength to actuate all of the bells between which, because of their parallel arrangement, it is divided. Hence every bell responds to the call. It is possible to operate twenty or more bells thus, and as many as ten are frequently used at present. The fact that every bell responds to each call, of itself makes a limitation of the party line to a moderate number of subscribers desirable. This difficulty may be removed by selective signalling. Methods for doing this have been proposed, among others one of great interest based upon an electrical tuning of the receiving apparatus at each station, so as to respond by electric resonance to a call of one particular frequency. Selective signalling has not, however, as yet been much utilized in practice, chiefly because the large number of subscribers on the party line would keep it too busy for their convenience.

Common Battery System.—Until recently it has been customary to place a local battery with each subscriber to actuate his transmitter. This method is simple, but is open to serious objection because of the large number of separate cells needed, the space occupied by them, and the expense of proper inspection. For this reason much thought has been given to the perfecting of a system in which a single large battery at the central office may be used. The "common battery system," as it is called, which in its present form is the invention of H. V. Hayes, has already come into use to a very considerable extent, and is now almost universally employed in newly established stations. The battery at the central station, composed of a number of storage cells, is situated in a bridge between the two sides of the circuits of the subscribers when these are connected for conversation. The accompanying diagram represents the essential portions of the apparatus as it stands after such connexion has been made. Each pole of the battery B is connected with one end of a repeating coil, C_1 C_1, C_2 C_2, having two windings with a common point at the battery terminal. One of the free ends of the wires of each repeating coil goes to subscriber S, the other to subscriber S′. In these circumstances a current flows from the central main battery through one of the windings of the repeating coil C_1 through the circuit to subscriber S, traversing the receiver R and the microphone M, back to B through one of the windings of C_2. Likewise a current from B flows through the second winding of the repeating coil C_1 through the circuit to subscriber S′, traversing the receiver R′, the microphone M′, and thence back to B through the second set of windings of C_2. The transmitters are therefore in direct circuit with the battery, no local induction coil being used. Assuming the circuit connexions to be made as shown in the diagram, then if subscriber S speaks into the transmitter M, the undulatory current thus produced traverses the circuit C_1 R M C_2 B_2. The inductive action of the one set of windings of the repeating coils C_1 C_2 upon the other set causes a similar undulatory current to traverse the circuit C_1 R′ M′ C_2 B, and thus to convey the message to the subscriber at S′. In this explanation the circuit between the two subscribers is supposed to have been closed. In practice, of course, this is only the case when both subscribers have removed their receivers from the suspending hooks. Hence suitable arrangements have to be made whereby the calling subscriber may notify the central station operator, and the operator may call up the subscriber who is wanted.

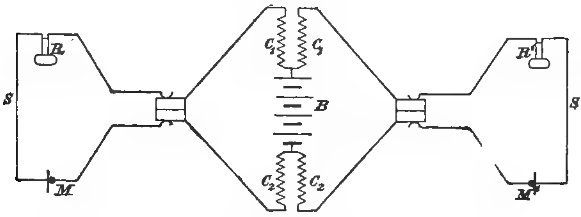

Diagram of Central Battery System.

For this purpose the calling system has been very conveniently modified. The magneto-bell previously used by the subscriber to call the operator is done away with, as are also the drop magnets at the station. For these last as a signalling device there is substituted a small incandescent electric lamp. This is normally dark, but by a simple arrangement of circuits, when a subscriber, wishing to call up the exchange, removes his receiver from the hook by which it hangs, the hook, which as usual constitutes a switch, closes a circuit containing a battery and a relay. The relay, thus actuated, closes in its turn at the station a circuit through the incandescent lamp, the glowing of which apprises the operator of the call.

In order that the operator at the central station may be able to call up subscriber wanted (S′), a condenser (not shown in the diagram) is permanently bridged around the cut-off switch of each subscriber, a call-bell being inserted in the condenser circuit. Hence the calling current from an alternating current generator at the station will ring up the desired subscriber through his condenser on throwing his line into the circuit; while, of course, no current from the main battery can traverse the condenser.

In recent practice several improvements in details have been introduced. Instead of allowing the signal lamp to glow as long as conversation is continued and show by its going out when this is finished, the operator in the act of answering the call throws this lamp out of gear, and in completing the connexion between the two subscribers two auxiliary incandescent lamps ("supervisory lamps") are introduced in such a way that, so long as the receivers of both subscribers are removed from the hooks, the lights do not glow, a relay keeping them shunted out of circuit; but when either of the subscribers puts his receiver on the hook, the corresponding lamp glows. When both lamps glow the operator knows that the conversation is finished and removes all connexions between the two subscribers. No local induction coil was originally used in this system, but more recently it has been found advantageous to employ one.

Automatic Systems.—Many attempts have been made to do away with operators at the central station by making the circuit connexions between different subscribers automatically. These automatic systems are very complicated, but have nevertheless been used with as many as 2000 subscribers. The lines from every subscriber enter the central office, and conductors connected with them are placed in parallel with one another, so that if proper cross-connexions are made the circuit between two subscribers is completed as desired. The cross-connexion is accomplished by a series of shafts carrying projecting circuit-connecting arms set spirally, and susceptible of both rotation and lateral displacement, so that one or another pair of conductors will be connected according to the position of the shaft. This is moved into the proper position by means of a step-by-step mechanism actuated from the transmitting station by a key. The energy necessary to operate the mechanism is derived from a battery at the central station. (C. R. CR.)

Telescope.—The principal advances made in connexion with the telescope in the last two decades of the 19th century consisted in the construction of several refractors of much greater size than had ever before been attempted, and in the development of the photographic telescope with comparatively short focus and large field, of the "equatorial coudé" of Loewy, and of the fixed horizontal telescope, in which the object is viewed by reflection in a mirror.

Optical glass.

Before the size of the refracting telescope could be increased, it was necessary to command masses of optical glass larger than manufacturers had previously found it practicable to mould. Up to 1880, Feil of Paris, successor and son-in-law of Guinand, had been among the most successful makers, and his greatest improvement was to increase the possible size of the flint discs. Formerly these were more difficult to make than discs of crown, owing to the tendency of the heavier portions, especially the lead, to sink to the bottom of the pot. It is believed that the principal improvement made by Feil, by which this difficulty was surmounted, consisted simply in constantly stirring the melted glass in the pot. However this may be, very large flint discs are now more easily made than those of crown. About the end of 1883 Feil's factory fell into the hands of Mantois (died 1900), who soon proved himself the most successful maker of great discs that has ever appeared. His first large discs were made for the 36-inch equatorial of the Lick Observatory in California, the glasses for which were figured by Alvan Clark and Sons, the mounting being made by Warner and Swasey of Cleveland. This telescope, which was completed and erected at Mount Hamilton early in 1888, offers no radically new features in construction. A few years later was mounted the great Yerkes telescope of the

University of Chicago, having an aperture of 40 inches, which, with the other large telescopes of recent construction, is described elsewhere (see OBSERVATORY).

In the usual form of refracting telescope the instrument is pointed directly at the object to be observed, the diurnal motion of which it must follow. The longer the instrument, the more massive must be its mounting and the greater the mechanical difficulties encountered, both in construction and management. Especially inconvenient is the continual motion of the eye-piece, which the observer must follow in order that he may look into the telescope. The idea of surmounting these difficulties by keeping the telescope fixed in position, and throwing the rays of the body to be observed into it by reflection from a plane mirror, was worked out by Foucault, and such a mirror, with its mountings, was called by him a siderostat, a term which is sometimes applied to the entire instrument, telescope included. A construction of this sort, in which the telescope is pointed towards the depressed pole, so that the eye-piece must be fixed in an elevated position while the observer looks down into it, is described in the *Encyclopædia Britannica,* vol. xxiii. p. 152, but it is so far from being a convenient form of mounting that little or no use has ever been made of it.

Fixed horizontal telescopes.

In the form now preferred the telescope is fixed in a horizontal position, an arrangement that offers every advantage of the other form, except that the motion of the mirror requires a more complex mechanism, owing to the variation of the angle of reflection with the diurnal motion. The reduction of the observations is more simple when the telescope is in the line of the meridian; this position is therefore generally preferred. The principal advantages of this form are: (1) There is mechanically no limit to the length of the telescope, so that, with any diameter of object-glass, the telescope may be lengthened so as to obtain an image of any required size. This is especially important in photography. (2) The clockwork and other appliances required to move the siderostat are lighter and smaller than those required to move a large telescope. (3) The observer remains in a fixed position so long as he chooses to observe any one object. (4) If a photographic plate be exposed in the focus, the linear distance corresponding to one second of arc can be accurately determined by measuring the distance between the principal point of the objective and the photographic plate. The position angle can also be obtained by photographing a fine silver plumb line upon the plate, though it should be remarked that this determination of the position angle is subject to the important limitation that the time of exposure must be short. The most serious inconvenience of this form is that the image formed in the focal plane undergoes a diurnal rotation around the axis of the instrument. It follows that in long exposures the eye-piece or photographic plate must itself rotate. Such a movement involves no mechanical difficulty, but it interferes with the photographing of the plumb line. This drawback disappears in the case of a photograph of the sun, which is necessarily instantaneous; this form is therefore preferable to all others as a photoheliograph. An additional advantage, where simplicity and cheapness are an object, is that the rudest form of clockwork may be used in moving the mirror; in fact, no mechanical motion whatever is necessary in an instantaneous photograph like that of the sun, since it is only necessary to move the mirror by hand to such a position as to bring the image upon the photographic plate. The operation is, however, facilitated by a rude form of clockwork, which will keep the image approximately in the right position, an exact adjustment being made by hand.

The great Paris telescope.

The greatest refracting telescope, and the longest telescope of any, constructed by Gautier for the Paris Exposition of 1900, is arranged on this plan. The objective of this instrument is 1·25 metres (49 inches) in diameter, and has a focal length of 60 metres, or nearly 200 feet. Two object-glasses are provided, one for visual, the other for photographic purposes. These are of the ordinary curves, the flint nearly plano-concave, and the crown double convex. With such a focal length a moderate magnifying power and a large angular field of view are scarcely possible. Without any eye-piece an ordinary eye capable of being accommodated on objects at a distance of 7 or 8 inches would secure a magnifying power of 300 times by simply looking at the image in the air, and the only difficulty in doing this would be that the apparent diameter of the field of view would be that of the object-glass, and the actual diameter in arc only about twelve seconds. The field of an eye-piece 6 inches in diameter would be only about eight minutes. The field of view that could be advantageously included on a photographic plate would be small in proportion. This would, however, be an advantage where a great enlargement of a minute object was required, as in the case of star clusters and satellites of the outer planets. Up to the time of writing, the qualities of the object-glass and the reflector as regards perfection of images have not, so far as known, been subjected to any severe test, and the question of what this instrument can do is therefore still unsettled. Of its theoretical practicability there seems to be no doubt, and its success is mainly a matter of mechanical skill.

The coelostat.

To the devices for photographing objects by reflecting their rays into the object-glass of a telescope, a new one has been added, termed the coelostat. This is a plain mirror turning on an axis parallel to itself and to the axis of the earth. The normal to such a mirror as the latter rotates is always directed towards some point of the celestial equator. It is made to revolve with one-half the apparent diurnal motion of the stars. The image of the celestial sphere, reflected from such a moving mirror, remains at rest at every point. Its drawbacks are the obliquity of the angle of reflection, which can never be less than that of the declination of the star, and may be greater to any extent. It is necessary that the telescope receiving the ray shall be directed towards a point having the same declination as that of the star to be photographed, so that a fixed telescope cannot be used.

Loewy's mounting.

Equatorial telescopes of the new and ingenious construction designed by M. Loewy (see *Ency. Brit.*, vol. xxiii. pp. 152, 153) have, up to the present time, been mounted for the most part only at some French observatories, notably those of Paris and Nice. The great advantage of the instrument is the rapidity and convenience with which it may be manipulated. The observer is always seated in a fixed and comfortable position at the eye-piece, and the mounting is such that from this point he can read both the hour circle and the declination circle. The position of the eye-piece remains invariable, whatever the object at which the instrument may be pointed. The eye-piece is sheltered by a building which has a movable sliding wing whereby the lower part of the instrument, including the object-glass, may be sheltered from the weather when not in use. The main building in which the observer is seated may be warmed in winter without seriously affecting vision through the telescope. The result of these arrangements is that all the ordinary observations, especially those involving the use of a micrometer, may be carried on much more effectively than with the ordinary construction, in which the observer is obliged to follow the eye-piece at various heights round the interior of the dome. The drawbacks of the instrument are those arising out of the double reflection, the result of which is that to any possible defects of the object-glass are added those of the form of the mirrors. There is necessarily a certain amount of light lost in two reflections—how much will depend largely on the condition of the silvered surfaces. The Messrs Henry, who have, we believe, figured the mirrors for such of these instruments as have yet been made, have been remarkably successful in their work, not only as regards the flatness of the reflecting surfaces, but in mounting the mirrors so as to keep them free from flexure in the various positions of the instrument.

Secondary aberration.

The most serious defect of the refracting telescope arises from the secondary chromatic aberration, due to the so-called irrationality between the respective dispersive powers of flint and crown glass. This irrationality consists in the fact that the ratio of the dispersive power of flint glass to that of crown glass continually increases as we pass from the red to the violet end of the spectrum; consequently, if we arrange a combination of flint and crown lenses so as to bring all the light in some one region of the spectrum, say the yellow, to the same focus, the light of all other colours will be brought to a more distant focus. It is remarkable that this defect remains unchanged whatever combinations of the various sorts of crown and flint glass we may choose. Its exact nature and amount may be defined thus: Choose any part of the spectrum, say that near wave-length 540, the light of which is to be concentrated to a point at the focus. Imagine a plane, the "focal-plane," passing through this focus at right angles to the axis of the objective. Then the light of every other wave-length, coming as it does to a more distant focus, will meet the focal plane in a circle. This is the "circle of aberration" for that light, and is of course larger the more the wave-length deviates from 540. Let us take as a standard of comparison the circle of aberration in which falls the light of some other assumed wave-length, say 440, as that by which we are to measure the aberration. We then have these propositions:—

I. The radius of the circle of aberration is a certain invariable fraction of the aperture of the objective, and is independent of its focal length.

II. This fraction is the same whatever combination of crown and flint glass is used,[1] and varies but little with the figures of the lenses, provided that the condition of correcting the spherical aberration is satisfied.

III. It follows from I. that when the radius of the circle of aberration is reduced to arc by dividing it by the focal length, it varies directly as the aperture and inversely as the focal distance of the objective; that is, it varies as the ratio A : L where A is the aperture and L the focal distance. Hence, if we use a given magnifying power upon any number of telescopes for which A : L is the same, the apparent diameter of the circle of aberration will be the same in all.

To give a definite numerical form to these propositions we put μ, the index of refraction of the glass of a lens for any ray; c, the curvature of a lens, that is, the sum of the reciprocals of its radii of curvature, these being taken as positive when convex, negative when concave; s, the reciprocal of the focal distance of a lens; a, the radius of its aperture; and $\nu=\mu-1$.

The simplest theory of the subject, which it is not necessary to develop here, shows that the focal length of a lens for light of refractive index μ is given by the equation

$$s=(\mu-1)c=\nu c.$$

Let us represent by ν_1 and ν_2 the values of ν for the two rays to be brought together in an achromatic combination, and represent by dashed letters the quantities relating to the flint lens. If we then put k for the ratio of dispersions of the two glasses, or

$$k=\frac{\nu_2-\nu_1}{\nu'_2-\nu'_1},$$

we must have between the curvatures of the lenses the relation

$$c'+kc=0.$$

The reciprocal of the focal length of the combination will then be given by any one of the equations

$$\begin{aligned} s&=\nu_1c+\nu'_1c'=\nu_2c+\nu'_2c' \\ &=(\nu_1-k\nu'_1)c=(\nu_2-k\nu'_2)c. \end{aligned}$$

Now let us consider any third ray whose values of ν are ν_3 and ν'_3. If all these rays passing through the objective of radius a fall on a perpendicular plane at the distance D from the objective, they will form a circle whose radius ρ is

$$\rho=a\{1-\mathrm{D}(\nu_3c+\nu'_3c')\}.$$

If we take for D the focal distance for the first two rays, or $\frac{1}{s}$, ρ will be the radius of the circle of aberration for the third ray, and we shall have

$$\begin{aligned} \frac{\rho}{a}&=1-\frac{\nu_3c+\nu'_3c'}{s} \\ &=\frac{(k(\nu'_3-\nu'_1)+\nu_1-\nu_3)c}{s}. \qquad \text{(A)} \end{aligned}$$

Were the ratio of dispersion of the two glasses the same through the entire spectrum, we should have

$$\nu_3-\nu_1=k(\nu'_3-\nu'_1),$$

and therefore $\rho=0$. But owing to the irrationality just described, this is never the case with the usual flint and crown glasses. To find the value of ρ/a for these glasses in some concrete cases, we take the indices of refraction found by Müller for a crown and three kinds of flint. (*Publicationen des Astrophysikalischen Observatoriums zu Potsdam*, Bd. IV., Th. 1.) The results for the rays C, D, F, and Hγ were:—

Ray.	Crown.	Flint. (1)	Flint. (2)	Flint. (3)
C . .	1·51509	1·57590	1·61974	1·64586
D . .	1·51767	1·57992	1·62462	1·65131
F . .	1·52383	1·58991	1·63685	1·66509
Hγ . .	1·52880	1·59832	1·64727	1·67691

Let us suppose that the combination is to unite the rays D and F, which would be the case with the somewhat "under-corrected" objectives of Schroeder. Taking the combinations of the crown glass with the several flints in the table, we have

$$\begin{aligned} \nu_1&=0·51767\,; \quad \nu_2=0·52383\,; \\ \nu'_1&=0·57992\,; \quad 0·62462\,; \quad 0·65131\,; \\ \nu'_2&=0·58991\,; \quad 0·63685\,; \quad 0·66509\,; \\ k&=0·6165\,; \quad 0·5038\,; \quad 0·4470\,; \\ s&=0·1601c\,; \quad 0·2031c\,; \quad 0·2265c. \end{aligned}$$

These numbers all refer to the united rays D and F. From the formula (A) we now find, for the radii on the focal plane formed by the rays C and Hγ respectively,

$$\begin{aligned} &\text{Ray C,} \quad \rho=·0006a\,; \quad ·0006a\,; \quad ·0007a\,; \\ &\text{Ray H}\gamma, \ \rho=·0014a\,; \quad ·0014a\,; \quad ·0014a. \end{aligned}$$

The minute differences in the case of ray C doubtless arise from the omitted decimals, so that we may regard the three results as identical. Our conclusion is: *In the focus of an ordinary achromatic telescope, the light of ray C is spread out in a circle whose diameter is* ·0006 *of the aperture of the objective, and that of ray Hγ in a circle of* ·0014 *of the aperture.* It follows that if the ratio of focus to aperture is the very common one of 15 : 1, the diameters of these circles of aberration expressed in arc will be 9″ and 19″.

In the mathematical theory of the problem a second approximation to perfect achromatism can be reached by combining three glasses of different dispersive powers in the various parts of the spectrum. The required combination depends upon the solution of three equations for the three rays that are to be combined. It happens, however, that the usual forms of crown and flint glass form a series, such that no advantage can be gained in this way. The coefficients of the three equations to be solved are the refractive indices for the three rays to be combined in the case of the three different kinds of glass, but in the kinds of glass alluded to, however varied may be these indices, their determinant vanishes. The result is that every triple combination will be equivalent to some combination of two kinds of glass, and no advantage can be gained by the addition of the third lens. If success is to be reached in this way, we must find glasses not belonging to the usual series. The problem has therefore been attacked on another side by seeking for new kinds of glass, the dispersions of which would not be affected by the irrationality of flint and crown glass. The best known of the efforts in this direction are those of Schott and Co. of Jena. This firm has succeeded in producing combinations said to be nearly free from the defect in question. It is necessary that the glass should admit of being made in large and at the same time homogeneous masses, and that it should not deteriorate with time, the importance of the first requirement arising from the circumstance that it is only with large telescopes that the secondary aberration becomes a serious fault. The astronomer, therefore, will not regard the problem as solved until telescopes of large size can be made with glass of the required quality. It does not appear that this practical solution of the problem has yet been reached.

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[1] This proposition is at variance with statements sometimes made by experts, and based on wave-lengths measured by Fraunhofer and others. But the writer has found it quite true for all combinations of glass for which he has been able to procure accurate data, and is not aware that it has been disproved by any actual experiment. He believes the error to have arisen from the circumstance that what were formerly called the Fraunhofer lines are really groups of lines where the position measured will depend on the power used.

In the Royal Astronomical Society's *Journal* for March 1894 Mr H. Denis Taylor described a perfectly achromatic refractor which may be made of three different kinds of Jena glass, but it does not appear that Mr Taylor's conception has yet been realized by the construction of any telescope of considerable size. The astronomical work of the world, visual as well as photographic, is therefore mainly carried on with object-glasses of the traditional construction affected by the defect in question.

The question has sometimes been considered whether the secondary aberration cannot be diminished by giving suitable curves to the lenses of the objective. The writer, however, has not been able to find that any material diminution can be brought about in this way, and the defect must therefore be regarded as inherent in the refracting telescope, and, so long as any combination of ordinary flint and crown glass is used for the lenses, incapable of material diminution except by increasing the focal length of the instrument.

Reflecting telescopes.

In the circumstances it might be expected that renewed attention would be devoted to the possibility of improving the reflecting telescope. It is therefore a curious fact that no serious attempt has yet been made to construct such an instrument equal in size to the celebrated reflector of Lord Rosse, made in 1845. The aperture of this instrument is 6 feet, while 4 feet seems to have been the practical limit in the case of any reflecting telescope in actual use. So far as the writer is aware, the most successful constructor has been Dr A. A. Common. To the practical difficulties connected with the management of such an instrument must be added that of so supporting the mirror that it shall preserve its figure in all positions. The great foe to the effectiveness of the mirror is the action of gravity upon it, producing a flexure which is fatal to the quality of the images. Although the problem of overcoming this difficulty is a purely mechanical one, a satisfactory solution has not been reached in the case of any mirror more than 4 feet in diameter. An additional defect in the reflector has been pointed out by Mr Schaeberle in papers published in the *Astronomical Journal*, vols. xviii. and xix. He shows that, while a parabolic mirror will form in its focus a perfect image of an object in the axis of the paraboloid, yet the image deteriorates rapidly when the object does not lie in that axis. This general fact is an obvious result of theory, but, until Schaeberle investigated this subject, no one had any conception of the rapidity with which the image might deteriorate towards the margin of the field of view. It follows from Schaeberle's results that, in the parabolic reflector, the deterioration begins a very few minutes away from the centre of the field and increases with great rapidity. It ought to be added that, in practice, it does not seem that the image deteriorates so rapidly as might be inferred from the theory. In any case, the effectiveness of the reflector for photographing nebulæ has been demonstrated by Keeler with the Crossley reflector of the Lick Observatory. Reference has been made in the article ASTRONOMY (vol. xxv.) to the extraordinary number of nebulæ found with this instrument. The absence of a secondary spectrum seems to be an advantage which compensates very serious defects in the geometrical quality of the focal image.

Photographic telescopes.

In the article TELESCOPE, in the ninth edition of this work, it was shown how, owing to the irrationality of the dispersions of flint and crown glass, a telescope achromatized for visual purposes is not suitable for photographing the heavenly bodies. For the latter purpose the flint lenses must be relatively less curved than for a visual instrument, the object being to bring the photographic rays as nearly as possible to the same focus. With this exception, the main features of the two telescopes, especially in their mounting, are similar. An accurate clock-motion is essential in the photographic instrument. In some of the first efforts to photograph the heavenly bodies with a telescope the focal image was enlarged by an eye-piece, but this practice has been abandoned, owing to the distortion of the image to which it gave rise, and photographs are now made by exposing the sensitized plate in the photographic focus of the instrument. From what we have said of the secondary aberration, it will be seen that, in theory, its amount in a photographic telescope of given aperture should be independent of the focal length. It would follow that, in photographing the stars for the purpose of measurement, the longer the focus the better, so long as the plate remains of manageable size, because we then have the heavens pictured on a larger scale, while the images of the stars remain unchanged in magnitude. Moreover, the quantity of light being the same with a given aperture whether the focus be long or short, a photograph should be taken in the same time with the short telescope as with the long one. In practice, however, this is not found to be the case, and the image is impressed more quickly on a plate in the focus of a short telescope than of a long one of the same aperture. This is probably due to the effect of atmospheric undulations upon the images of the stars. In using a visual telescope the observer can always choose moments when the images are exceptionally good; but the photographic plate can make no such choice, and must receive the impressed image with all the undulations the latter happens to have during the time of exposure. The effect of this cause increases in direct proportion to the length of the telescope. Practically, therefore, no advantage seems to be gained by greatly increasing the focal length of the photographic instrument for astronomical purposes. Some points of interest brought out by the use of such an instrument are these: (*a*) Objects can be photographed which are too faint to be visually perceptible with a telescope of the same size. This is especially the case with faint nebulæ, which are discovered by photography though entirely invisible to the eye. (*b*) The impression made by a star is not proportional to the product of the brightness into the time of exposure. For example, a star half as bright as another must be exposed more than twice as long to produce an equal photographic effect. The law of intensity of impression as a function of the brightness and time of exposure is not yet precisely established.

A new method of photographing with a telescope corrected for the visual rays only has been devised by Mr Ritchie of the Yerkes Observatory, and put into successful operation in connexion with the 40-inch telescope there. The method depends on three conditions: first, the use of the Cramer isochromatic photographic plates, having the property that, although the sensitiveness diminishes from the violet rays towards the green in the usual way, there is an increase of sensitiveness in the region of the lower green and yellow; second, this region is that in which the rays are most concentrated in the visual telescope; third, a colour screen is made of a collodion film of a greenish yellow tint, which cuts off all the light except that near the region of greatest concentration. The result is that the moon and star-clusters are photographed with a sharpness equal to that of the axial image in the best reflector, and of a breadth of field which the latter does not admit of. The drawback is the loss by absorption of the photographic energy of the blue rays, but this is of no importance where the faintest possible objects do not have to be pictured.

Photography is now being applied to the accurate measurement of small areas in the heavens, the method being to measure the linear distances and position-angles of the images on the photographic plates. If the distance is considerable, a degree or more, the most difficult problem that arises is to determine the value in arc of the unit of length, say one millimetre, on the plate. There are two ways of doing this. One is to measure the linear distance between two stars of which the angular distance is accurately known, and the other to compute the required factor from the measured focal length and other constants pertaining to the instrument. The solution of the problem in geometrical optics thus involved does not present serious difficulties. In photographing the heavens on an extended scale, a larger field of view is required than in the case of a visual telescope. The necessity of securing this result without distorting the images of stars near the edge of the field has led to the invention of several forms of objectives materially different from those of the visual telescope, and similar to those of the ordinary camera. The end has generally been reached by a combination of two objectives, separated by a greater or less interval; each being an achromatic combination, there are four glasses in all. Mr H. D. Taylor has proposed a triple combination which is said to admit of photographing a field 30° in diameter; it is composed of a double concave flint between two convex crown glasses, the glasses being separated by considerable intervals. Whether a combination of three or four lenses be used, it is certain that there is, in each case that may be presented, a system of curves of the lenses which will make the distortion a mathematical minimum; but the problem of determining these curves rigorously is so complicated that no general solution has yet been reached. (S. N.)

Tell, William.—The setting up in 1895 in the market-place in Altdorf of a fine statue of Tell and his son, and the opening in 1899 just outside Altdorf of a permanent theatre, wherein Schiller's play is to be represented every Sunday during the summer months, show that the popular belief in the Tell legend is still strong, despite its utter demolition at the hands of a succession of scientific Swiss historians during the 19th century. Professor Gisler of Altdorf (in his book, *Die Tellfrage*, Bern, 1895) has also made an attempt to rehabilitate it from the purely historical point of view. He is well acquainted with all the researches that have been made, but tries to save Tell's refusal to do reverence to the hat, his leap from the boat on the lake, and his slaying of the bailiff in the "Hollow Way." To effect the rescue of these incidents, he boldly admits the forgeries in the registers, abandons all the traditional dates, throws over Tschudi's account, and regards the shooting by Tell of the apple from his son's head as an "ornamental addition" to the tale. Save a mention of the Tell chapel on "Tellsplatte" in 1504 (the first known before was that by Tschudi in 1572), and a proof that the pilgrimages to Bürglen and Steinen had nothing to do with "St Kümmerniss," as her images are preserved in the *parish churches* of those villages, whereas the pilgrims go to the *chapels* therein, he brings forward no new evidence. His book is a striking proof that the popular Tell legend cannot claim the support of authentic history, while his attempt to find room for the atrocities of the wicked bailiffs elsewhere than at Altdorf consists only in suggesting an intricate series of possibilities, none of which are supported by any positive evidence. In a pamphlet (*Die Sagen v. Tell u. Stauffacher,* Basel, 1899) Herr August Bernouilli has applied the same sort of method to all the legends relating to the origin of the Swiss Confederation, but despite his exceeding ingenuity and zeal in spinning theories (for he has no new evidence whatsoever to bring forward), he cannot be said to have succeeded in vindicating any kernel of historical truth in these legends, even by his desperate plan of first eliminating all their characteristic features. (W. A. B. C.)

Tellicherry, a seaport town of British India, in the Malabar district of Madras, between Cannanore and the French settlement of Mahe. Population (1891), 27,196; municipal income (1897–98), Rs.48,450. The old fort still stands. The town is now a busy centre of export trade in coffee, cocoanut produce, spices, and sandal-wood. In 1897–98, 10 vessels entered and cleared for foreign trade, with an aggregate burthen of 17,171 tons. The Basel Protestant mission has a station here. The municipality manages the Brennen College, with 42 students in 1896–97, in which year also the two high schools had 473 pupils.

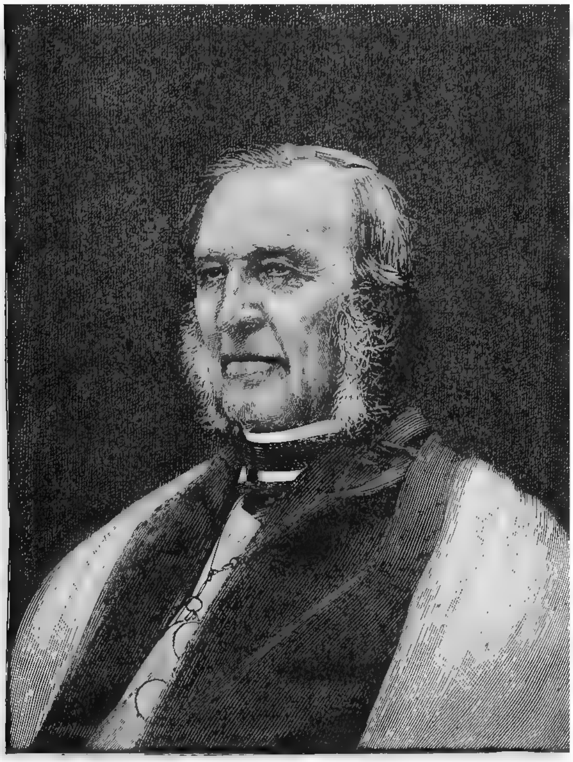
Tembuland. See Kaffraria.

Temesvár, a municipal town and capital of the county of Temes, Hungary, 160 miles south-east of Budapest. It is the most important centre of traffic and industry of south Hungary. Among its educational establishments are the Roman Catholic Institute, two upper gymnasia, a *real*-school, an infantry cadet school, two training institutes for teachers, two upper girls' schools, an upper commercial school, several special industrial schools, &c. Its industrial establishments include factories for tobacco, safes, cloth, matches, artificial manure and felt, besides breweries and distilleries. There is an electrical tramway for local traffic. Population (1891), 43,438; (1901), 53,033.

Temple, a city of Bell county, Texas, U.S.A., 36 miles south-west of Waco, at the intersection of lines of the Gulf, Colorado and Santa Fé and the Missouri, Kansas, and Texas railways, at an altitude of 698 feet. It is in a cotton region, and contains compresses, gins, oil-mills, and agricultural implement works. Its principal industry is in handling the cotton crop of the surrounding country. It was settled in 1882. Population (1890), 4047; (1900), 7065, of whom 360 were foreign-born and 1425 negroes.

Temple, Frederick (1821-——), Archbishop of Canterbury, was born in the island of Santa Maura, 30th November 1821, being the son of Major Octavius Temple, governor of Sierra Leone. He was educated at Blundell's School, Tiverton, and Balliol, Oxford, where he took a double first in 1842. At first he had to struggle with very narrow means, but as soon as he had passed through his university course, fortune smiled upon him. He became fellow and mathematical lecturer of his college, was ordained in 1846, and was appointed principal of Kneller Hall Training College in 1848. In 1858, after having been for some time a Government inspector of schools, he was elected headmaster of Rugby

School, in succession to Dr Goulburn, afterwards dean of Norwich. He also became chaplain to Queen Victoria. In 1860 the famous *Essays and Reviews* was published. The first essay in that volume, *The Education of the World*, was by Dr Temple, and though its contents were almost universally admitted to be unobjectionable, he was involved in the criticism bestowed on the rest, in spite of the fact that it was expressly stated that the responsibility of each author was limited to his own essay. Dr Temple's firmness, impartiality, and strict justice gained for him the respect and affection of his pupils, and rendered his administration of Rugby most successful. In 1869 Dr Temple, who had supported the disestablishment of the Irish Church and was known as a Liberal, was offered the bishopric of Exeter by Mr Gladstone. The appointment raised a storm in both the High and the Low Church camps. The old controversy in reference to the *Essays and Reviews* was revived, and the opposition was carried to the extent of a public protest against Dr Temple's appointment. At the confirmation of his election at St Mary-le-Bow, Cheapside, counsel were instructed to object to it, but ultimately their objections were overruled, and Dr Temple was duly consecrated on 21st December. During the sixteen years of Dr Temple's tenure of the see of Exeter, his firm and vigorous, as well as kindly rule, coupled with indisputable soundness, availed to dissipate all prejudices against him; and when, on the death of Dr Jackson in 1885, he was translated to London, the appointment gave general satisfaction. Dr Temple displayed the same vigour, firmness, and impartiality in his administration of the see of London as he had done at Exeter; and on the sudden death of Archbishop Benson in 1896, Dr Temple was appointed to the see of Canterbury. Dr Temple's archiepiscopal career has not been without its noteworthy features. He has presided over the Lambeth Conference of the bishops and archbishops of the Anglican Communion, which, usually held every ten years, was fixed for 1897 as the thirteenth centenary of the founding of the see of Canterbury by Augustine. In the same year Dr Temple and his brother archbishop issued an able reply to an encyclical of the Pope denying the validity of Anglican orders. The pronouncement of the Pope was drawn from him in consequence of negotiations which had been entered into by the Abbé Portal and the Abbé Duchesne on the side of the Roman Church, and by Lord Halifax, Father Puller, and others on the side of the Anglicans, with the view of bringing about the reunion of the two Churches on the basis of the recognition of the validity of Anglican orders. A publication called the *Revue Anglo-Romaine*, which contained communications from Roman and Anglican divines, was started in support of this movement. The project was, however, ultimately condemned by the Pope in the encyclical referred to. To this encyclical the reply of the two archbishops, which was published in Latin and English, was regarded on the Anglican side as a dignified and satisfactory answer. In 1900 the two archbishops were once more called upon for united action on behalf of the Anglican Church. The complaints against recent innovations in ritual having become very serious, and having given rise to some animated debates in Parliament, the united episcopate resolved, in accordance with the directions in the Book of Common Prayer, to refer the vexed questions of the use of incense in divine service, and the practice of reservation of the elements in the Lord's Supper, to the archbishops for their decision. After the matter had been fully argued out before them, the archbishops pronounced against the practices in question. Dr Temple's energy and industry in the performance of his archiepiscopal functions at his advanced age commanded general admiration. In 1902 he discharged the important duties of his office at the solemn coronation of King Edward VII. in Westminster Abbey.



Archbishop Temple.

(*From a photograph by J. Russell and Sons, London.*)

Temple, Sir Richard, Bart. (1826–1902), English administrator, a descendant in the female line of the Temples of Stowe, was born 8th March 1826, and after being educated at Rugby and Haileybury, joined the Bengal Civil Service. His industry and ready pen soon obtained appreciation, and after acting as private secretary for some years to John Lawrence in the Punjab, and gaining useful financial experience under James Wilson, he was appointed Resident at Haidarabad. In 1867 he was made K.C.S.I. In 1868 he became a member of the central Government, first as foreign secretary and then as finance minister; and he did admirable work during the famine of 1874, in the course of which he was made lieutenant-governor of Bengal. His services were recognized by the bestowal of a baronetcy in 1876. In 1877 he was made governor of Bombay, and his activity during the Afghan war of 1878–80 was untiring. In 1880 he left India to enter on a political career in England, but it was not till 1885 that he was returned as a Conservative for the Evesham division. Meanwhile he produced several books on Indian subjects. In Parliament he was assiduous in his attendance, and he spoke on Indian subjects with admitted authority; but he was not otherwise a parliamentary success, and to the public he was best known by the caricatures in *Punch*, which exaggerated his physical peculiarities and made him look like a lean and hungry Indian tiger. In 1885 he became vice-chairman of the London School Board, and as chairman of its finance committee he did useful and congenial work. In 1892 he changed his constituency for the Kingston division, but in 1895 he retired from Parliament, being in 1896 made a

Privy Councillor. He had kept a careful journal of his parliamentary experiences, intended for posthumous publication; and he himself published a short volume of reminiscences. On 15th March 1902 he died at Hampstead. He was twice married, and left a daughter and three sons, all of the latter distinguishing themselves in the public service.

Temryuk, a district town and seaport of Russia, northern Caucasia, in the government of Kubañ, on the Sea of Azov, 48 miles north-north-west of Krymskaya station on the North Caucasian railway. It was the seat of a Turkish fortress, Abass, till 1774, and is now a growing seaport for the export of grain, and has many flour-mills in its neighbourhood. It is in regular communication by steamer with Ekaterinodar. Population (1897), 14,476.

Tenasserim, a division of Lower Burma, bordering on Siam, 36,086 square miles, divided into six districts—Toungoo, Salwen, Thatôn, Amherst, Tavoy, and Mergui. Population (1891), 912,051, living in 3603 villages; (1900), 1,137,776. They paid a revenue in 1898–99 of Rs.34,87,686.

The population consisted of 763,771 Buddhists and Jains, 53,577 aborigines (chiefly Karens), 30,351 Hindus, 28,799 Mahommedans, 17 Parsis, and 35,536 Christians, the great majority of whom were Karens. The total area of the division is 23,085,040 acres, of which in 1898–99 the area cultivated was 1,249,695 acres; there were 2,151,066 acres under forests, 13,388,842 acres were uncultivable, and 6,255,286 acres were available for cultivation, besides 40,151 acres of current fallow. This division and that of Arakan are the oldest British possessions in Burma. The headquarters of the Commissioner are at Moulmein.

Ten Brink, Bernhard Egidius Conrad (1841–1892), German philologist, of Dutch origin, was born at Amsterdam on 12th January 1841, but was sent to school at Düsseldorf, and afterwards studied at Münster, and later under Diez and Delius at Bonn. In 1866 he began to lecture at the Münster Academy on the philology of the English and Romance languages. In 1870 he became professor of modern languages at Marburg, and after the reconstitution of Strasburg University he was appointed English professor there. In 1874 he began to edit, in conjunction with Scherer, E. Malim, and E. Schmidt, *Quellen und Forschungen zur Sprache und Kulturgeschichte der germanischen Völker*. He devoted himself for many years to the study of Chaucer. In 1877 he published *Chaucer-Studien zur Geschichte seiner Entwickelung und zur Chronologie seiner Schriften*; in 1884, *Chaucer's Sprache und Verskunst*. He also published critical editions of the *Prologue* and the *Compleynte to Pité*. Ten Brink's work in this direction stimulated a revival of Chaucer study in the United Kingdom as well as in Germany, and to him was indirectly due the foundation of the English Chaucer Society. He was a great teacher as well as an accurate and brilliant writer, and from many countries students flocked to his lecture-room. His *Studies in Beowulf* proved a valuable contribution to the study of Early English, and he contributed to Paul's *Grundriss der germanischen Philologie* an important article on Early English literature. Perhaps his best known work is his *History of English Literature*, which was unfortunately never completed, and broke off just before the Elizabethan period. Ten Brink, therefore, never made any important contribution to Shakespeare literature, though it was his intense admiration of this poet that first attracted him to the study of English. Five lectures on Shakespeare delivered at Frankfort were published after his death, and show his contempt for the Baconian theory and his thorough appreciation and grasp of his subject. His *History of English Literature* and his work on Chaucer's language and versification were translated into English. (A. Z.)

Ten Kate, Jan Jacob Lodewijk (1819–1889), Dutch divine, prose writer, and poet, was born at The Hague, 23rd December 1819. He started in life as a solicitor's clerk. It was his friend, Dr Heldring, pastor at Hemmen, in Gelderland, who, discovering in Ten Kate the germs of poetical genius, enabled him to study theology at the University of Utrecht (1838–43). Having completed his studies, Ten Kate became pastor at Middelburg, Amsterdam, and other places, meanwhile developing well-nigh ceaseless activity, both in prose and lyric poetry. Among his prose works may be mentioned the travel papers (Rhine, 1861; Italy, 1857–62), *Christelijke Overdenkingen* ("Thoughts of a Christian," 1849–52), and other religious studies. His early poetry was in the main original. The best known of his poems were—*Ahasverus op de Grimsel* ("Ahasuerus on the Grimsel," 1840); *Zangen des Tijds* ("Songs of the Times," 1841); *Legenden en Mengelpoëzie* ("Legends and Detached Poems," 1846); *In den Bloemhof* ("In the Flower Garden," 1851); *De Schepping* ("The Creation," 1866); *De Planeten* ("The Planets," 1869); *De Jaargetijden* ("The Seasons," 1871); *De Psalmen* ("The Psalms," 1874); *De Vrouw in het Nederlandsch Lied* ("Woman in Dutch Song," 1882); *Palmtakken en Dichtbloemen* ("Palm-branches and Flowers of Poesy," 1884). Ten Kate reached the pinnacle of his poetic fame in *The Creation*, *The Planets*, and *The Seasons*. These poems certainly show a masterly grasp of his mother tongue and a wonderful facility of expression, coupled with graceful vigour and fertile fancy. These qualities he also plentifully displayed in the innumerable translations he made of many of the masterpieces of foreign poetry in nearly every European language. He had not only an extraordinary aptitude for learning alien idioms, but also the gift of translating foreign lyrics into clear, fluent, and beautiful Dutch verse. Ten Kate's versatility in this respect has never been equalled; it extended from Tasso and Andersen to Dante, Schiller, Victor Hugo, Milton, Tennyson, and Longfellow. Ten Kate died at Amsterdam, 24th December 1889. His complete *Poetic Works* were published after his death in 12 volumes (Leyden, 1891). (H. TI.)

Tennessee, one of the south central states of the United States of America. It extends from the Appalachian mountains on the E. to the Mississippi river on the W., and lies between 35° and 36° 36′ N. and 81° 37′ and 90° 28′ W. Its area is 42,050 square miles, only 300 square miles of which is water surface. The population in 1900 was 2,020,616, as against 1,767,518 in 1890—an increase of 253,098, or 14·3 per cent. Ever since 1830 the increase has been continuous and without marked fluctuations except between 1870 and 1880, when it was 22·6 per cent. The average number of persons to the square mile was, in 1890, 42·3; in 1900, 48·4. Of the total population in 1900, 1,021,224 were males and 999,392 were females. Only 17,746 (less than 1 per cent.) were foreign-born. The negroes numbered 430,678 in 1890 and 480,243 in 1900, an increase during the decade of 11·5, as compared with an increase of 15·2 among the white population. Among 375,046 adult white males, 52,418, or 13·9 per cent., were illiterate (unable to write); among 112,236 negro males of like age, 53,396, or 47·6 per cent., were illiterate. The principal cities, and the only ones having over 10,000 in population in 1900, were Memphis, on the Mississippi (102,320); Nashville, the capital (80,865); Knoxville (32,637), Chattanooga (30,154), and Jackson (14,511). The population is chiefly rural; of 104 incorporated towns only 29 had in 1900 a population of more than 2000, and of these 21 had less than 5000, and only three had more than 5000 and less than 10,000. The urban population, including under this head all persons in places of more than 4000 inhabitants, increased from 11·4 per cent. of the total population in 1890 to 13·4 per cent. in 1900.

Education.—In 1900 the school population—between the ages of six and twenty-one years—was 768,843 (whites, 573,287; coloured, 195,556). The total actual enrolment in the public schools was 485,354, or only three-fifths of the school population, partly to be explained by the fact that the limits of school ages are so wide, few going to school under eight years and most leaving before seventeen. The total average daily attendance was 338,566 (whites 270,662; coloured, 67,904). The country schools are of two kinds—primary schools with six grades, and secondary schools with two additional grades. There are 5262 primary and 940 secondary schools for whites, and 1558 primary and 53 secondary schools for coloured. There are thus 6202 schools for white and 1611 for coloured children, with 8239 teachers. In the secondary schools there are only 18,443 pupils. There are, in addition, about 1000 private schools with an enrolment of 50,000 pupils. The schools in the towns and cities have from ten to twelve grades, and are divided into primary schools and high schools. There are 79 town schools for whites and 50 for coloured, with 956 teachers. The total number of public schools is 7954, with 9195 teachers, of whom 1834 are coloured. The total value of schoolhouses and other school property is $3,063,567. The total amount expended for the country schools in 1900 was $1,751,047, and for city schools $597,006—total $2,348,053. The average salary of teachers in country schools is $31.16 a month, in city schools $53.31. The average cost of tuition per pupil in country schools is $1.07 a month for less than five months, in city schools $1.87 a month for eight and a half months. The State University, at Knoxville, was chartered in 1794 by the first General Assembly of the territory, and was the first distinctly non-sectarian college established in America, and the second one to be opened west of the Alleghanies. It receives the appropriations of the national Government for agricultural and mechanical colleges and for agricultural experiment stations. The university includes a college with departments of agriculture, engineering and mechanics, and the arts; a graduate department; and schools of law, medicine, dentistry, and engineering. It occupies sixteen large brick and stone buildings, situated in beautiful grounds of thirty-eight acres, 1000 feet above the sea. The value of its buildings and grounds in 1900 was $462,566, of its invested funds $425,000, of its equipment $112,500. Its library numbers 22,425 volumes. In 1900 its total income (not including professional schools) was $83,859. The university had in 1900 750 students and 90 professors and instructors. The Vanderbilt University at Nashville, the property of the Methodist Episcopal Church South, was endowed chiefly by the elder Cornelius Vanderbilt of New York. It is organized in seven departments: arts, theology, law, medicine, pharmacy, dentistry, and engineering. Its property was in 1900 valued at $850,000, and it had 777 students and 89 instructors. The Peabody Normal College at Nashville is managed by the Peabody Board of Education. It uses the buildings and property of the University of Nashville, which has also a medical department, a college of music, a model school, and an academy. The Normal College in 1900 had 28 instructors and 602 students; the medical department 25 instructors and 210 students. The Peabody Board supports 200 scholarships in the Normal College, which are given to students from the Southern states. The University of the South, controlled by the episcopal dioceses of ten Southern states, is situated at Sewanee, the South-western Presbyterian University at Clarksville, and the South-western Baptist University at Jackson. The Fisk University in Nashville is an institution for coloured persons.

Charities.—The school for the blind at Nashville has three buildings, ten acres of land, and other property, aggregating in all $220,000 in value, with 185 pupils, at an annual cost of $76,881. The school for the deaf and dumb at Knoxville has five buildings and twelve acres, valued at $185,000, and 227 pupils, at an annual cost of $82,081. The industrial school at Nashville has five buildings and 92 acres, worth $150,784. It costs $130,528 a year to maintain this school for 600 pupils. There are three asylums for the insane. The Eastern Hospital at Knoxville has three buildings and a large farm, which cost $292,800; the Central Hospital near Nashville has seventeen buildings and 460 acres, valued at $426,500; and the Western Hospital at Bolivar has one building and 300 acres, valued at $393,350. In the three hospitals are 1280 patients at a cost of $375,401, or $140 per patient per annum. The state maintains also a home for disabled soldiers of the Civil War, which has five buildings and 450 acres, valued at $57,500, with 120 beneficiaries, at a cost of $19,000 a year. The total investment in charitable and educational institutions is $1,725,934, and the total annual charge for their 2396 pupils and inmates is $683,810.

Prisons.—In his biennial message to the General Assembly of 8th January 1901 the Governor says: "The penitentiary has not only been made self-sustaining, but has been so successfully worked that the labour of the convicts is utilized to reimburse the state for the money expended in their conviction. Most of the money thus realized comes from the [state] coal mines. The present system is far preferable to that formerly prevailing, whereby the convicts were leased to contractors." On 1st December 1900 there were 1744 convicts—544 whites and 1200 negroes. In the main prison at Nashville were 1110, including the women and delicate, whose net earnings in 1900 were $125,000. At the state mines were 634 able-bodied men and a few women, whose net earnings averaged $52,000 a year.

Railways.—The principal railways are the Southern, with 561 miles and a total valuation of $10,241,142; the Nashville, Chattanooga, and St Louis, with 879 miles and a total valuation of $14,051,470; the Louisville and Nashville, with 525 miles and a total valuation of $13,305,650; and the Illinois Central, with 266 miles and a total valuation of $8,137,834. The total mileage of railways on 1st July 1899 was 3129; number of miles of lines per 100 square miles of territory, 7·5; number of miles per 10,000 inhabitants, 15. The assessed valuation of the property of the railways distributable throughout the counties is $52,943,494, and of their localized property $2,352,918—total value $55,296,412; average value per mile on the distributable property in Tennessee, $17,623. The total state tax per annum on railways is $201,410; county tax, $474,144; municipal, $73,452. The railways pay over one-sixth of the taxes collected by assessment of property.

Taxation.—The total valuation of land in 1900 was $171,527,025, or $6.61 an acre; the total valuation of town lots was $120,338,355, and of other property, $48,493,768; or, adding the railway, telegraph, and telephone property, the total valuation of all taxable real property is $387,050,050. The rate of taxation for state purposes is 35 cents per $100. Real property bears nearly the entire burden of taxation. In 1899, when the assessed value of real property (excluding railways) was $271,021,726, the assessed valuation of personal property, excluding railway property, was only $37,693,230, or 12·2 per cent. of the whole. The ratio in neighbouring states with similar industries ran from 30 to 50 per cent., showing that 15 to 30 per cent. of personal property escaped. The state tax on real property yielded in 1900, net $1,022,029. Clerks of courts paid in certain fees, which brought the total returns from counties up to $1,556,989. Many privileges are taxed, amounting in 1900 to $417,199. Other sources of state revenue are: fees for charters, building and loan associations, insurance, and coal oil inspection. The total receipts for 1900 were $6,120,231; total disbursements, $6,095,299. The total bonded indebtedness is $16,953,266. Since 1899 10 per cent. of the gross receipts is carried to a sinking fund.

Miscellaneous.—There were 207 banks in 1900—national 48, state and private 159—with a total paid-up capital and surplus of $17,370,662, and deposits of $45,686,251. The number of newspapers and periodicals was 306. There are 27 cotton and 21 woollen-mills. The value of the annual production of flour is $13,000,000, of lumber $6,000,000, of leather $2,400,000; of cottonseed oil there are produced 3,200,000 gallons, and of distilled spirits 1,100,000 gallons. The largest churches are the following: the Methodist Episcopal Church South has 132,000 members; the Baptist has 115,000 white members, 62,000 coloured members; Cumberland Presbyterian, 43,000; Presbyterian, 18,300; Roman Catholic, 18,000; and Protestant Episcopal, 6000 members.

Agriculture.—Possessing many kinds of soils, spread out at all altitudes from 6000 feet down to 300 feet above sea-level, with a climate varying from the semi-tropical on the Mississippi river in the west, to the boreal on the mountain plateaus of the east, Tennessee has the greatest variety of agricultural and horticultural products. It has something in every column of the census of agriculture. Wheat, oats, rye, and barley mature well in the valleys of the eastern and central districts; maize is a great crop in all parts; tobacco is produced in nearly all quarters; and cotton is at home in the south-western corner of the state. Potatoes, sorghum, broom-corn, and peanuts are important crops also in the middle and west. Small fruits and vegetables are produced in large quantities for the great cities. The eastern section is well adapted to large fruits, and the grape does well all over the state. Nutritious grasses grow well, and stock-raising and dairying are great industries in the central and eastern portion. The following table shows the acreage, production and value of the principal crops in 1899:—

	Acreage.	Production.	Farm Value.
	Acres.	Bushels.	Dollars.
Corn (maize)	3,374,574	67,307,390	28,059,508
Wheat	1,426,112	11,924,010	7,882,697
Oats	235,313	2,725,330	887,940
Potatoes	27,103	1,404,097	817,419
Sweet potatoes	23,374	1,571,575	883,620
Orchard fruits	208,625	...	1,479,915
Hay	645,617	802,720 (tons)	6,811,577
Cotton	623,137	234,592 (bales)	8,192,642
Tobacco	71,849	49,157,550 (℔)	2,748,495

In 1899 Tennessee had 309,000 horses, of an average value of $43 per head; 140,000 mules, of an average value of $48; 240,000 milch cows, of an average value of $24; 287,000 other cattle, of an average value of $19; and 252,000 sheep, of an average value of $2.37. The poultry industry is a considerable one in the central and eastern parts.

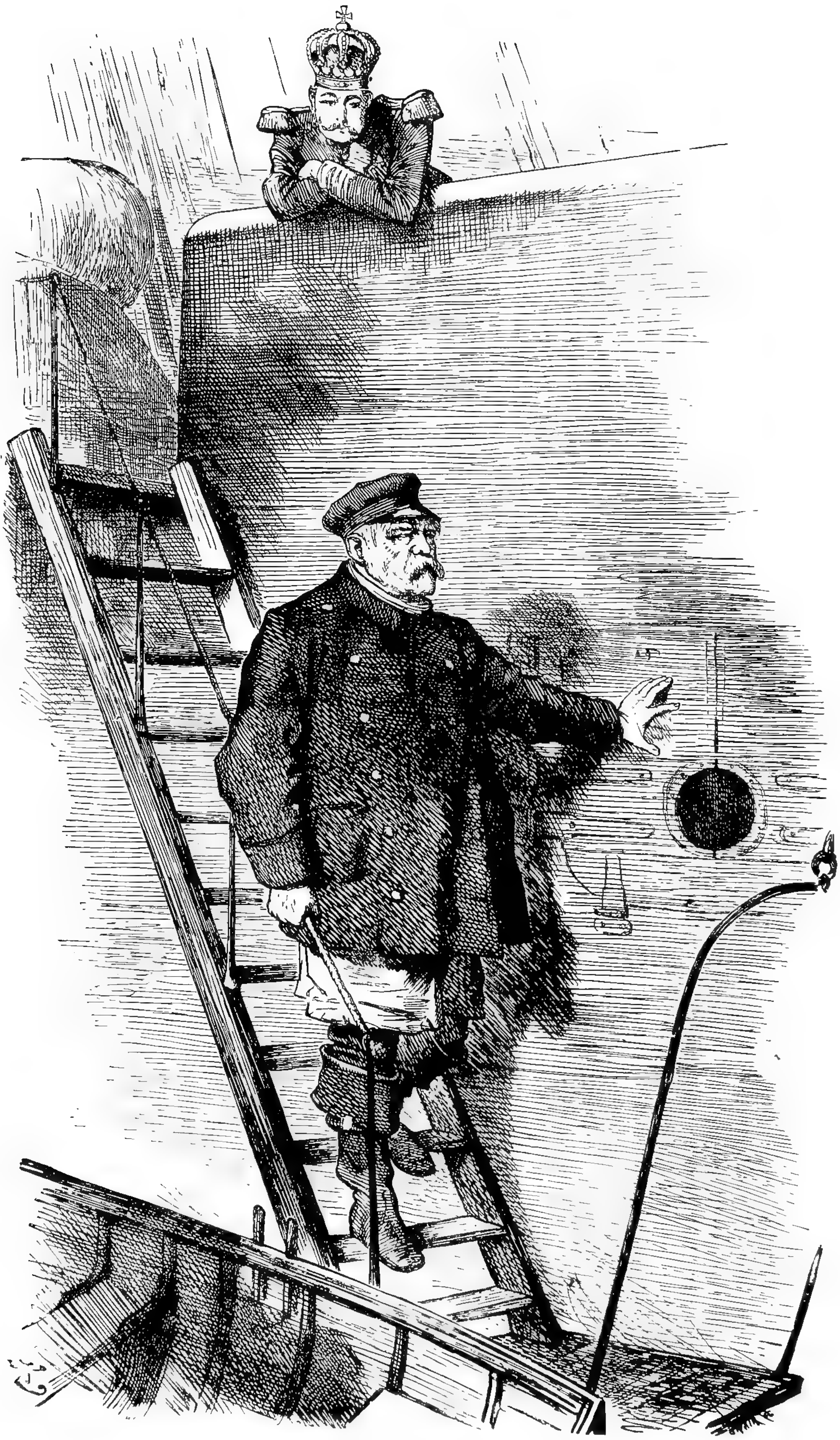
Mining.—The chief mineral productions in 1900 were coal, 3,904,048 short tons; coke, 494,438 short tons; iron ore, 700,000 long tons; copper, 116,000 long tons; and zinc, 3968 short tons. Phosphate mining is a new and great industry in middle Tennessee. In 1900 450,556 short tons of phosphate were produced, valued at $1,352,568 at the mines. The total number of persons employed in mining industries was in 1900 as follows: in coal mining 9181, in iron ore mining 1082, in copper mining and smelting 886, in phosphate mining 3000. Including some other small mines, the total was 15,000.

Administration.—The state government has the usual departments, legislative, executive, and judicial. The legislature has two chambers, the house and the senate; its members are elected for two years, and their sessions are limited to ninety days. The governor is elected for two years. In case of vacancy the speaker of the senate succeeds him. The legislature elects the secretary of state, the comptroller, and the treasurer; the governor appoints, subjected to confirmation by the senate, the superintendent of public instruction, the superintendent of prisons, the commissioner of agriculture, and the commissioner of labour and mines. The Supreme Court consists of five judges, elected for eight years. There are also chancery courts, circuit courts, and a court of chancery appeals. The large counties have separate criminal courts. The affairs of the counties are administered by the justices of the peace, elected two or more from each civil district, which is the smallest unit of government. The magistrates have both legislative and judicial powers. Each county has a sheriff, a trustee (collector of taxes and treasurer), a register, and clerks of courts. Towns and cities are incorporated by special Act of the legislature, and usually have a mayor and common council, with the ordinary municipal offices. Suffrage is free to male citizens of the United States who have been one year in the state and six months in the county. The Australian ballot system is in use in the larger towns and counties.

Political Changes.—During the last part of the decade from 1880 to 1890 an agrarian movement swept over the southern and western states, resulting in the organization of farmers in various societies called "granges," "wheels," &c., which were finally all united in a national "Farmers' Alliance." These organizations were naturally strong in Tennessee, an agricultural state, and for a time exerted a great influence in politics. They captured the Democratic party, which of recent years has controlled the state, and elected their nominee for governor in 1890 upon a platform which proposed many changes looking to the restriction of the business of the professional and commercial classes, especially the so-called "middlemen" who dealt in agricultural products or supplies, and to the advancement of the agricultural industries. The new governor was a farmer and the leading spirit in the Alliance, but his constituents were disappointed in their expectation of unreasonable and impossible changes. The most serious event during this administration was a miners' war, which grew out of the penitentiary lease system. Tennessee had had the lease system since 1867. The able-bodied convicts, a large majority of whom were young negro men, were leased to companies, who used them in manufacturing shoes and waggons, and in working marble quarries and coal mines. Under this system the people were relieved of the burden of supporting the convicts, who were made to bring the state a revenue of more than one hundred thousand dollars a year. Great discontent grew up, however, among the labourers, especially the miners. Free men could not get work at the coal mines, and the people living in the mining districts objected to having large bodies of convicts among them. The trouble began in July 1891, and continued at intervals until the autumn of 1892. The miners attacked the prisons and set the convicts at liberty at many places. They openly defied state authorities, and overpowered the first militia that was sent against them. The authorities did not get control until a considerable force of reorganized militia had been put in the field. Judge Peter Turney, an old-time Democrat, chief justice of the Supreme Court of the state, was nominated by the Democrats and elected governor in 1892 as a protest against the rather weak measures of the state government in the miners' war. These disturbances were soon brought to an end. Governor Turney advocated the abolition of the penitentiary lease system, the erection of a new large penitentiary, and the working of convicts in coal mines owned by the state. These measures were all carried out. Convicts are employed in various manufactures in the prison, in raising field and garden crops for their own use, and the more able-bodied ones are utilized in mining coal, upon property owned by the state, to be used in the capitol, asylums, and other state institutions. Governor Turney was a candidate for re-election in 1894, and the Republicans nominated Mr H. Clay Evans. At the close of the election both candidates claimed the office. The matter was carried before the legislature for investigation and settlement, and resulted in a bitter contest. The laws of Tennessee require that every citizen between 21 and 50 years of age shall pay a poll-tax every year or forfeit his right to vote. The legislative investigation showed that many men had voted who had not paid their poll-tax, and that in counties where this occurred Mr Evans had received his largest majorities. He was therefore declared not legally elected, and Governor Turney was inaugurated and served the full term. The chief legislative act of later years was the adoption of a "uniform text-book law," which provided a commission to select tax-books to be used in the public schools and to make contracts with publishers for supplying them at moderate and uniform prices. This Act went into effect 1st July 1899, with a contract which was to continue in force for a period of five years. (C. W. D.)

Tennessee River, the longest and most important branch of Ohio river, U.S.A. It takes its source in numerous streams in the Appalachian valley in south-western Virginia and east Tennessee, and in the mountains of western North Carolina. Among these head-waters are the Holston, Clinch, and Powell rivers of east Tennessee and the Nolichucky, Big Pigeon, French Broad, and Little Tennessee of North Carolina. The Tennessee is popularly regarded as commencing at the junction of the Holston and French Broad, near Knoxville, Tennessee. Thence it flows south-westwards through the Appalachian valley into Alabama, where it turns to west-north-west and, just touching Mississippi, returns into Tennessee. It crosses that state and also Kentucky, flowing nearly north to its mouth at Paducah. Its length from its mouth to Knoxville is 639 miles, and, following up the Holston to its source, 782 miles. Its drainage basin comprises 43,897 square miles. It is navigable from its mouth to Muscle Shoals in Alabama, and thence, by slack water navigation, to Knoxville.

Tenniel, Sir John (1820-——), English humorous and satirical artist—specially identified with *Punch*—was born in London in 1820. He educated himself for his career, and although he became a probationer, and then a student, of the Royal Academy, he soon left the schools, where at that time there was little teaching. In 1836 he sent his first picture to the exhibition of the Society of British Artists, and in 1845 contributed a 16-feet cartoon, "An Allegory of Justice," to the competition, held in that year, of designs for the mural decoration of the new Palace of Westminster. For this he received a £200 premium and a commission to paint a fresco in the Upper Waiting Hall (or "Hall of Poets") in the House of Lords. In spite of his tendency towards "high art," he was already known and appreciated as a humorist, and his early companionship with Charles Keen fostered and developed his talent for scholarly caricature. At Christmas time 1850 he was invited by Mark Lemon to fill the position of joint cartoonist (with John Leech) on *Punch*, from which Richard Doyle, offended by the attitude adopted by the paper towards the Papal see at the time of the so-called "aggression," had suddenly resigned. On the strength of his remarkable illustrations to Æsop's Fables, in which artistic power, humour of observation, and knowledge of animal life were equally apparent, Tenniel was selected on Douglas



"Dropping the Pilot." By Sir John Tenniel.

(By permission of the Proprietors of "Punch.")

Jerrold's initiative, to fill the breach, and he contributed his first drawing in the initial letter appearing on p. 224, vol. xix. His first "cartoon" was "Lord Jack the Giant Killer": it showed Lord John Russell, whose letter on the "aggression" had recently been published, valiantly assailing with the sword of truth and liberty Cardinal Wiseman, armed with a crozier. In 1852 we have Tenniel's first superb lion, and his first obituary cartoon (*q.v.* under CARICATURE). Gradually he took over altogether the weekly drawing of the political "big cut," which John Leech was happy to resign into his hands in order to restrict himself to his pictures of life and character. Leech's work consisted for the most part of farce; Tenniel's was high comedy, and not infrequently tragedy; and the freedom of the humorist heightened the severer beauties of the satirist. When Leech died his friend continued his work alone, and except in 1864, 1868, and 1875–6–7–8, during short spells of illness or holiday, he did not miss a single week. About 2300 cartoons, innumerable minor drawings, double-page cartoons for *Punch's Almanac* and other special numbers, and 250 designs for *Punch's Pocket-books*, comprise the sum of Sir John Tenniel's work for the periodical in the service of which he spent the greater portion of his life. When Tenniel retired from the service of *Punch* in January 1901 he received the honour of a farewell banquet (12th June), at which Mr A. J. Balfour, then leader of the House of Commons, presided and was supported by distinguished representatives of all that was best in English life. On that occasion Mr Balfour's description of Tenniel as "a great artist and a great gentleman" was applauded by the press of the whole country.

The main quality of Sir John Tenniel's work is accuracy of drawing, precision of touch, grace and dignity of conception, and—so far as such things can be compatible—geniality of satire. Tenniel raised the political cartoon into a classic composition, from which a sense of nobility is rarely absent. The beauty and statuesqueness of his ideal figures recall the influence, perhaps, of Cornelius and Overbeck—that German manner which was characteristic of many of our finer draughtsmen upon wood at the middle of the 19th century. But Tenniel's work is always original, unforced, and fresh; and it never suggests, what is the fact, that the artist's work is drawn exclusively from memory, and never from the model. It may be mentioned that Tenniel's wonderful observation has been conducted, and his knowledge accumulated, literally through a single eye, the other having been lost during a fencing bout in his youth. It was in recognition not only of his ability as an artist in black and white, but of his service in infusing good humour and good taste into one phase of political life, that a knighthood was conferred upon him on Mr Gladstone's recommendation in 1893. Without pronounced political opinions of his own, Sir John Tenniel adopted in his work those of his paper, of which the Whig proclivities were to some degree softened by his pencil. The political history not of England only, but to some extent of the world, of half a century appears in Sir John Tenniel's weekly cartoons, which are dignified by a number of types invented by the artist, the classic beauty of which may be looked for in vain in kindred work by any previous cartoonist. (Take, for example, Sir John's famous picture of "Dropping the Pilot" [see Plate], which appeared in *Punch* on 20th March 1890, vol. xcviii. pp. 150–51.) Two public exhibitions of Sir John Tenniel's work have been held, one in 1895 and the other in 1900. Sir John Tenniel is also the author of one of the mosaics, "Leonardo da Vinci," in the South Court in the Victoria and Albert Museum; while his highly stippled water-colour drawings have appeared from time to time in the exhibitions of the Royal Institute of Painters in Water Colours, of which society he was elected a member in 1874. As an illustrator on the wood-block he stands very high; his "Lalla Rookh" is perhaps the finest of all his work in point of conception, refinement, power, and technical excellence.

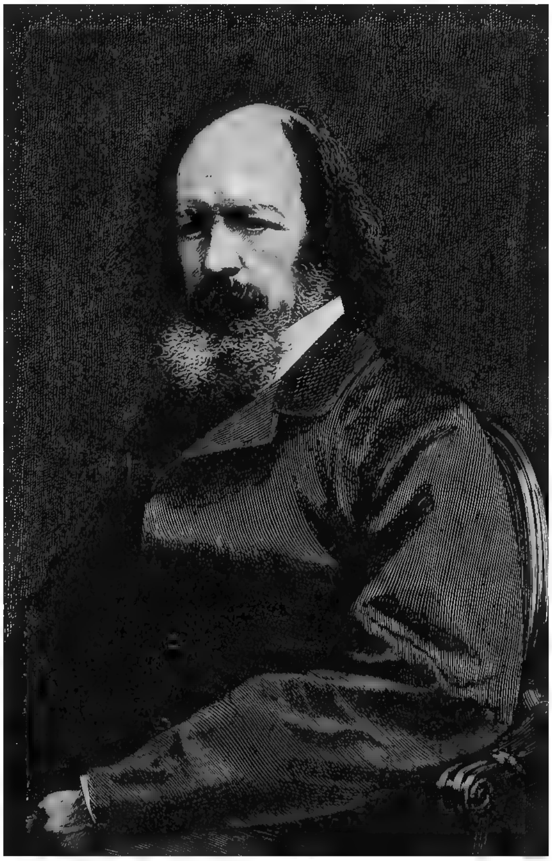
WORKS ILLUSTRATED—(1) *Juvenile Verse and Picture Book*, 1846; (2) *Undine*, 1846; (3) *Æsop's Fables*, 100 drawings, 1848; (4) Blair's *Grave*, 1858; (5) Shirley Brooks's *The Gordian Knot*, 1860, and (6) *The Silver Cord*, 1861; (7) Moore's *Lalla Rookh*, 69 drawings, 1861; (8) Lewis Carroll's *Alice's Adventures in Wonderland*, 1866; (9) *The Mirage of Life*, 1867; (10) Carroll's *Through the Looking-Glass*, 1870; and the following in collaboration: (11) Pollok's *Course of Time*, 1857; (12) *Poets of the Nineteenth Century*, 1857; (13) Poe's Works, 1857; (14) *Home Affections*, 1858; (15) Cholmondeley Pennell's *Puck on Pegasus*, 1863; (16) *The Arabian Nights*, 1863; (17) *English Sacred Poetry*, 1864; (18) *Legends and Lyrics*, 1865; (19) Tupper's *Proverbial Philosophy;* (20) Barry Cornwall's *Poems*, and other books. He also contributed to *Once a Week*, the Art Union publications, &c.

Tennyson, Alfred Tennyson, 1st BARON (1809–1892), English poet, was the fourth of the twelve children of the Rev. George Clayton Tennyson (1778–1831) and his wife Elizabeth Fytche (1781–1865). The Tennysons were an old Lincolnshire family settled at Bayou's Manor, where the poet's grandfather, Mr George Tennyson, M.P., resided, while the father was settled hard by in the rectory of Somersby. Here Alfred was born on the 6th of August 1809. The rich pastoral scenery of this part of Lincolnshire influenced the imagination of the boy, and is plainly reflected in all his early poetry, although it is now stated with authority that the localities of his subject-poems, which had been ingeniously identified with real brooks and granges, were wholly imaginary. At a very early age he began to write in prose and verse. At Christmas 1815 he was sent to the grammar school at Louth, his mother having kept up a connexion with this typical Lincolnshire borough, of which her father, the Rev. Stephen Fytche, had been vicar. Tennyson was at this school for five years, and then returned to Somersby to be trained by his father. In the rectory the boys had the run of an excellent library, and here the young poet based his wide knowledge of the English classics. The news of Byron's death (19th April 1824) made a deep impression on him: it was a day, he said, "when the whole world seemed to be darkened for me"; he went out into the woods and carved "Byron is dead" upon a rock. Tennyson was already writing copiously—"an epic of 6000 lines" at twelve, a drama in blank verse at fourteen, and so on: these exercises have, very properly, not been printed, but the poet said of them at the close of his life, "It seems to me, I wrote them all in perfect metre." The family was in the habit of spending the summer holidays at the coast of the county, commonly at Mablethorpe, and here Tennyson gained his impressions of the vastness of the sea. FitzGerald very justly attributed the landscape character of Tennyson's genius to the impress left on his imagination by "old Lincolnshire, where there were not only such good seas, but also such fine hill and dale among the wolds."

In 1827 Frederick Tennyson (1807–1898), the eldest surviving brother, uniting with his younger brothers Charles (1808–1879) and Alfred, published at Louth an anonymous collection of *Poems by Two Brothers*. The "two" were Charles and Alfred (whose contributions predominated), and who shared the surprising profits, £20. On the 20th February 1828 Charles and Alfred matriculated at Trinity College, Cambridge, where Frederick was already a scholar. The poet told the writer of these lines that his father would not let him leave Somersby till, on successive days, he had recited from memory the whole of the odes of Horace. The brothers took rooms at 12 Rose Crescent, and afterwards moved into Trumpington Street (now 157 Corpus Buildings). They were shy, and made at first few friends; but they gradually gathered selected associates around them, and Alfred grew to be looked up to at Cambridge "as to a great poet and an elder brother" by a group which included Trench, Monckton Milnes, Spedding, Thompson, FitzGerald, Brookfield, and, most of all, A. H. Hallam (1811–1833). In June 1829 Tennyson won the Chancellor's prize medal for his poem called "Timbuctoo." With great imperfections, this study in Miltonic blank verse displays the genius of a poet, in spite of a curious obscurity both of thought and style. Here are already both richness and power, although their expression is not yet clarified by taste. But by this time Tennyson was writing lyrics of still higher promise, and, as Arthur Hallam early perceived, with an extraordinary earnestness in the worship of beauty. The results of this enthusiasm and this labour of the artist appeared in the volume of *Poems, chiefly Lyrical*, published in 1830. This book would have been astonishing as the production of a youth of twenty-one, even if, since the death of Byron six years before, there had not been a singular dearth of good poetry in England. Here at least, in the slender volume of 1830, was a new writer revealed, and in "Mariana," "The Poet," "Love and Death," and "Oriana," a singer of wonderful though still unchastened melody. Through these, and through less perfect examples, was exhibited an amazing magnificence of fancy, at present insufficiently under control, and a voluptuous pomp of imagery, tending to an over-sweetness. The veteran S. T. Coleridge, praising the genius in the book, blamed the metrical imperfection of it. For this criticism he has himself constantly been reproved, and Tennyson (whose impatience of anything like censure was phenomenal) continued to resent it to the end of his life. Yet Coleridge was perfectly just in his remark; and the metrical anarchy of the "Madelines" and "Adelines" of the 1830 volume showed that Tennyson, with all his delicacy of modulation, had not yet mastered the arts of verse.

In the summer of 1830 Tennyson and Hallam volunteered in the army of the Spanish insurgent Torrijos, and marched about a little in the Pyrenees, without meeting with an enemy. He came back to find his father ailing, and in February 1831 he left Cambridge for Somersby, where a few days later Dr George Tennyson died. The new incumbent was willing that the Tennysons should continue to live in the rectory, out of which they did not turn until six years later. Arthur Hallam was now betrothed to Emily Tennyson (afterwards Mrs Jesse, 1811–1889), and stayed frequently at Somersby. This was a very happy time, and one of great physical development on Alfred's part. He took his share in all kinds of athletic exercises, and it was now that Brookfield said, "It is not fair that you should be Hercules as well as Apollo." This high physical zest in life seems to have declined after 1831, when his eyes began to trouble him, and he became liable to depression. The poetical work of these three years, mainly spent at Somersby, was given to the world in the volume of *Poems* which appeared at the end of 1832. This was one of the most astonishing revelations of finished genius ever produced, certainly by a young man of less than four-and-twenty. Here were to be read "The Lady of Shalott," "The Dream of Fair Women," "Œnone," "The Lotos-Eaters," "The Palace of Art," and "The Miller's Daughter," with a score of other lyrics, delicious and divine. The advance in craftsmanship and command over the *matériel* of verse shown since the volume of 1830 is absolutely astounding. If Tennyson had died of the savage article which presently appeared in the *Quarterly Review*, literature would have sustained terrible losses, but his name would have lived for ever among those of the great English poets. Indeed, it may be doubted whether, in several directions, he ever surpassed the glorious things to be found in this most exquisite and most precious book. It was well that its publication was completed before the blow fell upon Tennyson which took for a while all the light out of his life. In August 1833 Arthur Hallam started with his father, the great historian, for Tirol. They went no farther than Vienna, where Mr Hallam, returning to the hotel on the 15th September 1833, found his son lying dead on a sofa: a blood-vessel had broken in his brain. His body was brought back to England, and buried at Clevedon on the 3rd January 1834. These events affected Tennyson extremely. He grew less than ever willing to come forward and face the world; his health became "variable and his spirits indifferent." The earliest effect of Hallam's death upon his friend's art was the composition, in the summer of 1834, of *The Two Voices;* and to the same period belong the beginnings of the *Idylls of the King* and of *In Memoriam*, over both of which he meditated long. In 1835 he visited the Lakes, and saw much of Hartley Coleridge, but would not "obtrude on the great man at Rydal," although "Wordsworth was hospitably disposed." Careless alike of fame and of influence, Tennyson spent these years mainly at Somersby, in a uniform devotion of his whole soul to the art of poetry. In 1837, to their great distress, the Tennysons were turned out of the Lincolnshire rectory where they had lived so long. They moved to High Beech, in Epping Forest, which was their home until 1840. The poet was already engaged, or "quasi-betrothed," to Emily Sellwood, but ten years more had to pass before they could afford to marry. At Torquay, in 1838, he wrote *Audley Court* on one of his rare excursions, for he had no money for touring, nor did he wish for change: he wrote at this time, "I require quiet, and myself to myself, more than any man when I write." In 1840 the Tennysons moved to Tunbridge Wells, and a year later to Boxley, near Maidstone, to be close to Edmund Lushington, who had now married Cecilia Tennyson. Alfred was from this time more and more frequently a visitor in London.

In 1842 the two-volumes edition of his *Poems* broke the ten years' silence which he had enforced himself to keep. Here, with many pieces already known to all lovers of modern verse, were found rich and copious additions to his work. These he had originally intended to publish alone, and an earlier privately-printed *Morte d'Arthur, Dora, and other Idylls*, of 1842, is the despair of book-collectors. Most of those studies of home-life in England, which formed so highly popular a section of Tennyson's work—such as "The Gardener's Daughter," "Walking to the Mail," and "The Lord of Burleigh"—were now first issued, and, in what we have grown to consider a much higher order, "Locksley Hall," "Ulysses," and "Sir Galahad." To the older and more luxurious lyrics, as reprinted in 1842, Tennyson did not spare the curbing and pruning hand, and in some cases went too far in restraining the wanton spirit of beauty in its youthful impulse. It is from 1842 that the universal fame of Tennyson must be dated; from the time of the publication of the two volumes he ceased to be a curiosity, or the darling of an advanced clique, and took his place as the leading poet of his age in England. Among the friends whom he now made, or for the first time cultivated, were Carlyle, Rogers, Dickens, and Elizabeth Barrett. Material difficulties now, however, for the first time intruded on his path. He became the victim of a certain "earnest-frothy" speculator, who induced him to sell his little Lincolnshire estate at Grasby, and to invest the proceeds, with all his other money, and part of that of his brothers and sisters, in a "Patent Decorative Carving Company": in a few months the whole scheme collapsed, and Tennyson was left penniless. He was attacked by so overwhelming a hypochondria that his life was despaired of, and he was placed for some time under the charge of a hydropathic physician at Cheltenham, where absolute rest and isolation gradually brought him round to health again. The state of utter indigence to which Tennyson was reduced greatly exercised his friends, and in September 1845, at the suggestion of Henry Hallam, Sir Robert Peel was induced to bestow on the poet a pension of £200 a year. Never was public money expended in a more patriotic fashion. Tennyson's health slowly became restored, and in 1846 he was hard at work on *The Princess;* in the autumn of this year he took a tour in Switzerland, and saw great mountains and such "stateliest bits of landskip" for the first time. In 1847 nervous prostration again obliged him to undergo treatment at Prestbury: "They tell me not to read, not to think; but they might as well tell me not to live." Dr Gully's water-cure was tried, with success. *The Princess* was was now published, in a form afterwards considerably modified and added to. Carlyle and FitzGerald "gave up all hopes of him after *The Princess,*" or pretended that they did. It was true that the bent of his genius was slightly altered, in a direction which seemed less purely and austerely that of the highest art; but his concessions to public taste vastly added to the width of the circle he now addressed. The home of the Tennysons was now at Cheltenham: on his occasional visits to London he was in the habit of seeing Thackeray, Coventry Patmore, Browning, and Macready, as well as older friends, but he avoided "society." In 1848, while making a tour in Cornwall, Tennyson met Hawker of Morwenstow, with whom he seems—but the evidence is uncertain—to have talked about King Arthur, and to have resumed his intention of writing an epic on that theme. In his absent-minded way Tennyson was very apt to mislay objects; in earlier life he had lost the MS. of *Poems, chiefly Lyrical,* and had been obliged to restore the whole from scraps and memory. Now a worse thing befell him, for in February 1850, having collected into one "long ledger-like book" all the elegies on Arthur Hallam which he had been composing at intervals since 1833, he left this only MS. in the cupboard of some lodgings in Mornington Place, Hampstead Road. By extraordinary good chance it had been overlooked by the landlady, and Coventry Patmore was able to recover it. In this way *In Memoriam* was dragged back from the very verge of destruction, and could be published, in its original anonymous form, in May 1850. The public was at first greatly mystified by the nature and object of this poem, which was not merely a chronicle of Tennyson's emotions under bereavement, nor even a statement of his philosophical and religious beliefs, but, as he long afterwards explained, a sort of *Divina Commedia,* ending with happiness in the marriage of his youngest sister, Cecilia Lushington. In fact, the great blemishes of *In Memoriam,* its redundancy and the dislocation of its parts, were largely due to the desultory manner of its composition. The poet wrote the sections as they occurred to him, and did not think of weaving them together into a single poem until it was too late to give them real coherency. The metre, which by a curious naïveté Tennyson long believed that he had invented, served by its happy peculiarity to bind the sections together, and even to give an illusion of connected movement to the thought.



Alfred Tennyson.

(From a photograph by Elliott and Fry, London.)

The sale of Tennyson's poems now made it safe for him to settle, and on the 13th June 1850 he was married at Shiplake to Emily Sarah Sellwood (1813–1896). Of this union no more need be said than was recorded long afterwards by the poet himself, "The peace of God came into my life before the altar when I wedded her." Every species of good fortune was now to descend on the path of the man who had struggled against ill luck so long. Wordsworth died, and on the 19th November 1850 Queen Victoria appointed Tennyson Poet Laureate. The salary connected with the post was very small, but it had a secondary value in greatly stimulating the sale of his books, which was his main source of income. The young couple took a house at Warninglid, in Sussex, which did not suit them, and then one in Montpelier Row, Twickenham, which did better. In April 1851 their first child was born dead. At this time Tennyson was brooding much upon the ancient world, and reading little but Milton, Homer, and Virgil. This condition was elegantly defined by Carlyle as "sitting on a dungheap among innumerable dead dogs." In the summer of 1851 was made the tour in Italy, of which *The Daisy* is the immortal record. Of 1852 the principal events were the birth of his eldest son, the second Lord Tennyson, in August, and in November the publication of the *Ode on the Death of the Duke of Wellington.* In the winter of 1853 Tennyson entered into possession of a little house and farm called Farringford, near Freshwater, in the Isle of Wight, which he leased at first, and afterwards bought: this beautiful place, ringed round with ilexes and cedars, entered into his life and coloured it with its delicate enchantment. In 1854 he published *The Charge of the Light Brigade,* and was busy composing *Maud* and its accompanying lyrics; and this volume was published in July 1855, just after he was made D.C.L. at Oxford: he was received on this occasion, which may be considered his first public appearance, with a "tremendous ovation." The reception of *Maud* from the critics, however, was the worst trial to his equanimity which Tennyson had ever had to endure, nor had the future anything like it in store for him. He had risen in *Maud* far above his ordinary serenity of style, to ecstasies of passion and audacities of expression which were scarcely intelligible to his readers, and certainly not welcome. It is odd that this irregular poem, with its copious and varied music, its splendid sweep of emotion, its unfailing richness of texture—this poem in which Tennyson rises to heights of human sympathy and intuition which he reached nowhere else, should have been received with bitter hostility, have been styled "the dead level of prose run mad," and have been reproved more absurdly still for its "rampant and rabid bloodthirstiness of soul." There came a reaction of taste and sense, but the delicate spirit of Tennyson had been wounded. For some years the world heard nothing from him; he was at Farringford, busying himself with the Arthurian traditions. He had now become an object of boundless personal curiosity, being already difficult to find, and the centre of amusing legends. It was in 1857 that Bayard Taylor saw him, and carried away the impression of a man, "tall and broad-shouldered as a son of Anak, with hair, beard, and eyes of southern darkness." This period of somewhat mysterious withdrawal from the world embraced a tour in Wales in 1857, a visit to Norway in 1858, and a journey through Portugal in 1859. In 1857 two Arthurian poems had been tentatively and privately printed, as *Enid and Nimue, or the True and the False,* to see how the idyllic form would be liked by the inner circle of Tennyson's friends. In the summer of 1859 the first series of *Idylls of the King* was at length given to the world, and achieved a popular success far beyond anything experienced before by any English poets, save perhaps Byron and Scott. Within a month of publication, 10,000 copies had been sold. The idyls were four in number, "Enid," "Vivien" (no longer called "Nimue"), "Elaine," and "Guinevere." These were fragments of the epic of the fall of King Arthur and the Table Round which Tennyson was so long preparing, and which he can hardly be said to have ever completed, although nearly thirty years later he closed it. The public and the critics alike were entranced with the "sweetness" and the "purity" of the treatment. A few, like Ruskin, were doubtful about "that increased quietness of style"; one or two already suspected that the "sweetness" was obtained at some sacrifice of force, and that the "purity" involved a concession to Victorian conventionality. It was not perceived at the time that the four idyls were parts of a great historical or mystical poem, and they were welcomed as four polished studies of typical women: it must be confessed that in this light their even perfection of workmanship appeared to greater advantage than it eventually did in the general texture of the so-called "epic." In 1859 "Boadicea" was written, and "Riflemen, Form!" published in *The Times*. Urged by the Duke of Argyll, Tennyson now turned his attention to the theme of the Holy Grail, though he progressed with it but fitfully and slowly. In 1861 he travelled in Auvergne and the Pyrenees, with Clough, who was to die a few months later; to this year belong "Helen's Tower" and the "Dedication" of the *Idylls* to the Prince Consort, "These to his Memory." The latter led to Tennyson's presentation in April 1862 to the Queen, who "stood pale and statue-like before him, in a kind of stately innocence," which greatly moved his admiring homage. From this time forth the poet enjoyed the constant favour of the Sovereign, though he could never be moulded into a conventional courtier. He now put the Arthurian legends aside for a time, and devoted himself to the composition, in 1862, of "Enoch Arden," which, however, did not appear until 1864, and then in a volume which also contained "Sea Dreams," "Aylmer's Field," and, above all, "The Northern Farmer," the first and finest of Tennyson's remarkable studies in dialect. In April of this year Garibaldi visited Farringford; in February 1865 Tennyson's mother died at Hampstead in her eighty-fifth year; in the ensuing summer he travelled in Germany. The time slipped by with incidents but few and slight, Tennyson's popularity in Great Britain growing all the time to an extent unparalleled in the whole annals of English poetry. This universality of fame led to considerable practical discomfort; he was besieged by sight-seers, and his nervous trepidation led him perhaps to exaggerate the intensity of the infliction. In 1867 he determined to make for himself a haven of refuge against the invading Philistine, and bought some land on Blackdown, above Haslemere, then a remote corner of England; here Mr James Knowles began to build him a house, ultimately named Aldworth. This is the time of two of his rare, privately printed pamphlets, *The Window; or, the Loves of the Wrens* (1867), and *The Victim* (1868). The noble poem *Lucretius*, one of the greatest of Tennyson's versified monographs, appeared in May 1868, and in this year *The Holy Grail* was at last finished; it was published in 1869, together with three other idyls belonging to the Arthurian epic, and various miscellaneous lyrics, besides *Lucretius*. The reception of this volume was cordial, but not so universally respectful as Tennyson had grown to expect from his adoring public. The fact was that the heightened reputation of Browning, and still more the sudden vogue of Swinburne, Morris, and Rossetti (1866–1870), considerably disturbed the minds of Tennyson's most ardent readers, and exposed himself to a severer criticism than he had lately been accustomed to endure. He went on quite calmly, however, sure of his mission and of his music. His next volume (1872), *Gareth and Lynette* and *The Last Tournament*, continued and, as he then supposed, concluded the *Idylls of the King*, to the great satisfaction of the poet, who had found much difficulty in rounding off the last sections of the poem. Nor, as he was to find, was the poem yet completed, but for the time being he dismissed it from his mind. In 1873 he was offered a baronetcy by Gladstone, and again by Disraeli in 1874; in each case the honour was gracefully declined. Believing that his work with the romantic Arthurian epics was concluded, Tennyson now turned his attention to a department of poetry which had long attracted him, but which he had never seriously attempted —the drama. He put before him a scheme, which he cannot be said to have carried far, that of illustrating "the making of England" by a series of great historical tragedies. His *Queen Mary*, the first of these chronicle-plays, was published in 1875, and played by Mr Irving at the Lyceum in 1876. Although it was full of admirably dramatic writing, it was not theatrically well composed, and it failed on the stage. Extremely pertinacious in this respect, the poet went on attempting to storm the theatre with assault upon assault, all practically failures until the seventh and last, which was unfortunately posthumous. To have really succeeded on the stage would have given Tennyson more gratification than anything else, but he was not permitted to live long enough to see this blossom also added to the heavy garland of his glory. Meanwhile *Harold*, a tragedy of doom, was published in 1876; but, though perhaps the finest of its author's dramas, it has never been acted. During these years Tennyson's thoughts were largely occupied with the building of Aldworth. His few lyrics were spirited ballads of adventure, inspired by an exalted patriotism—"The Revenge" (1878), "The Defence of Lucknow" (1879)—but he reprinted and finally published his old suppressed poem, *The Lover's Tale*, and a little play of his, *The Falcon*, versified out of Boccaccio, was produced by the Kendals at their theatre in the last days of 1879. Tennyson had reached the limits of the three-score years and ten, and it was tacitly taken for granted that he would now retire into dignified repose. In point of fact, he now started on a new lease of poetical activity.

In 1880 he published the earliest of six important collections of lyrics, this being entitled *Ballads and other Poems*, and containing the sombre and magnificent "Rizpah." In 1881 *The Cup* and in 1882 *The Promise of May*, two little plays, were produced without substantial success in London theatres: the second of these is perhaps the least successful of all the poet's longer writings, but its failure annoyed him unreasonably. This determination to be a working playwright, pushed on in the face of critical hostility and popular indifference, is a very curious trait in the character of Tennyson. In September 1883 Tennyson and Gladstone set out on a voyage round the north of Scotland, to Orkney, and across the ocean to Norway and Denmark. At Copenhagen they were entertained by the king and queen, and after much fêting, returned to Gravesend: this adventure served to cheer the poet, who had been in low spirits since the death of his favourite brother Charles, and who now entered upon a phase of admirable vigour. During the voyage Gladstone had determined to offer Tennyson a peerage. After some demur, the poet consented to accept it, but added, "For my own part, I shall regret my simple name all my life." On the 11th March 1884 he took his seat in the House of Lords as Baron Tennyson of Aldworth and Farringford. He voted twice, but never spoke in the House. In the autumn of this year his tragedy of *Becket* was published, but the poet at last despaired of the stage, and disclaimed any hope of "meeting the exigencies of our modern theatre." Curiously enough, after his death *Becket* was the one of all his plays which enjoyed a great success on the boards. In 1885 was published another interesting miscellany, *Tiresias and other Poems*, with a posthumous dedication to Edward FitzGerald. In this volume, it should be noted, *The Idylls of the King* was completed at last by the publication of "Balin and Balan"; it contained also the superb address "To Virgil." In April 1886 Tennyson suffered the loss of his second son, Lionel, who died in the Red Sea on his return from India. The untiring old poet was steadily writing on, and by 1886 he had another collection of lyrics ready, *Locksley Hall Sixty Years After*, &c.; his eyes troubled him, but his memory and his intellectual curiosity were as vivid as ever. Late in 1888 he had a dangerous attack of rheumatic gout, from which it seemed in December that he could scarcely hope to rally, but his magnificent constitution pulled him through. He was past eighty when he published the collection of new verses entitled *Demeter and other Poems* (1889), which appeared almost simultaneously with the death of Browning, an event which left Tennyson a solitary figure indeed in poetic literature. In 1891 it was observed that he had wonderfully recovered the high spirits of youth, and even a remarkable portion of physical strength. His latest drama, *The Foresters*, now received his attention, and in March 1892 was produced at New York, with Miss Ada Rehan as Maid Marian. During this year Tennyson was steadily engaged on poetical composition, finishing "Akbar's Dream," "Kapiolani," and other contents of the posthumous volume called *The Death of Œnone*, 1892. In the summer he took a voyage to the Channel Islands and Devonshire; and even this was not his latest excursion from home, for in July 1892 he went up for a visit to London. Soon after entering his eighty-fourth year, however, symptoms of weakness set in, and early in September his condition began to give alarm. He retained his intellectual lucidity and an absolute command of his faculties to the last, reading Shakespeare with obvious appreciation until within a few hours of his death. With the splendour of the full moon falling upon him, his hand clasping his Shakespeare, and looking, as we are told, almost unearthly in the majestic beauty of his old age, Tennyson passed away at Aldworth on the night of the 6th October 1892. *Cymbeline*, the play he had been reading on the last afternoon, was laid in his coffin, and on the 12th he was publicly buried with great solemnity in Westminster Abbey. Of the twelve eminent men who supported the coffin, seven had already followed him in 1902—Argyll, Dufferin, Selborne, Jowett, Froude, Lowell, and Paget. Lady Tennyson survived until she reached the age of her husband when he died, and was buried at Freshwater in August 1896.

The physical appearance of Tennyson was very remarkable. Of his figure at the age of thirty-three Carlyle has left a superb portrait: "One of the finest-looking men in the world. A great shock of rough, dusky, dark hair; bright, laughing, hazel eyes; massive aquiline face, most massive yet most delicate; of sallow brown complexion, almost Indian-looking, clothes cynically loose, free-and-easy, smokes infinite tobacco. His voice is musical, metallic, fit for loud laughter and piercing wail, and all that may lie between; speech and speculation free and plenteous; I do not meet in these late decades such company over a pipe." He was unusually tall, and possessed in advanced years a strange and rather terrifying air of sombre majesty. But he was, in fact, of a great simplicity in temperament, affectionate, shy, still exquisitely sensitive in extreme old age to the influences of beauty, melancholy, and sweetness. Although exceedingly nearsighted, Tennyson was a very close observer of nature, and at the age of eighty his dark and glowing eyes, which were still strong, continued to permit him to enjoy the delicate features of country life around him, both at Aldworth and in the Isle of Wight. His *Life* was published, with admirable piety and taste, in two volumes, by his son, Hallam, second Lord Tennyson, in 1897.

At the time of his death, and for some time after it, the enthusiastic recognition of the genius of Tennyson took popular forms which were excessive and which it was obvious could not be enduring. We are now feeling the reaction against this extravagance, and criticism has of late been little occupied with the poet. The reason of this is easy to find. For an unusually long period this particular poetry had occupied public and professional opinion, and all the commonplace things about it had been said and re-said to satiety. It lacks for the moment the interest of freshness; it is like a wonderful picture seen so constantly that it fails any longer to concentrate attention. For a final estimate of Tennyson we must wait until a generation arises which is not under the spell of the overwhelming personal prestige which his sixty years of unceasing production gave him among his younger contemporaries. No poet has ever held England, no poet but Victor Hugo has probably ever held any country, quite so long under his unbroken sway as Tennyson did. As he recedes from us, however, we begin to see that he has much closer a relation to the great Georgian writers than we used to be willing to admit. The distance between the generation of Wordsworth and Coleridge and that of Byron and Shelley is not less—it is even probably greater—than that which divides Keats from Tennyson, and he is more the last of that great school than the first of any new one. The qualities in which he seems to surpass his immediate predecessors are exactly those which should be the gift of one who sums up the labours of a mighty line of artists. He is remarkable among them for the breadth, the richness, the substantial accomplishment of his touch; he has something of all these his elders, and goes farther along the road of technical perfection than any of them. We still look to the earlier masters for supreme excellence in particular directions: to Wordsworth for sublime philosophy, to

Coleridge for ethereal magic, to Byron for passion, to Shelley for lyric intensity, to Keats for richness. Tennyson does not excel each of these in his own special field, but he is often nearer to the particular man in his particular mastery than any one else can be said to be, and he has in addition his own field of supremacy. What this is cannot easily be defined; it consists, perhaps, in the beauty of the atmosphere which Tennyson contrives to cast around his work, moulding it in the blue mystery of twilight, in the opaline haze of sunset: this atmosphere, suffused over his poetry with inestimable skill and with a tact very rarely at fault, produces an almost unfailing illusion or mirage of loveliness, so that, even where (as must sometimes be the case with every poet) the thought and the imagery have little value in themselves, the fictive aura of beauty broods over the otherwise undistinguished verse. Hence, among all the English poets, it is Tennyson who presents the least percentage of entirely unattractive poetry. In his luminous subtlety and his broad undulating sweetness, his relationship with Virgil has long been manifest; he was himself aware of it. But he was also conscious that his exquisite devotion to mere lucidity and beauty might be a snare to him, and a happy instinct was always driving him to a study of mankind as well as of inanimate nature. Few English writers have known so adroitly as Tennyson how to bend the study of Shakespeare to the enrichment of their personal style. It should be added that he was a very deep and original student of literature of every description, and that the comparatively few specimens which have been preserved of his conversation contain some of the finest fragments of modern appreciation of the great poets which we possess. This is worthy of consideration in any attempt made to sketch the mind of a man who was above all other masters of recent literature an artist, and who must be studied in the vast and orbic fulness of his accomplishment in order to be appreciated at all. (E. G.)

Tenterden, a municipal borough and market town of Kent, England, in the Ashford parliamentary division of the county, 18 miles south-east of Maidstone, on the South-Eastern and Chatham railway. The town received incorporation charters from Henry VI. and Elizabeth. The church (Perpendicular), with its famous steeple, is well known for the legend connecting it with Goodwin Sands. The story is that the Abbot of St Augustine, Canterbury, diverted the funds by which the sea-wall protecting Earl Godwin's island Lomsa was kept up, for the purpose of building Tenterden steeple, the consequence being that in 1099 an inundation took place and "Tenterden steeple was the cause of the Goodwin Sands." Population (1881), 3620; (1901), 3243.

Tepic, a territory of the Mexican Republic, bounded on the N. by the states of Sinaloa and Durango, on the S. by Jalisco, on the E. by Zacatecas and Jalisco, and on the W. by the Pacific. Area, 11,279 square miles. Population (1895), 148,776; (1900), 149,677. The territory is divided politically into six *partidos*. The value of the agricultural products in 1896 was $6,990,622. The mining interests are also important. The capital, TEPIC, has a population of 14,560, fine public buildings, and considerable manufacturing interests, which would be largely increased with better transportation facilities, but there are no railways in the territory. San Blas is the principal port, and does a large business with the entire Pacific coast. It is connected with Tepic by a fairly good waggon road.

Teplitz, or TÖPLITZ (Czech, *Teplice*, which signifies "warm bath"), a town and watering-place in Bohemia, 47 miles north-west of Prague. Population (1890), 20,262; (1900), 24,110, mostly German and Catholic. In 1895 the village of Schönau was incorporated with the town, which now bears the official name of Teplitz–Schönau. In addition to its textile, chemical, and hardware industries, Teplitz now manufactures machinery and metal goods, glass, imitation jewellery, hosiery and knitted goods, stoneware, and sugar, besides carrying on dyeing and calico-printing. The patients now number nearly 6000, and the passing visitors over 23,000.

Terek (Russian, *Terskaya Oblast*), a province of north Caucasia, Russia, bordering on the Caspian Sea. It has an area of 23,548 square miles, and its population, which was 615,660 in 1884, numbered 933,485 (domiciled only) in 1897, when the female population numbered 445,996, and the urban population 115,179. According to Dr Pantukhoff's researches, malaria is prevalent everywhere except at the foot of the mountains, and is especially deadly along the Caspian shore. Notwithstanding this, however, there has been a steady flow of Russian immigration into the province, the Russian population now forming considerably more than a third of the whole; in 1895 there were 312,443 Russians out of a total population of 871,148. In the same year the numbers of the inhabitants of other nationality were (approximately): Ossets, 90,000; Kabardians, 80,000; eastern mountaineers (Tchetchens, Ingushes), 316,500; Kumyk Tatars, 31,500; Armenians, 13,700; the remainder being—Georgians (4500), Germans (8440), and Persians (2400). The province is divided into seven districts, the chief towns of which are Vladikavkaz (43,843), which is also the capital of the province, Groznyi (15,599), Kizlyar (7324), Nalchik (2571), Pyatigorsk (18,638), Sunzhinsk and Khasavyurt, the two last being mere nomad centres of administration. Other towns are Georgievsk (11,532) and Mozdok (14,583). Agriculture has developed greatly on the prairies, and in 1900 the total area under cereal crops was 1,336,900 acres, while the average yield in 1895–99 was: Rye, 786,000 cwt.; wheat, 1,525,000 cwt.; oats, 256,000 cwt.; and barley, 411,000 cwt.—all cereals, 8,273,000 cwt.; also potatoes, 1,172,000 cwt. The vine is very extensively cultivated, especially in the districts of Kizlyar and Pyatigorsk, where no less than 1,500,000 gallons of wine are made annually. Improved agricultural machinery is coming more and more into general use. Cattle-breeding is widely engaged in, and fishing is a valuable source of income, especially at the mouth of the Terek, where nearly 2000 tons of fish are obtained and 2770 cwt. of caviare made every year. Bees are generally kept, there being in the province over 200,000 hives, which yield every year about 4,000,000 roubles worth of honey and wax. Melons, cucumbers, sunflowers, &c., are extensively grown. Manufacturing industry is still in its infancy, and in 1898 the aggregate returns of all factories only amounted to a little over 4,000,000 roubles. Mining is also insignificant in character, only 106 ℔ of silver (Sadonsk) and 1890 cwt. of lead being produced in 1889. Naphtha, however, is obtained in large and growing quantities (390,500 tons in 1899) at Groznyi. Some salt is also obtained. The railway, which formerly stopped at Vladikavkaz, on the northern slope of the Caucasus, has now been continued from the Beslan station, near Vladikavkaz, to Petrovsk on the Caspian Sea, and thence to Baku, where it joins the trans-Caucasian line from Batum to Baku. There were in 1898, 15 middle schools for boys and girls, and 389 primary schools (15,445 boys and 5118 girls). No less than 115 had school gardens, while sericulture was taught in 40 primary schools and bee-keeping in 16.

Tergovista, the chief town of the district of Dãmbovitza, Rumania, picturesquely situated at the foot of the Carpathians, on the right bank of the Jalomitza, 48 miles N.N.W. of Bucharest. Population (1900), 9398. Formerly it was the capital of Wallachia, and in the 16th century had a population of 60,000, and contained 70 churches and 40 convents within its strongly fortified enceinte. In 1515 Neagru Bassaraba, the founder of the cathedral of Curtea d'Argesh, constructed the metropolitan church at Tergovista, one of the finest in the country, which with several others is still existent.

Tergu Jiu, chief town of the district of Gorj, Rumania, 60 miles N.N.W. of Craiova and near the Transylvanian Alps. It is the seat of the court of first instance, and has five churches. The annual fair is held on 15th August. Anthracite coal is found in the neighbourhood. Population (1895), 5400; (1900), 6634.

Terim. See ARABIA.

Termini, a seaport town of the province of Palermo, Sicily, Italy, on the north coast, 23 miles east-south-east of Palermo by rail. It has an archæological collection, a picture gallery, a technical school, and a navigation school, and produces macaroni (a speciality), olive oil, wine, liquorice, sulphur, and lime. It has also tunny-fishing, and trade in sulphur, fish, fruits, &c. The harbour is 12 to 25 feet deep. In 1897 it was cleared by 276 vessels of 82,398 tons. There is a hydropathic attached to the baths. Population (1881), 22,861; (1899), about 32,000.

Termites are insects with four wings which are developed outside the body (a large proportion of the individuals become adult, however, without wings appearing at all). The wings are of nearly one size, of long, narrow form, of paper-like consistence, and in repose are placed flat on the back of the insect so that only one wing shows. After a short time the wings are shed, and only small stumps remain as evidence of the individual being a winged form. The mouth has strong mandibles. Formerly Termites were classed as a part of the Order Neuroptera, but more recently they have been separated by certain zoologists from the true Neuroptera, and associated with some other forms as an Order Corrodentia. By Packard they have been associated with Mallophaga, and called Platyptera. They are, however, really an isolated form as much allied to Orthoptera as to Neuroptera, and now constitute by themselves the Order Isoptera, of which about 300 species are known. There is no great structural diversity in the Order, all the species being referred to the single family Termitidæ, which is therefore synonymous with the Order Isoptera. Termites are more widely known as White Ants, but as they are extremely different from true ants, and as they are rarely white, this designation is very deceptive, and should be abandoned.

Termites are found only in warm climates, where they are sometimes very destructive. They are vegetarian, but occasionally eat, or destroy, dry animal matter. The basis of their alimentary regimen is woody matter. Some of them make use of fungi growing in their abodes as food; some cut and store grass; others prepare a peculiar kind of food, which is stored in a tough, dry form, so that it has to be moistened before it can be eaten. Termites are social insects; many of them construct large edifices called termitaria and often spoken of as nests. A termitarium frequently contains an enormous number of individuals forming the society or colony. Termites are totally different in structure and development from all other social insects, but their social existence exhibits numerous analogies with that of the ants and other social Hymenoptera. The most remarkable of these analogies is that the reproduction of the species in each community is confined to a single pair, or to a very limited number of individuals. The members of one society or colony, however numerous or dissimilar they may be, are the descendants of a single pair. The colony is—so far as is known, and on this, as well as on many other points, authentic information is scanty—first started by a pair of winged individuals that cast their wings, secrete themselves in a suitable place, and produce young; the colony, however huge, being subsequently developed by the extreme fertility of the reproductive pair. Very little is known as to how long a colony endures, and, as there is greaty variety in the social conditions of different kinds of Termites, it is probable that there is considerable difference as to the point in question. As a rule a family or colony has only a single termitarium, but there are cases in which a single family has several separate abodes, though usually only one of them is a real home containing reproductive individuals. The social life in Termites, as well as in all other social insects, is clearly a development of the family life. It is accompanied by extraordinary modifications of the forms of the individuals constituting the society, and by a great division of labour. As regards the forms, or castes, Termites differ totally from other social insects; in the latter case there are great differences between the males and females, and the whole of the castes are of the female sex, whereas in Termites the males and

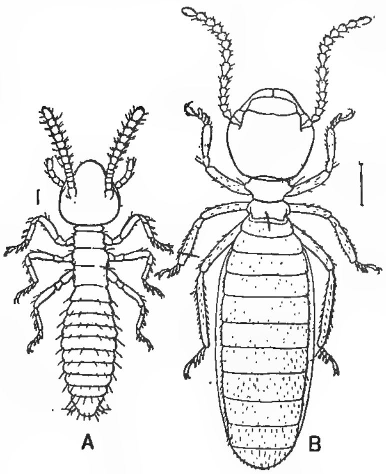


FIG. 1.—A, newly hatched termite; B, worker termite; *Termes nemorosus.*

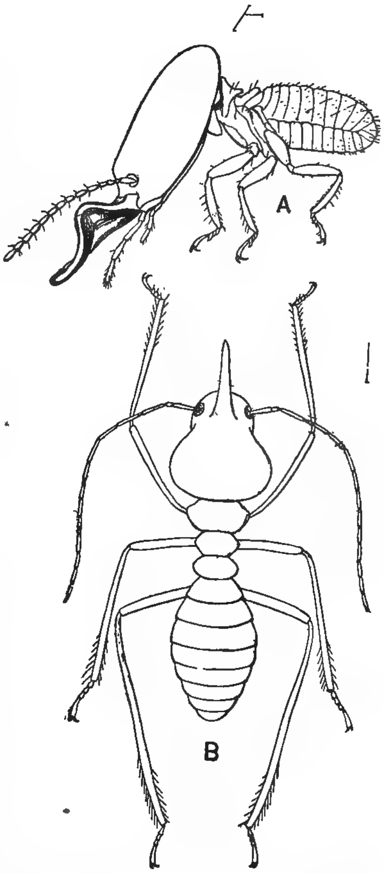


FIG. 2.—A, mandibulate soldier of *Termes nemorosus*; B, nasute soldier of *T. hospitalis.*

females are extremely similar, and the castes are in no way correlative with sex. As the Termite life is a family life, and as there is normally only a single pair of reproductive individuals in each community, it is easily comprehensible that if anything goes wrong with this pair, the community is at once thrown into a state of complete disorganization. But this misfortune is mitigated by a method which Termites have of keeping individuals in an undifferentiated state, and of turning some of them speedily into reproductive individuals, whereby the community is restored to something like a natural condition of activity and growth.

Apart from the forms that are merely juvenile, the following kinds of adults are normally present in a colony; (1) workers, (2) soldiers, (3) winged individuals ready to leave the nest, (4) king and queen.

(1) The *worker* Termite resembles the young in general appearance, and, like the young, has no trace of wings (Fig. 1). The two segments behind the head are more contracted, so that head, thorax, and abdomen are more differentiated than they are in the young. The colour too is different, the young being milky-white, whereas the adult worker is variously pigmented according to its species, but is never milky-white. The worker is generally blind, and in only a few species does it possess rudimentary eyes. The species of the group Calotermitides have no workers. In the other species the workers look after the eggs and young, and perform most, if not all, the industrial work of the community. They are also, in some cases, effective combatants, though quite destitute of any special structures to suit them for this purpose. The sexual organs do not undergo development, but it has been satisfactorily ascertained that both sexes are represented amongst the workers. In certain species the workers seem to be dimorphic, so far as size is concerned, but this point has apparently been only very inadequately considered. Workers form a very large but variable proportion of the members of a community.

(2) The *soldier* Termite is the most extraordinary feature of Termitid biology. It is more varied than any of the other castes, so that most of the species of Termites can be best distinguished by their soldiers. The chief feature of the soldier is an extraordinary development of the head, or of the head and mandibles. There are two very distinct kinds of soldiers: (*a*) the flat-headed or mandibulate soldier, and (*b*) the nasute or rostrate soldier (Fig. 2). In the first kind the head is usually developed out of all proportion to the rest of the body; the mandibles are frequently enormous, and, being in many cases asymmetric, give the appearance of deformity. In the nasute soldier the head is thick or convex, and may be described as unicorn—that is to say, it is prolonged in the middle so as to form a single pointed horn; the mandibles are never largely developed. No species of Termite has both mandibulate and nasute soldiers, although the reverse is sometimes still stated in books. The soldiers of some species are, however, dimorphic to the extent that larger and smaller forms occur in the same nest without intermediates. In other cases soldiers of simply variable size exist. The soldier is blind and wingless, though in a few soldiers minute wing-rudiments can be detected. As in the worker, the development of the sex organs is arrested, but both sexes are represented. The function of the soldiers is probably, as stated by Haviland, defence. The mandibulate soldiers use their heads as blocks to stop gaps in the nests, and employ terrifying but somewhat theatrical devices, making threatening motions and producing noises by movements of the head and thorax. The nasute soldiers emit a fluid from the tip of the rostrum, and dab it upon their enemies with some skill. Soldiers are present in all species of Termites except the South American genus Anoplotermes. It is a remarkable fact that in the group Calotermitides soldiers exist although there are no workers, but in this case the function of the soldier seems to be very much that of a worker. Grassi says that in *Calotermes flavicollis* all the individuals of a community work for the common welfare. Moreover, in the Calotermitides no very great development of the heads or mandibles occurs.

(3) *Adult or Winged Termite.*—Such of the young as do not become workers or soldiers grow and develop after the fashion usual in exopterygote insects. Moults take place, the wing-pads gradually increase in size, eyes appear, and finally pigmentation takes place, and the winged insect is perfected at the last moult (Fig. 3). In prosperous colonies these winged insects are produced in large numbers and emerge at intervals as swarms. They have extremely feeble powers of flight, and apparently scarcely any other capability. They are a favourite food of a large number of animals, including even man. They have well-developed eyes and ocelli, and differ from all the other forms by their greater pigmentation. The function of these adults is to diffuse the species, and to favour crossing outside the family circle. Attainment of this second end is, in some cases, favoured by the fact that the whole of the individuals constituting a swarm consist of one sex only. This extraordinary fact is attested by Grassi, but has not yet received the attention it merits. If a Termite colony be compared with a tree or plant, the winged forms, it is clear, functionally correspond to the flowers and seeds of the tree; indeed, Fritz Müller and Grassi go further, and conclude that the modes of diffusion and reproduction of Termites are analogous to the modes of plants of continuing the species by means of cleistogamic as well as ordinary flowers. The force of this comparison will be better appreciated after the reader has made himself acquainted with the facts connected with the neoteinic forms of Termites.

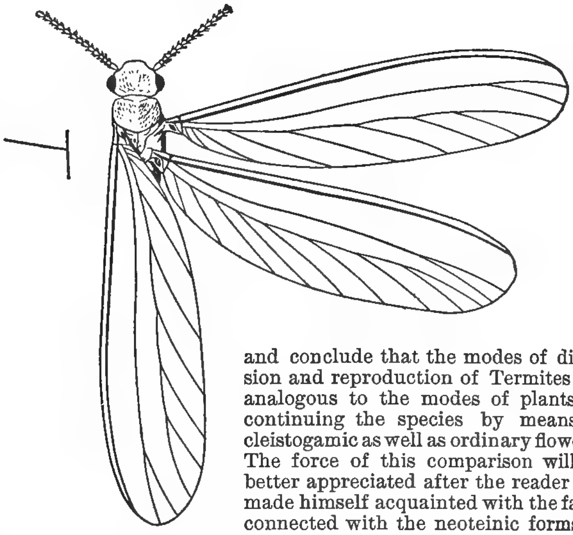


Fig. 3.—Adult Winged Termite: *T. nemorosus*; wings of the right-hand side expanded.

(4) *King and Queen.*—As a rule each community includes only a single pair of individuals apt for reproduction; these are the royal pair, or king and queen (Fig. 4). They are adult Termites that have shed the wings they formerly possessed. The queen usually undergoes an extraordinary increase in the size of the abdomen, which may be distended to many hundred times its original capacity (Fig. 4, A). In many species the king and queen are confined in a royal cell, out of which they cannot move, though the workers, owing to their smaller size, can get in and out to tend them. In other cases the queen only is so imprisoned, the king being able to leave the cell. In still other cases neither king nor queen is effectually imprisoned. Much discrepancy of opinion exists as to the invariable presence of a king in each nest; this, however, is explained by Haviland's observation that the king is active and timid, and when a nest is opened seeks safety by running away and concealing himself, so that he is sometimes only discovered when the very last fragment of the nest is brought under scrutiny. Another point on which extremely diverse opinions are expressed is the copula of the sexes. It is usually stated that the swarming of Termites is analogous to that of bees and ants, in which groups of insects the conjunction of the sexes takes place at this period, and at this period only. In the Termites the reverse is the case. The swarming is not at all a nuptial flight; indeed, at that time the sexes are not apt for reproduction. Copulation only takes place after a pair have cast their wings and have established themselves together. It is repeated at intervals, and is thus quite dissimilar from the corresponding phenomenon in Hymenoptera. The male has no intromittent organs, so that

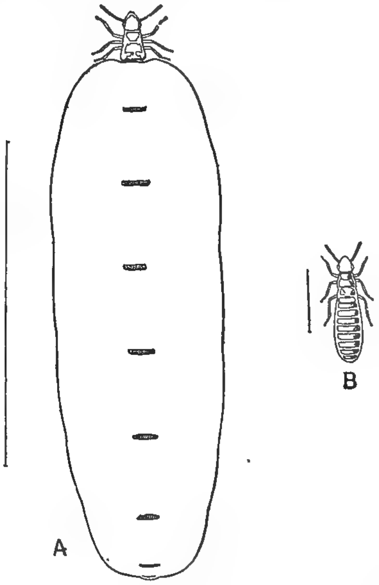


Fig. 4.—A, queen; B, king: *T. nemorosus.*

copula during flight is impossible. Grassi has actually witnessed the act in subsequent life. Haviland is of opinion that in some cases the male fertilizes the eggs without connexion with the female.

(5) *Neoteinic and Substitution Forms.*—When a colony of Termites is deprived of king and queen it can replace them by forms specially prepared. These substitution forms are of two kinds—(*a*) normal adult individuals, and (*b*) neoteinic forms. The latter may be described as unnatural kings and queens possessing reproductive powers, though the wings have never been developed and some other parts of the body have not taken on the fully adult state. Haviland removed the royal pairs from nests of *Termes malayanus*, and after three or four months again examined the nests: in three out of the five cases substitution pairs exactly resembling the original ones, with well-formed wing-stumps, were present; in the other two cases he failed to find the royal cell, and believes that the loss had not been repaired. In other species the bereavement is made good by means of neoteinic instead of normal individuals, and in certain species neoteinic forms are abundantly found. In the case of substitution forms there is usually more than one pair present in a colony, and sometimes numerous pairs exist. Grassi says that in Sicily the colonies of *Termes lucifugus* are kept up entirely by neoteinic kings and queens; in other words, the swarms are nearly or quite useless. The neoteinic forms are compared to cleistogamous flowers; and this curious case is parallel with that of a species of plant whose reproduction should be accomplished entirely by its cleistogamous flowers, though at the same time it produced perfect flowers in abundance. The condition recorded by Grassi is probably extremely exceptional. Fritz Müller found once a colony in which a true king was acting as consort to a considerable number of neoteinic queens, no true queen being present.

In order to understand the curious phenomena presented by the castes and variety of forms of a single species of Termite, it is necessary to become acquainted with their food-habits, which are very peculiar and may be described as communistic. Termites have the habit of eating their cast skins and even their dead companions, and in fact their system of keeping the nest clean seems to be that of eating the refuse of their own bodies till it no longer contains any digestible matter. This cannibalism is the more remarkable, as they will not eat other Termites. The most curious part of their dietary is their complex system of feeding from the matters contained in the alimentary systems of their fellows. When a Termite wishes food it strokes the body of another individual with its antennæ, and the specimen thus caressed exudes from the posterior or from the anterior part of the body a drop of matter, which is eaten by the hungry one. The matter exuded from the posterior part of the body appears to be very different from that yielded by the mouth, so that there are at least two kinds of this excretory food. The proctodæal food (that which comes from the posterior part of the body) is in great favour with adult Termites, but so far as is known it is not used for feeding the newly born young, which are believed to be fed on matter elaborated in the bodies of the adult workers and communicated by their mouths. Subsequently the young take also proctodæal food, and triturated vegetable matter.

Origin of the Castes.—When Termites are hatched from the eggs none of the remarkable differences that are manifested in the individuals in subsequent life can be detected. The sexes are in Termites extremely similar in external characters. When the young are hatched they all appear nearly exactly alike, though on careful examination the sexes can be distinguished. But no other difference than that of sex can be detected. In the article on ANT in vol. ii. of the *Encyclopædia Britannica* it was stated (p. 99) that "the distinction between soldier and worker can be easily seen in the egg." This is contradicted by all modern observations, and is certainly erroneous. It is true that considerable difference of opinion exists as to when the distinction between soldier and worker first becomes evident, but all are agreed that it is not till after the growth is to some extent accomplished. The discrepancy that exists in opinions on this point is due to the facts: (1) that different species have been under observation; and (2) that the modification of the larva to form a soldier may commence at more than one period of the development even in the same species. It being ascertained that all Termites commence as undifferentiated larvæ, the question arises as to what causes the differentiation into castes. This question is the more important as two of the castes (the worker and soldier) do not at all resemble their parents. Grassi, from an examination of the individuals of a large number of nests of *Termes lucifugus*, arrived at the conclusion that all start as undifferentiated larvæ, and that the regular development of Termes up to the perfect insect may undergo a deviation at various periods of life leading to the formation of workers, of neoteinic forms, or of soldiers, the last passing through the stadium of the young worker. He attributes this deviation, which may take place at various periods, to the influence of food, and attaches special importance to the salivary food. The soldiers have no wings; nevertheless a larva, or young nymph that has the rudiments of wings, can be made into a soldier. Grassi has found juvenile specimens that have already assumed the soldier form, although they possess the rudiments of wings. It appears from his observations that the worker may be considered as a form with arrested development, and the soldier as a form with arrested and much diverted development, while the neoteinic forms are individuals in which the reproductive organs are perfectly developed, while some of the bodily structures have suffered arrest of development and even some amount of atrophy.

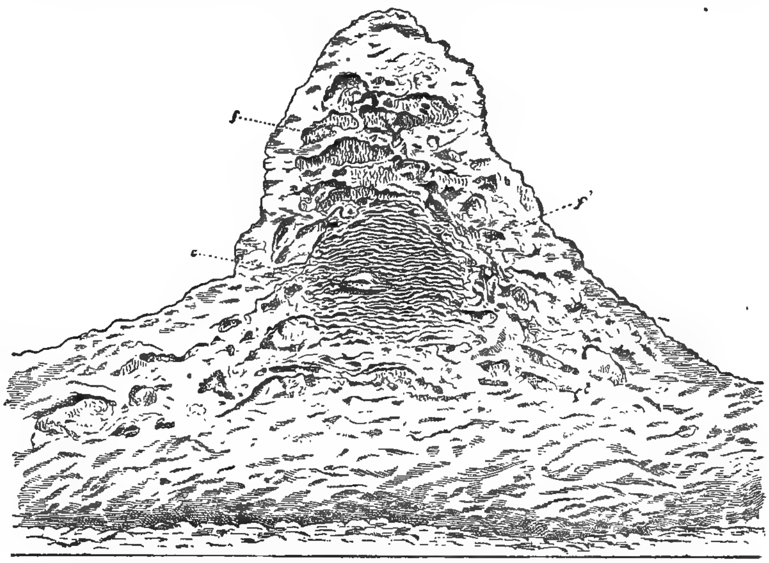


FIG. 5.—Termitarium of *Termes malayanus*: *f*, fungus-chamber; *c*, royal cell.

The soldier form of Termite presents most difficult questions to the biologist, its special structures bearing no approximation to any characters possessed by the parents. Various theories have been proposed to account for this fact, but they are mere guesses. We may, however, mention that it is possible that soldiers and workers occasionally produce young. This has never been actually observed, but specimens have been found with the sexual organs partially developed, and Silvestri has recorded the occurrence of workers with some of the characters of the females, in South America, in a nest of *Termes strunchii*.

Termitaria.—There is nothing in which Termites display more variety than in their dwellings. These are sometimes not constructions at all. The primitive *Calotermes flavicollis*—in which there is no worker—frequently inhabits rotten places in trees; at most it increases these a little by excavation, and modifies the passages by slight and imperfect barricades. In the case of this species the community never attains a greater number than one thousand individuals, and even this is comparatively rare. On the other hand we have the huge solid structures, 10 or 12 feet high, delineated by Smeathman with cattle standing on their summits. Saville Kent has observed termitaria in Australia 18 feet high. As a rule large termitaria do not occur in considerable numbers in a restricted area, but there are exceptions even to this. At Somerset, Cape York, there is one of the most remarkable Termite cities of the world. Viewed from the sea, it appears as if the plain for a mile or more in extent were covered with pointed pillars varying, according to different accounts, from 6 to 13 feet in height, broad at the base and tapering to the summit, forming regular symmetrical pyramids. In this part of Australia there is also found the "compass," "magnetic," or "meridian" Termite, the mounds of which have somewhat the shape of a tombstone, and have always the same orientation, the wider face of the structure always extending north to south. It has been suggested that this is connected with the necessity of regulating the temperature or the amount of desiccation of the nest, but there is no evidence whatever on the point. A termitarium on being opened displays a vast number of irregular chambers separated by thin partitions (Fig. 5, *f*), the royal cell being placed in the middle (Fig. 5, *c*). The material used is of an earthy nature, but the interiors of many earthy termitaria are largely composed of woody fibre, the refuse proceeding from the alimentary canals of the insects being used for this purpose. A considerable number of the larger Termites use fungi for their food-stuff. There are special chambers where these are cultivated, the matter on which the fungus is grown being of a woody nature and sponge-like in its structure. The fungi make their appearance as small globules. Probably the spores or mycelium are placed in the mass when it is formed by the Termites; but very little is yet known as to this fungus and its mode of treatment by them.

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Ternate, one of the two Dutch residencies in the East Indian Archipelago, exercising authority over the area of the ancient kingdoms of Ternate and Tidor (see AMBOYNA and MOLUCCAS). The residency consists of the following groups of islands: the Gilolo or Halmaheira group, the Bachian and the Obi group, the Sula islands, the islands near the western half of New Guinea (Gebeh, Vaigeu, Saluwatti, Misol), the western half of New Guinea as far as 141° E., with the islands in Geelvink Gulf on the north coast of New Guinea, along with others on the south coast. To this residency also belong the state of Banggaai and the Banggaai group in East Celebes. The residency stretches from 2° 43′ to 8° 45′ S., and 121° to 141° E., with an area of 155,800 square miles. The Dutch Government exercises direct authority only over parts of Ternate, Halmaheira, Bachian, and Obi islands. Its rule over the other groups it carries on through the sultans of Ternate and Tidor. The island of Ternate, near the west coast of Gilolo, its volcano, products, &c., were fully described by the Resident De Clercq, who visited the different groups of the residency, more especially the western half of New Guinea. Both the island and town of Ternate suffer from their isolation, and have never regained the importance they had in former centuries. Ternate is a little town, and, in spite of its good harbour, carries on no considerable trade or shipping, numbering only 3000 inhabitants. The density of population throughout the whole residency is calculated at from 0·5 to 1 per square kilometre.

Recent History.—The breaking up of the old Government of the Moluccas has not only not injured Ternate, it has tended to make it perhaps the most important Dutch-Indian political centre of the archipelago east of Celebes. Nominally the sultan is still ruler, but virtually his powers were greatly curtailed by his conventions with the Dutch-Indian Government, under which he surrendered, with the concurrence of his grandees, many of his former rights to the Dutch Resident, who has become the *de facto* governor of the easternmost colonial possessions of Holland, especially since the transfer of Dutch New Guinea in 1901. To the same residency also belongs Tidor, which, however, still has its own sultan, whose dominion likewise extends to other islands, Bachian, Buru, &c. Among the rights surrendered by the sultan of Ternate to the Dutch were those of granting monopolies and mining concessions, now vested in the Dutch Resident. The island of Bachian is being worked by a kind of chartered company. For surrendered rights and privileges the sultan and his grandees received monetary compensations in the shape of annual subventions, and these are also being paid for the losses formerly incurred by the wilful destruction of the nutmeg plantations. The restrictions in the growing of nutmegs have long since been removed, and many nutmeg plantations, with free labour, have been started in Ternate since 1885. In fact, experts now believe that Ternate, and not Banda, was originally the centre of nutmeg-growing. It is a curious fact that Christianity has declined in Ternate latterly, though formerly it was an early stronghold and the number of Europeans settled there has materially increased. (M. K.; H. TI.)

Terni, a town and episcopal see of Perugia, Umbria, Italy, amongst the Apennines, 70 miles north by east of Rome by rail. It has important iron and steel works and iron foundries, at which armour-plates, guns, and projectiles are made for the Italian navy, also steel castings, machinery, and rails, a royal arms factory, and lignite mining. There is a school of industry. Population (1900), 11,000.

Terracina, a town and episcopal see of the province of Rome, Italy, on the Mediterranean coast, 18 miles west-north-west of Gaeta. Excavations made in 1894 on the site of the reputed palace of Theodoric prove it to have been a magnificent temple of Venus, 111½ feet long by 65½ feet wide. Population (1900), 6500.

Terre Haute, a city of Indiana, U.S.A., capital of Vigo county, on the Wabash river, in the western part of the state. It is regularly laid out, divided into ten wards, has a good water-supply, is sewered, and well paved with bricks and granite blocks. Five lines of railway meet here—the Chicago and Eastern Illinois; the Cleveland, Cincinnati, Chicago, and St Louis; the Evansville and Indianapolis; the Evansville and Terre Haute; and the Vandalia. It is in a coal and natural gas region. In 1900 it contained 429 manufacturing establishments, with a total capital of $8,938,107. They employed 5427 hands, and the product had a value of $27,784,619. The leading articles of manufacture were distilled liquors with a value of $16,041,747, flour with a value of $1,363,338, and clothing with a value of $826,000. In 1900 the assessed valuation of real and personal property was $20,414,090, the net debt was $392,455, and the tax-rate was $25.20 per $1000. Terre Haute contains a number of educational institutions, among them the Rose Polytechnic Institute, a technical school opened in 1883. In 1899 the faculty numbered 20, and the attendance was 103. Population (1890), 30,217; (1900), 36,673, of whom 2952 were foreign-born and 1520 negroes.

Terrell, a city of Kaufman county, Texas, U.S.A., on the Texas Pacific and the Texas Midland railways, in the north-eastern part of the state, in the cotton and timber region. Population (1890), 2988; (1900), 6330, of whom 211 were foreign-born and 1517 negroes.

Terriss, William [William Charles James Lewin] (1847–1897), English actor, was born in London, 20th February 1847. After trying the merchant service, medicine, sheep-farming in the Falkland Isles, and tea-planting in Bengal, in 1867 he definitely took to the professional stage, for which his handsome presence, fine voice, and gallant bearing eminently fitted him. He quickly came into favour in "hero" parts, and appeared at the principal London theatres from 1868 onwards. In 1880 he joined Irving's company at the Lyceum, playing such parts as Cassio and Mercutio, and in 1885 he acted there with Mary Anderson, as Romeo to her Juliet, &c. He was then engaged to take the leading parts in Adelphi melodrama, and it was in this capacity that for the rest of his career he was best known, though he occasionally acted elsewhere, notably with Irving at the Lyceum in *Ravenswood*, *Henry VIII.*, *Faust*, and *Becket*. No more popular stage hero ever trod the boards, and his robust method was particularly effective in naval or military parts. On 16th December 1897, as he was entering the Adelphi Theatre, he was stabbed to death by a madman, Richard Archer Prince.

Terry, Ellen Alicia (1848——), English actress, was born at Coventry, 27th February 1848. Her parents were both in the theatrical profession, as also have been her sisters Kate, Marion, and Florence, and her brother Fred. Ellen Terry's first appearance was made at the age of eight, under the Keans' management, as the child Mamilius in *The Winter's Tale*, at the Princess's Theatre, London. This was followed by her appearance as Puck at the same theatre. Two years later she played the part of Prince Arthur in *King John* with such artless grace as to win high praise. From 1860 to 1863 and again from 1867 to 1868 she acted with various "stock companies," amassing valuable experience. During this period she acted, in 1867, for the first time with Henry Irving, playing Katherine to his Petruchio in *The Taming of the Shrew* at the Queen's Theatre. When quite a girl she married G. F. Watts the painter, but the marriage was dissolved at an early date. Between 1868 and 1874 she was again absent from the stage (having married Mr E. A. Wardell, an actor whose professional name was Kelly), but she reappeared in leading parts at the Queen's Theatre under Charles Reade's management. In 1875 came an event which set the seal of popular approval on her fame as an actress, in the shape of an engagement to play Portia in an elaborate revival of *The Merchant of Venice* under the Bancrofts' management at the old Prince of Wales's Theatre. Her performance was, indeed, the one bright spot in what proved otherwise an unexpected failure. This was followed by a succession of smaller triumphs at the Court Theatre, culminating in her beautiful impersonation of Olivia (in W. G. Wills's play of that name) in 1878, the result of which was her engagement by Henry Irving as his "leading lady" for the Lyceum Theatre and the beginning of a long artistic partnership. Her Shakespearian impersonations at the Lyceum have been Ophelia in 1878, Portia in 1879, Desdemona in 1881, Juliet and Beatrice in 1882, Viola in 1884, Lady Macbeth in 1888, Katherine (in *Henry VIII.*) and Cordelia in 1892, Imogen in 1896, and Volumnia (in *Coriolanus*) in 1901. Of these Portia and Beatrice were most entirely suited to her method and temperament. Some of Ellen Terry's other most notable performances were as the Queen in Wills's *Charles I.* in 1879, Camma in Tennyson's *The Cup* in 1881, and Margaret in Wills's *Faust* in 1885. With the Lyceum company she several times visited the United States. In 1902, while still acting with Sir Henry Irving, she appeared with Mrs Kendal in Mr Beerbohm Tree's revival of *The Merry Wives of Windsor* at Her Majesty's Theatre.

Teruel, a province of Spain, area 2363 square miles. Population (1887), 241,865; (1897), 247,762. The birth-rate is 3·99 per cent., the proportion of illegitimates being 2·11 per cent.; the death-rate is 3·55 per cent. Education is in a very backward state. The industries are comparatively unimportant. Much land is devoted to pasture that could be cultivated. Extensive forests with fine timber are as neglected as some important coal-beds in the eastern districts. Several hundred thousand acres are devoted to pasture, and forests cover about 600,000 acres.

Teruel, capital of the above province, on the Guadalaviar. Population (1887), 9423; (1897), 9938. Three suburbs have sprung up outside the walls, with broader, well-built streets. Teruel has several good hospitals and asylums for the aged and children, an institute, a normal training school, primary schools, a public library, an athenæum, a meteorological station, a large prison, and eleven churches, besides the handsome cathedral. The town hall is a solid modern building, and the bull-ring is also modern.

Teschen (Czech, *Těv̌ín*; Polish, *Cieszyn*), the chief town of a government district in Austrian Silesia, formerly the capital of the duchy of Teschen, 65 miles south-west of Cracow. Population (1890), 15,220; (1900), 19,142 (estimated at 53 per cent. German, 43 per cent. Polish, and 4 per cent. Czech). It has a museum and four high schools. Its industries have received an important addition in the State printing and lithographic works, and the manufacture of small arms, vehicles, leather, and cloth, together with large saw-mills. There is a considerable trade in spirits, beer, and liqueurs, iron wares, furniture, and timber, cheese, lard, &c.

Testamentum Domini ("Testament of our Lord").—Extracts from the book which bears this title, contained in an 8th-century MS. at Paris, were published by Lagarde in 1856 (*Reliquiae iuris ecclesiastici antiquissimae 80–89*); and a Latin fragment, edited by Dr Montague James, appeared in 1893 (*Texts and Studies*, i. 154). The whole book was first published in Syriac in 1899, with a Latin translation by Mgr Rahmani, the Uniat Syrian Patriarch of Antioch. His text is that of a 17th-century MS. at Mosul, the colophon of which says that the Syriac text was translated from the original Greek "*a Jacobo paupere*," evidently James of Edessa, in A.D. 687; but he makes use of other material, including an Arabic version made from a Coptic copy written in A.D. 927. The Mosul MS. contains the whole Bible in the Peshitto version, followed by the Syrian "Clementine Octateuch," *i.e.*, the collection of ecclesiastical law, in eight books, which was used by the Nestorians and Jacobites. Of this the *Testament* forms the first two books; and according to the title (which, apparently by an error, is made to apply to the whole eight books) it contains the "testament, or words which our Lord spake to His holy Apostles when He rose from the dead." Plainly, it is one of that series of writings, claiming to embody the fundamental rules of the Church, which culminates in the Apostolical Constitutions (*q.v.*).

It falls into three distinct parts: an apocalyptic introduction (book i. chapters 1–18; the division into books, however, is clearly not original); a "church order" proper (i. 19–ii. 24); and a conclusion (ii. 25–27) of the same apocalyptic character as the introduction. (*a*) The *Introduction* professes to contain the record of the revelation of Himself by the Lord to His Apostles, with whom are Martha, Mary, and Salome, on the evening after His resurrection. He is represented as unfolding to them, at their request, the signs of the end, and giving them instruction on various other topics. Incidentally, the fact becomes plain that this section is composed from the standpoint of Asia Minor and Syria, that it dates from soon after the time of Maximin (235–38) and Decius (249–51), and that it springs from a Christian community of a strictly puritan type. (*b*) The *Church Order* follows the general lines of the Canons of Hippolytus and similar documents. It describes the Church and its buildings (i. 19); the office of the bishop and his functions (i. 19–27); the mystagogic instruction (i. 28) common to this and the Arabic Didascalia, where it occurs in an earlier form, and based in part upon the Gnostic "Acts of Peter"; the presbyter (i. 29–32); the deacon (i. 33–38); confessors (i. 39); the "widows who have precedence in sitting" (i. 40–43), apparently the same persons who are spoken of elsewhere as "presbyteresses" (i. 35, ii. 19); the subdeacon (i. 44) and the reader (i. 45), the order of whose offices seems to have been inverted; virgins of both sexes (i. 46); and those who possess *charismata* or spiritual gifts (i. 47). Next come the regulations for the laity, including the whole course of preparation for and admission to baptism (ii. 1–8), confirmation (ii. 9), and the eucharist (ii. 10); after which there follows a series of miscellaneous regulations for Easter and Pentecost (ii. 11–12), the agape (ii. 13), the funds of the Church (ii. 17–20), the visitation of the sick (ii. 21), the use of psalmody (ii. 22), the burial of the dead (ii. 23), and the hours of prayer (ii. 24). (*c*) The *Conclusion* (ii. 25–27) brings us back to the injunctions of the Lord as to the keeping of these precepts, a special charge to John, Andrew, and Peter, and a statement that copies of the Testament were made by John, Peter, and Matthew, and sent to Jerusalem by the hands of Dosithaeus, Sillas, Magnus, and Aquila.

In all this there is much that is peculiar to or characteristic of the *Testament*. First and foremost is its ascription to the Lord Himself, which we can hardly be mistaken in regarding as an attempt to claim yet higher sanction than was claimed by the various compilations which were styled "apostolic." This fact alone would lead us to infer the pre-existence of certain of the latter. Again, the whole tone of the *Testamentum* is one of highly strung asceticism, and the regulations are such as point by their severity to a small and strictly organized body. They are "the wise," "the perfect," "sons of light"; but this somewhat Gnostic phraseology is not accompanied with any signs of Gnostic doctrine, and the work as a whole is orthodox in tone. They are set in the midst of "wolves," despised and slighted by the careless and worldly: there is frequent mention of "the persecuted," and of the duty of "bearing the cross." There appears to be no *locus poenitentiae* for serious sins excepting in the case of catechumens, and there is a notable "perfectionist" tone in many of the prayers. *Charismata*, and above all exorcisms, occupy a very important place: there is a vivid realization of the ministry of angels, and the angelic hierarchy is very complete. Great stress is laid upon virginity (although there is not a sign of monasticism), upon fasting (especially for the bishop), upon the regular attendance of the whole clerical body and the "more perfect" of the laity at the hours of prayer. The church buildings are very elaborate, and the baptistery is oblong, a form found apparently only here and in the Arabic Didascalia. Amongst the festivals mentioned are the Epiphany, Easter, and Pentecost. With regard to the prayers, they are based upon forms common to this and other Church orders, but have many lengthy interpolations of an inflated and rhapsodic kind. The bishop appears to rank far above the presbyters (more conspicuously so, for example, than in the Canons of Hippolytus), and the presbyters are still divided into two classes, those who are more learned and those who are of mature age. The deacons have functions in the Eucharist and about the altar which point to an early date; they have also much administrative work of an important kind, and especial provisions are made for the care of the sick and the dead, and the burial of those who perish by shipwreck. One of the deacons is to be chosen as "chief deacon" (*protodiaconus* i. 19, *cf.* i. 34), and is charged with the care of pilgrims. There are no doorkeepers or singers, who begin to appear *circ.* A.D. 340. The honour given to confessors is very conspicuous, and points back to an early date. But remarkable above all is the position given to women. We have "widows having precedence" or presbyteresses, three in number, deaconesses, virgins, and widows who are in receipt of the alms of the Church; and the first named occupy a place of very great dignity, which is almost unequalled elsewhere (excepting in the earlier form of the apocryphal and Montanistic *Acts and Martyrdom of Matthew*, where the relation of the πρεσβῦτι and deaconess corresponds with that of the *Testament*), and which was formally condemned by the Council of Laodicea in Phrygia.

What conclusion is to be drawn, then, as to the age and character of the *Testament?* Mgr Rahmani's view, that it is a work of the 2nd century, is universally discredited; nor has Dr Funk's contention found acceptance, that it and the Canons of Hippolytus are alike derived ultimately from the eighth book of the *Apostolic Constitutions*. It is now generally agreed that the Apocalypse at the beginning is pre-Nicene (A.D. 250–325), and that it originates from Asia Minor, probably from Montanistic circles. On its first appearance, however, Dr Harnack contended that this was an independent work, upon which the Church Order had been grafted, and that as a whole it dated from *circ.* A.D. 400. To this it must be replied that the unity of thought and atmosphere is such as to show that the work is one whole (subject no doubt to a certain amount of redaction and interpolation), and that the apocalyptic part was composed as an introduction to the rest. As to the central portion (i. 19–ii. 24) it is a Church Order of the same kind as the Canons of Hippolytus and the Egyptian Church Order, standing nearer to the latter than the former, and especially to the latter in the Latin form published in 1900 by Dr Hauler. The precise relation in which these three stand to one another still remains in a measure doubtful, but it seems probable that they are based upon a lost Church Order, to which the Canons of Hippolytus stands nearest. If this be the case, the *Testamentum* would seem to date from the latter part of the 3rd century, and to emanate from some Montanistic or semi-Montanistic community; and such is Mr Rackham's conclusion. With this agree most of the indications given above, especially that from the position of women in the *Testament;* and there is nothing which points strongly to a later date for the whole work.

On the other hand, it shows signs of later redaction, as was indeed inevitable in the case of work which has had a living history as part of a codex of Church law. Such signs may be discerned in the interpolations in the prayers; possibly in the reference to the chief deacon, for elsewhere no single deacon is distinguished *by name* until the close of the 4th century; in the reference to the Epiphany, which is first heard of elsewhere at the beginning of the 4th century. They probably point, as Bishop J. Wordsworth has suggested, to a redaction on a large scale about A.D. 400; but the evidence seems scarcely sufficient to justify the conclusion that this revision was due to the school of Apollinaris of Laodicea (died *circ.* A.D. 390).

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Tetschen, the chief town of the government district of the same name in north Bohemia, near the Saxon frontier, 20 miles E.N.E. of Teplitz. It is situated at the confluence of the Polzen with the Elbe, on the right bank of the latter river opposite Bodenbach, with which it is connected by a chain bridge (1855) and two railway bridges. It is the seat of an Austrian custom-house. The handsome château of the Thun family (built in 1667–73), which occupies a rocky height above the town, was at one time fortified, and was a place of some importance during the Seven Years' War. The shipping amounts to an annual total of over 4000 vessels. In addition to being the principal emporium for the Austrian traffic on the Elbe, Tetschen has a considerable industry, its products comprising chemicals, oil, soap, cotton stuffs, plaster of Paris, glazed and coloured paper, cellulose, beer, flour, preserved fish, &c. Population (1890), 7299; (1900), 9692.

Tetuan (*Tettáwan*), the only open port of Morocco on the Mediterranean, a few miles south of the Strait of Gibraltar, and about 40 miles east-south-east of Tangier. It contains many fine residences of Moorish families expelled from Spain. Exports: annual average of the years 1896 to 1900 inclusive, £5746; imports, £36,609. The shipping entered and cleared in 1899 and 1900 averaged 22,900 tons annually. Population about 25,000.

Teutoburger Wald, a mountain range of Germany, stretching north-west to south-east, along the borders of the Prussian provinces of Hanover and Westphalia and the principality of Lippe, for a distance of 70 miles, but with a width of only 1¼ to 3 miles. There is a well-marked main chain, accompanied, especially in the middle, by smaller subsidiary chains. The highest elevation is Völmerstod, 1535 feet, near the east end; but the height diminishes gradually towards the west. The main chain is pierced by several deep gaps or "doors," through some of which important railways have been carried; *e.g.*, the line connecting Paderborn and Hanover, and that connecting Herford and Hamm. The chief geological formations belong to the Cretaceous system, backed towards the north and east by Jurassic and Triassic formations. The entire range is for the most part well wooded. The name is first found in Tacitus, but it is uncertain which mountain range he intended to indicate; consequently it is still a matter of dispute amongst scholars where the famous battle in the Teutoburger Wald was actually fought in which Arminius, in the year A.D. 9, at the head of the Germanic tribes annihilated the legions of Varus. Mommsen considers it to have been fought near the source of the Hunte, north of Osnabrück, and beyond (north of) the range altogether. Nevertheless the Grotenburg (1275 feet), 2½ miles south-west from Detmold, is crowned with a heroic monument to Hermann (Arminius), the Cheruscan chief, erected in 1838–46 and 1875, at a cost of £13,500, the battlefield having been placed by some scholars at the south-west foot of that hill. The work, which was designed by E. von Bandel, consists of a gigantic statue of the chieftain, 56½ feet high, standing on an arched pediment 100 feet high. The materials employed are copper and iron.

Tewfik Mohammed (1852–1892), KHEDIVE OF EGYPT, son of the Khedive Ismail, was born on 15th November 1852. Although the eldest son, he was not sent to Europe to be educated, like his younger brothers, but was left to grow up in his native country. In 1866 Ismail succeeded in his endeavour to alter the order of succession to the Khediviate. The title, instead of passing to the eldest living male descendant of Mehemet Ali, was now to descend from father to son. Ismail sought this alteration mainly because he disliked his uncle, Halim Pasha, who was his heir-presumptive, and he is supposed to have imagined that he would be able to select whichever of his sons he pleased for his successor. But he found, after the change had been made, that the Powers interpreted the new arrangement as applying strictly to the eldest son. Tewfik therefore became heir-apparent. He was given a palace near Cairo to live in, and for twelve years he passed an uneventful life, farming, and establishing a reputation for good sense and fair dealing with his fellah tenants. In 1878 he was appointed President of the Council after the dismissal of Nubar Pasha. He held this office only for a few months; but this was long enough to show that, if he was unambitious and not particularly intelligent or energetic, he had the wisdom to refrain from taking a part in the intrigues which then formed the chief part of political life in Egypt. He went back to his estate, and settled down once more, with the single wife to whom he was devoted, to a quiet country life. He was not left undisturbed for long. On 26th June 1879 Ismail was deposed by the Sultan, who sent orders at the same time that Tewfik should be proclaimed Khedive. The new Viceroy was so little pleased by the news of his accession that he soundly boxed the ears of the servant who first brought it to him. For some months the country passed through troubled times. Tewfik's people were dissatisfied, his army disaffected; his advisers were nearly all of the adventurer class, with their own ends to gain; and he himself had neither the character of a strong ruler nor the experience that would have enabled him to secure an orderly administration of affairs. Disorder prevailed until November 1879, when the Dual Control was re-established by the Governments of Great Britain and France. For nearly three years Major Baring (afterwards Lord Cromer), Mr (afterwards Sir) Auckland Colvin, and M. de Blignières practically governed the country. During all this time the disaffection in the Egyptian army was increasing. Tewfik has been blamed for his failure to take a firm line with the rebels, but his attitude was governed by his relations with Great Britain and France, and it was his endeavour to carry out suggestions which constantly varied that finally led to the outbreak of Arabi Pasha's armed rebellion. In July 1882 the attitude of Arabi, who was carrying out defensive works on a large scale, made it necessary for the British Admiral (Sir Beauchamp Seymour, afterwards Lord Alcester) to declare that he would bombard the forts of Alexandria unless they were handed over to him. Before the bombardment began it was suggested to Tewfik that he should leave the city and embark either upon a man-of-war belonging to one of the neutral Powers, or in his own yacht, or in a mail steamer which was then in the port. His answer was, "I am still Khedive, and I remain with my people in the hour of their danger." At his palace of Ramleh, 3 miles from the town, he was beyond reach of the shells, but his life was nevertheless imperilled. When the rebel soldiers attacked the palace he managed to make his escape and to reach another palace after passing through the burning streets of Alexandria. Here he was obliged to agree that a guard of British blue-jackets should protect him from further risk. He showed his courage equally during the cholera epidemic at Alexandria in 1883. He had gone back to Cairo after the battle of Tel-el-Kebir, had consented to the reforms insisted upon by Great Britain, and had resumed the functions of a constitutional ruler under the guidance of Lord Dufferin, the British Special Commissioner. When the cholera broke out, he insisted upon going to Alexandria. His wife accompanied him, and he went round the hospitals setting an excellent example to the authorities of the city, and encouraging the patients by kind and hopeful words. In 1884 Sir Evelyn Baring went back to Egypt as diplomatic agent and consul-general of Great Britain. His first task was to demand that Tewfik should abandon the Sudan. Tewfik gave his consent with natural reluctance, but, having consented, he did everything he could to insure the success of the policy which Baring had been sent to carry out. He behaved with equal propriety during the negotiations between Sir H. Drummond Wolff and the Turkish envoy, Mukhtar Pasha, in 1886. His position was not a dignified one—that of a titular ruler compelled to stand by while others discussed and managed the affairs of his country. The Sultan was his suzerain; in Great Britain he recognized his protector: to the representative of each he endeavoured to show friendliness and esteem. As time went on his confidence in Baring increased, until at last he deferred to the strong mind of the British agent in almost everything. He had, like most weak men, occasional outbursts of activity, occasional impulses to act upon his own initiative. For instance, he dismissed Nubar Pasha at a moment when Baring was not in Egypt; and Riaz Pasha was also dismissed in his turn without any consultation between the Khedive and the British agent. Baring encouraged him to show his activity in matters of administration, and he took a strong interest in all matters connected with irrigation, education, and justice. He was not a strong man either in mind or in character, but he showed a genuine desire to govern his country for its own benefit. He understood the importance to Egypt of British assistance and support: his natural shrewdness made him accept the British conditions; his natural good feeling kept him from any inclination to intrigue. In private life he was courteous and amiable. He had no desire to keep up the unapproachable state of an Oriental ruler. Indeed, in many ways his manners and habits were less Oriental than European. He died on 7th January 1892, at the Helouan Palace near Cairo, and was succeeded by his eldest son, Abbas Pasha, born in 1874. (H. H. F.)

Texarkana, a city lying in the two states of Texas and Arkansas, the state line passing down the middle of the main street. The portion on either side of the line is, of course, a separate municipal corporation. Texarkana, Arkansas, is the capital of Miller county, and Texarkana, Texas, is in Bowie county. The altitude is 295 feet. It is regularly laid out on a level site, and is an important railway centre, no fewer than six railways intersecting here. It is situated in a timber and cotton region, contains cotton-gins, compresses, and oil-mills, and ships large quantities of cotton. It has lumber-mills and car shops. Population (1880), Texarkana, Ark., 1390; Texarkana, Texas, 1833—total, 3223; (1890), Texarkana, Ark., 3528; Texarkana, Texas, 2852—total, 6380; (1900), Texarkana, Ark., 4914; Texarkana, Texas, 5256—total, 10,170. Of the population of Texarkana, Ark., in 1900, 120 were foreign-born and 2078 negroes; of that of Texarkana, Texas, 192 were foreign-born and 1964 negroes.

Texas, the largest state of the American Union, situated on the south central border. In the closing decades of the 19th century it made great strides in its material welfare. In 1880 the state was still lavishly distributing its public domain to settlers, educational institutions, railways, and as rewards for services. Immigration was invited, and there was little thought of the vast landed legacy being exhausted. There were no railways except in the eastern third, aggregating hardly 500 miles. There were practically no constructed public highways, or laws for making them. Although ordinarily considered a prairie state, Texas possessed the largest area of woodland (64,000 square miles) of any American commonwealth, but the modern lumbering industry was unknown. Mining and manufacturing were undeveloped. The school system was in a primordial condition; there was no county superintendence and no system of instruction, the scholastic year was of only four months' duration, and the attendance limited to pupils between eight and fourteen years of age. The university and other institutions of higher education had not been organized. Since 1880 the population has steadily grown in number and density, although it is still the least densely settled of all the American states east of the Rocky Mountains, with the exception of Florida and the Dakotas, and has not attained one-half the average density (25·6) of population of the entire Union. In 1900 the public domain theoretically had been entirely expended, but in fact fully 40,000,000 acres were still owned by the commonwealth in trust for the public schools, university, and other state institutions. In 1880 the total population was 1,591,749, or 6·1 persons to the square mile; in 1890 it was 2,235,523, or 8·5 to the square mile; in 1900 it was 3,048,710, or 11·6 to the square mile. The increase in population from 1880 to 1890 was 40·4 per cent., and from 1890 to 1900 36·4 per cent. In 1900 there were 46 incorporated cities and towns having more than 2000 and less than 5000 inhabitants; 16 having more than 5000 and less than 10,000; 6 of more than 10,000 and less than 25,000; and 5 with more than 25,000, namely, San Antonio (53,321); Houston (44,633); Dallas (42,638); Galveston (37,789); and Fort Worth (26,688). The urban population (classing as such all persons living in places of more than 4000 inhabitants) was 13 per cent. of the total population in 1890, and 14·9 per cent. in 1900. Of the total population in 1900, 1,578,900 were males and 1,469,810 were females. The foreign-born numbered 179,357 and the negroes 620,722, being respectively 5·9 per cent. and 20·3 per cent. of the total population. The illiterate adult males (unable to write) numbered: native white, 30,017, out of 514,188; foreign-born white, 21,773, out of 85,773; negroes, 61,744, out of 136,875.

Agriculture and Forestry.—Since 1880 the state has become the largest cotton-producing state or country in the world. Texas also ranks first in the Union in the production of cattle and horses. There were in the state, according to the census of 1900, 352,190 farms, with an acreage of 125,807,017, of which 19,576,076 acres were improved, and 106,230,941 unimproved; 286,654 farms were owned by white persons, 65,536 by coloured. The total value of farm property was estimated at $962,476,273, and the value of the farm products at $239,823,244. The lumbering interest has grown to a vast industry, and its product has been distributed by rail over Mexico, the eastern Rocky Mountain states, and by ship to all the West Indian and South American ports. Other forest products of a local character, for which no statistics are obtainable, have also developed enormously. It is estimated that 500,000,000 feet of lumber are produced annually.

Mining and Manufactures.—It was not until 1889 that Texas finally passed a law permitting mineral claims upon the public lands by individuals; hence the development of its mineral resources has been backward. In 1898 the gold product was valued at $300, and the silver at $611,426. Coal mining has steadily increased; 686,734 short tons were produced in 1898, valued at $1,139,763. Lignite, vast beds of which formerly remained unused, is also mined in quantities. Salt, which used to be entirely derived from Europe, is now exported, the yield for 1898 being 254,284 barrels, valued at $119,700. The extensive beds of gypsum in the north-west are being worked; in 1898, 34,215 short tons were produced, valued at $58,130. Rich fields of cinnabar have been opened in Trans-Pecos province; 1000 flasks were produced in the state in 1900, valued at $50,000. Building materials, such as granites, sandstone, limestone, marbles, and cement, are growing in importance. In 1898 101,590,000 bricks were produced, valued at $602,988. Oil fields have been opened; 546,070 barrels of crude petroleum were produced, valued at $277,135, or seven times the amount produced in the previous year. There were 12,289 manufacturing establishments in 1900, an increase of 133·3 per cent. for the decade, with a capital of $90,433,882 and a product valued at $119,414,982.

Education.—Since 1880 the public schools have been organized upon a model system; state, county, and municipal superintendence has been provided; the standard and pay of teachers raised; the public school fund augmented, and vacation normal institutions established. The school age has been extended, and the number of teachers employed greatly increased. The permanent school fund consists of 30,000,000 acres of land, and cash and bonds. The latter in 1894 was $2,162,600; in 1899 it had increased to $6,447,247. The available annual school fund, the revenues from taxes and sale and lease of lands, in 1899 amounted to $3,232,624. In 1895-96 616,568 children were enrolled in the public schools, or 20·7 per cent. of the population. The number of teachers employed was 13,217. Of the children instructed in 1894, 472,963 were white and 157,340 coloured. The State University was not organized until 1884. It is under the control of a board of regents nominated by the governor. The main institution, situated at Austin, is the head of the state public school system, and admits students without entrance examinations from approved state high schools, the state normal school, and the agricultural and mechanical colleges, both sexes being admitted on equal terms. In 1899 there were 150 affiliated schools throughout the state, which, after thorough examination by a committee of the university faculty, sent graduates to the university without entrance examination. The income of the university is derived from bonds, the leases of lands belonging to the university (2,500,000 acres), and annual appropriations from the state. The total expenses for 1899-1900 were $155,366. In addition to the main university at Austin, there is a medical branch at Galveston, which requires a four years' course. The expenses of the medical department for 1899-1900 were $59,919. In 1897-98 the university had a total enrolment of 812 students.

Penal and Charitable Institutions.—The prison system has been placed entirely under state control, and its affairs are conducted upon a more humane and more economic basis. An institution for coloured dependents at Austin, a reformatory for youthful penal offenders at Gatesville, and a new and third insane asylum near San Antonio have been provided. A home for dependent Confederate soldiers has been established at Austin, in which about 100 unfortunates took refuge. By a legislative Act of 1899 a biennial appropriation of $250,000 was made for the relief of other indigent Confederate soldiers, which, distributed among 5000 applicants, gave a relief of $1.66 per month.

Finances and Banks.—The total valuation of the assessed property for 1886 was $630,591,029. In 1891 it was $856,202,283; in 1899 it was $921,927,231. Taxation is limited by the constitution to 35 cents on the $100 *ad valorem*, and the county and city taxes to 25 cents. Notwithstanding the enormous growth of wealth and population, the taxes and cost of administration have not increased. The revenues in 1886 from all sources were $2,916,488, and in 1899, $2,700,000. In 1899 there was a cash balance of $1,092,807 in the treasury above all expenses. In 1894 Texas had a bonded debt of $3,992,030. Of this sum $1,405,610 was held as a fund for its various institutions, only $756,990 being in the hands of individuals. In 1899 the debt was $3,989,445. The contract rate of interest has been reduced from a maximum of 12 to 10 per cent. and the legal rate from 8 to 6 per cent. In 1899 there were 194 national banks, which on 20th September of that year had loans and discounts amounting to $46,024,782.

Railways and Commerce.—The railways have increased in length since 1880 from less than 1000 to nearly 10,000 miles in 1900, a mileage exceeded only by Illinois. In 1880 vast trunk lines were initiated to connect the state with the north and east, and to cross the western half to the Rocky Mountains region and the Pacific Ocean. Eight trunk lines of the first and three of the second character now exist. Meanwhile additional railways were constructed in the eastern half. The total of miles in 1899 was 9702. The average indebtedness per mile was $38,267. The total earnings were $45,334,191; the working expenses were 71·73 per cent., or $32,518,118, and the net earnings 3·48 per cent. The national Government, by the expenditure of $6,000,000 upon a system of jetties in the harbour at Galveston, has increased the depth from 13 to 26 feet. The imports have increased from $1,157,370 in 1885 to $3,000,000 in 1899, and the exports from $12,680,000 in 1885 to $78,480,000 in 1899. Four hundred and sixty-eight steam vessels, with an aggregate of 833,497 tons, cleared from Galveston for foreign ports in the year ending 30th June 1899.

Recent History.—The governor is chosen for two years, and by popular custom is usually elected for two terms. There is practically but one party in Texas—the Democratic—and all questions are in reality determined by the popular primaries and state conventions. With the exhaustion of its public domain, the introduction of steam transportation, and the closer competition resulting from readjusted sound conditions, many large corporations began operations in Texas, for the rights and practices of which as public franchises there existed no adequate legislation. This legislation, and the discussion incident thereto, created a period of violent political antagonism, and resulted in a long struggle carried out upon the political rostrum, in the legislative halls, and in the state and Federal courts. Many laws were enacted, especially those regulating railways, and against alien ownership of lands and trusts. Suits were instituted in the courts to recover property illegally held by corporations, and in some instances millions of dollars reverted to the state treasury. The "Free Grass" movement was organized to express discontent at the introduction of barbed wire fences. The rural and pastoral population had held that all unfenced land was public commons. With the coming of the barbed wire all the previously open lands were rapidly enclosed, and thousands of settlers found themselves without pasturage. This feeling gave way to violence, and lawless mobs known as "Fence Cutters" destroyed thousands of miles of fence. Order was restored by the executive, and many just laws enacted protecting public rights.

The Farmers' Alliance.—The unusual interest in politics among the farmers and other labouring classes resulted in several organizations. Among these was a secret society known as the Farmers' Alliance, which originated in a meeting of a few neighbours in Pleasant Valley, Lampasas county, in February 1878. In 1886 this organization had grown to a membership of from 75,000 to 100,000 in Texas and 1,000,000 in the United States. The Farmers' Alliance manifested great interest in politics, due to the general belief that the railway charges for freight were exorbitant, and antagonism towards the railway interests was intensified. The movement, however, largely died out before 1900.

State Regulation of Railways.—By 1890 an amendment to the Constitution providing for a State Railway Commission was passed. The Commission had general powers for the regulation of railways in the state by prescribing rates of freight, and was a tribunal to hear complaints made by both parties. Through a series of suits in the Federal courts, railways were compelled to make restitution for past offences. Companies were compelled to bring back their principal offices and officers into the state from foreign states to which they had been removed. Other suits broke up pooling, and recovered for the state land which had been illegally obtained. By these suits 1,437,000 acres of land were restored to the public domain. Over $3,000,000 was saved to the producers from traffic taxation alone, without diminishing the receipts of the companies.

Alien Land Laws.—An Alien Land Law, passed by the legislature, was declared illegal by the Supreme Court of the United States. The legislature then passed a modified Alien Land Act, providing that no private corporation whose main purpose was ownership of land should hereafter be allowed to acquire land in the state, and requiring that all such corporations then owning land should sell it within fifteen years.

Special Incidents.—The twenty-first legislature passed an Act to define and punish conspiracies against trade, popularly known as the Anti-Trust laws. Suits were instituted against illegal insurance companies, and stopped their business in the state. In August 1887 the state was convulsed by the so-called Prohibition campaign, when an amendment to the constitution was submitted to the people prohibiting the manufacture and sale of liquors in the state except for mechanical and scientific purposes. The proposition was defeated by a vote of 220,627 against 129,270. The new state capitol building, commenced in March 1885, was dedicated on 16th May 1888. Parts of Texas have suffered many great natural disasters, such as droughts, storms, floods, and hurricanes. In May 1899 the Brazos river flooded the vast area of agricultural lands bordering it throughout the region of the coastal plain. In 1900 a sudden rise of the Colorado caused the breaking of a dam which the citizens of Austin had erected at a cost of more than a million dollars. On 8th September 1900 a hurricane struck Galveston, causing a loss of life estimated at 3000 and of property at twenty to thirty million dollars. The wind, which reached a maximum velocity of 96 miles an hour, piled the water of the Gulf upon the city to such an extent that every building on the sea front and for three blocks inland was destroyed, and all communication cut off.

A special session of the twenty-second legislature passed an election law providing for the registration of voters in cities of 10,000 population, known as the Australian ballot system. For years Texas had claimed jurisdiction over a tract lying in the south-west corner of Indian Territory between the forks of Red river, and had issued patents to the land therein, organized courts, and constructed school-houses and other public improvements. The Supreme Court decided that this area, known as Greer county, belonged to the United States. (R. T. H.)

Textiles.—In connexion with the history of textiles, much interest attaches to the considerable quantities of hand-woven textiles which have been discovered in Egypto-Greek, Roman, and Coptic cemeteries since 1885, and are now exhibited in many important European museums, particularly in the Victoria and Albert Museum at South Kensington. They illustrate varieties of weaving in linen and worsted threads such as were in general use amongst Greeks and Romans from the 1st and 2nd centuries before Christ up to the 8th and 9th centuries A.D., and elucidate many of those references to ancient woven fabrics which are quoted in the article on textiles in the ninth edition of this work. It is well to note that silken fabrics were practically unknown in Europe before the 1st century A.D., and anything approaching to a Western counterpart of the traditional Chinese silk manufactures, which are reported to have flourished 2000 B.C., cannot be said to have sprung into existence until the 6th or 7th centuries A.D.; after this period their development was due principally to Mahommedans or Saracens, who conquered, over-ran, and settled in many places about the Mediterranean during the 7th to the 11th centuries of our era.

The present article, however, deals with stuffs made with linen and worsted threads found in the abovementioned cemeteries, the sites of which have been laid bare at spots adjacent to the Nile, between the district of Fayúm on the north and the town of Assuan on the south, the more notable of them being Akhmîm (or Panopolis of the Greeks) and Antinoë (or Antinopolis, founded by the Roman Emperor Hadrian). Amongst the stuffs are simple shuttle-woven fabrics, the back and front of which are alike, weft and warp threads being equally visible, as in ordinary modern sailcloths and linens of different qualities. The plain stuff of the tunic in Fig. 5 (see Plate), and the material about the angel in Fig. 2, are samples of this simple weaving. There are also materials similarly woven with woollen threads, resembling flannels. Besides these, another distinctive class of textile is that in which its back and front, and more generally the front, only are woven with loops, giving a shaggy texture, as in modern bath or Turkish towels. Indications of this are seen in the outer margins of the square (Fig. 3), and on a reduced scale in Fig. 1. This shaggy-faced material was known to the Greeks under the names of *kaunakes* or *persis.* The ancient village of Thymetes in Greece was noted in the days of Aristophanes for its manufacture of such shaggy stuffs. Hesychius writes of *kaunakes* as being *etero-malla,* or shaggy on one side only. But in Roman times Pliny "recollects the *amphi-malla* [a textile with each side shaggy] and the long shaggy apron being introduced." The main parts of the large specimen (Fig. 1) are of such shaggy material. It dates from about the 3rd or 4th century, and was probably a covering to a couch or pall. The dark ornamental portions are of compact series of worsted tufts or loops, the texture of which is kindred to that of certain carpets. Finer and similar shaggy linen-faced material was also used for tunics.

The ornamental and decorative features which abound in these different linen textiles were almost invariably made with coloured threads of linen and wool by a simple inweaving process, the method and implements of which are identical with those of tapestry-weaving by hand. The largest and most complete tapestry-weavings are the great textile pictures or storied wall-hangings of the 15th and 16th centuries made in France and Flanders (*e.g.,* Arras, Brussels), and of the 17th and 18th centuries in France (*e.g.,* Gobelins, Beauvais tapestries). Now this tapestry-weaving method of producing intricate textile ornament, but on a far smaller scale, seems to have been used by all kinds of people, and as a method was certainly much earlier in the chronology of weaving than that of figured shuttle-weaving in a loom. The widespread range of its practice amongst various people is demonstrated by specimens made by natives of Borneo, by hill tribes of India, such as the Todas, by ancient dwellers in Peru, who may have been Toltecs and Aztecs, by nomad Turcoman tribes, by Scandinavians, by Greeks of the 5th century B.C., and of course by Romans. Ovid (*Metamorphoses*, vi., 55–69) gives a remarkable and minute description of this inweaving or tapestry-weaving method; and Martial appears to be referring to work of this character when he writes that the "Babylonian needle is now surpassed by the comb of the Nile," a small comb, to press down the inwoven wefts compactly between the warp threads, being a necessary implement in this ornamental thread work. Pliny notes that "a garment when it has been worn for some time is often embellished with wool from Egypt"; and Flavius Vopiscus in the 3rd century A.D. makes mention of the "linen cloths from Egypt . . . prized on account of their laboured embroidery": these references are particularly interesting when read in connexion with the specimens which have been collected from the cemeteries above mentioned. The greater number of these textiles proves the prevalence during the earlier centuries A.D. of the tapestry-weaving process for decorating costume as well as other articles, such as hangings and coverings. The angel or winged figure (Fig. 2) bearing the segment of a wreathed cross is 2 feet 3 inches in length, and is one of a confronted pair of such figures which ornamented a cloth or hanging at least 5 feet wide. The decorative device of confronted angels occurs in large and small sculptured reliefs and other decorative work of the 1st century A.D., and prevails for many centuries later; this tapestry-woven version of it is probably of the 4th century. Of corresponding date is the panel from a shaggy-faced linen (Fig. 3). The symmetrical arrangement of the circular and curved bands marking the plan of the entire pattern is frequent in patterns of Roman mosaics. The symbols in the four outside circles are those of the Evangelists, adapted in their forms from Gnostic emblems, and possess peculiar interest as early devices of Christian iconography. Possibly of the 2nd or 3rd century A.D. is the tree and vase ornament (Fig. 4), also from a cloth. The vase is designed in a characteristic Roman style. The formal arrangement of the branches and leaves, however, reflects a conventional treatment which is met with in Egyptian wall paintings 2000 B.C. Fig. 5 gives part of an elaborately

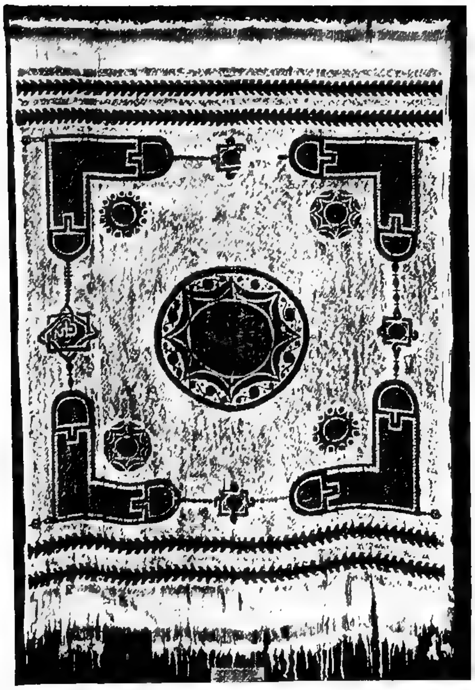

Fig. 1.—Covering for a couch, or a funeral pall. 3rd or 4th century A.D. (Egypto-Roman.)

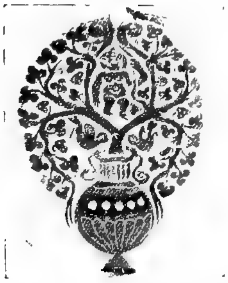

Fig. 4.—Tapestry woven ornament for a linen cloth. 2nd or 3rd century A.D. (Egypto-Roman.)

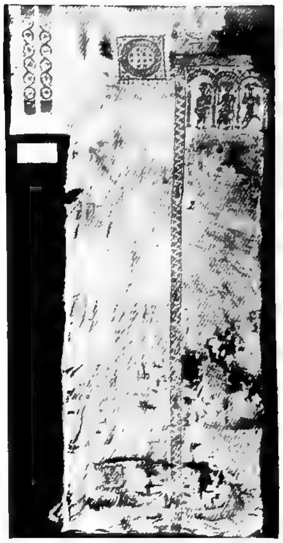

Fig. 5.—Half of a linen tunic with ornamental bands, etc., of tapestry weaving. 3rd century A.D. (Egypto-Roman.)

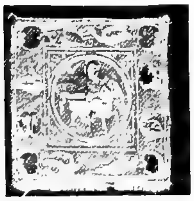

Fig. 7.—Square panel of fine coloured flax thread tapestry weaving. 2nd or 3rd century A.D. (Egypto-Roman.)

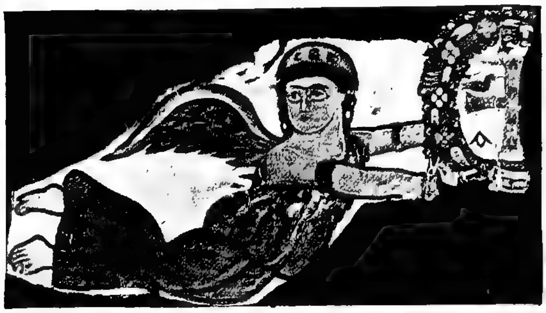

Fig. 2.—Figure of coloured tapestry weaving for a linen hanging. 4th century A.D. (Egypto-Roman.)

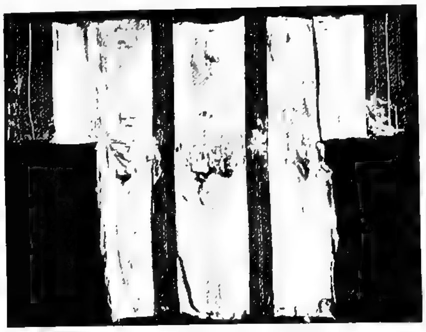

Fig. 6.—Wide-sleeved linen tunic with broad bands of tapestry weaving. Probably 3rd century A.D. (Egypto-Roman.)

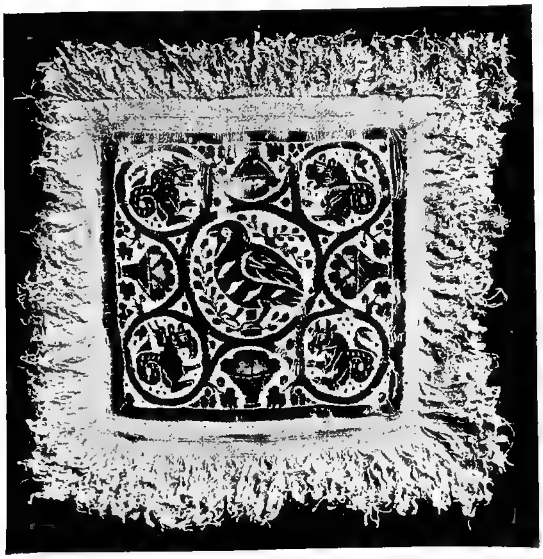

Fig. 3.—Ornamental square panel of tapestry weaving. 4th century A.D. (Egypto-Roman.)

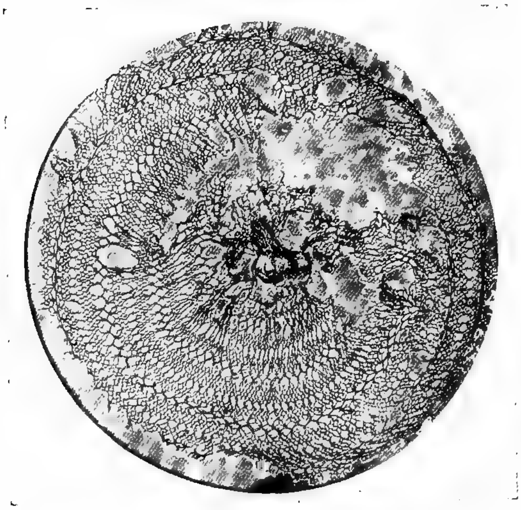

Fig. 8.—Net of flax threads. 2nd or 3rd century A.D. (Egypto-Roman.)

ornamented tunic, probably of the 3rd century A.D. The double bands to the sleeve, a narrow band along the length of the tunic, square panels on the shoulder and the lower part of the skirt, and a breast enrichment are all of well-designed devices wrought in tapestry-weaving. The wide-sleeved tunic (Fig. 6), decorated with broad bands of simpler ornament, is probably of 3rd-century work. The small square (Fig. 7) is of the daintiest texture, in fine flax thread tapestry-weaving, more delicate than any later work of this character, including even fine silk tapestry-weaving from China and Japan. It is possibly of 2nd or 3rd century work, and came from a child's tunic. The colours of this, as indeed of most of the tapestry-weavings in question, are bright and fresh. Passing to quite another class of textiles, an interesting example of variegated netting as made in the 2nd or 3rd century is given in Fig. 8, which is a prototype of lace made thirteen or fourteen hundred years later. In this and other specimens of similar nettings are forestalled those varieties of meshes formed by twisting and plaiting threads which, fourteen hundred years later, became the characteristic of the grounds or *réseaux* of Brussels, Valenciennes, Mechlin, Lille, and Buckinghamshire pillow-made laces.

Authorities.—The following works may be mentioned as likely to prove useful in investigating the history and character of the Egypto-Greek, Roman, and Coptic textiles above mentioned:—J. Karabacek. "Die Theodor Graf'schen Fünde in Ægypten" (*Die Textilien-Gräberfünde*), 8vo. Vienna, 1883.—Alan S. Cole. *Catalogue of Egyptian Tapestry-Woven and Embroidered Textiles in the South Kensington Museum.* London, 1887; *Egyptian Tapestry*, *Society of Arts—Cantor Lectures.* London, 1889.—A. Riegl. *Die ägyptischen Textilfünde im K.K. Österreichisch. Museum.* 13 photo-lithographs, 4to. Vienna, 1889.—E. Gerspach. *Les Tapisseries Coptes.* 153 (some coloured) illustrations, 4to. Paris, 1890.—R. Forrer. *Mein Besuch in El-Achmim.* 1 phototype and 36 process illustrations, 8vo. Strasburg, 1895; *Römische und Byzantinische Seiden-Textilien aus dem Gräberfelde von Achmim-Panopolis.* 28 pp., 17 (15 coloured) plates, and illustrations in the text, 4to. Strasburg, 1891.—Wladimir Bock. *Coptic Art. Coptic Figured Textiles.* 32 pp., 6 phototype plates, 4to. Moscow, 1897. (In Russian.)—W. Lowrie. *Christian Art and Archæology* (pp. 362–382, Textile Art). Process illustrations, 8vo. New York and London, 1901.—A. Gayet. *L'Art Copte* (pp. 317–327, Les Tissus). Process illustrations, 8vo. Paris, 1902.

(A. S. C.)

Thale, a town of Prussia, province of Saxony, on the north side of the Harz Mountains, 8 miles by rail south-west of Quedlinburg, in the picturesque valley of the Bode, and in the immediate vicinity of the Rosstrappe, the Hexentanz, and other notable spots in the Harz. It has an idiot asylum, an epileptic home, and the saline springs of Hubertusbad, and there are manufactures of enamelled wares and machinery, ironworks, and breweries. Population (1885), 4498; (1900), 9467.

Thames, the chief river of Great Britain, taking its rise in several small streams on the eastern borders of the counties of Gloucester and Wilts. Its source is generally held to be at a place known as Thames Head, in the parish of Coates, 3 miles south-west of Cirencester; but claims have also been advanced on behalf of the Seven Springs, the headwaters of the river Churn, 5 miles south of Cheltenham. The Thames leaves the Gloucester and Wilts borders near Lechlade, after which it separates successively Berks and Oxford, Berks and Bucks, Middlesex and Surrey, and finally, at its estuary, Essex and Kent. Between Lechlade and Oxford it has a winding course, passing near Faringdon and Bampton. The Windrush flows into it at New Bridge, the Evenlode at Eynsham, and the Cherwell at Oxford. It then flows in a southerly direction nearly as far as Reading, receiving on the right the Ock at Abingdon, the Pang at Pangbourne, and the Kennet at Reading; on the left, at Dorchester, the Thame. After passing Reading it bends northwards to Henley, eastwards to Great Marlow, and southwards to Maidenhead, receiving the Loddon near Henley. Winding in a south-easterly direction, it passes Eton, Windsor, Datchet, Staines, Chertsey, Shepperton, and Sunbury, then receiving the Colne from the left at Staines, and the Wey from the right at Shepperton. Flowing past Hampton Court, opposite to which it receives the Mole, and past Kingston, it reaches Teddington, and at the latter place its bulk is increased by the tidal wave. At Kew the outskirts of London are reached, and it flows through the metropolis and its suburbs for a distance of about 25 miles, till it has passed Woolwich. Gravesend, the principal town below Woolwich, is 26 miles from London, and the Medway flows into the Thames estuary at Sheerness, 45 miles from London. The estuary extends to the North Foreland at Margate. In the tideway the principal affluents of the Thames are the Brent at Brentford, the Wandle at Wandsworth, the Ravensbourne at Deptford, the Lea at Blackwall, the Darenth just below Erith, and the Ingreburn at Rainham.

The length of the river from Thames Head Bridge to London Bridge is $161\frac{1}{4}$ miles, and from London Bridge to the Nore, $47\frac{3}{4}$ miles, a total of 209 miles. The width at Oxford is about 150 feet, at Teddington 250 feet, at London Bridge 750 feet, at Gravesend 2100 feet, and at the Nore 3 miles. The height of Thames Head above ordnance datum, or average sea-level, is 356 feet, and that of the river at Lechlade 237 feet, the average fall between Lechlade and London, 143 miles, being 20 inches per mile. The watershed area of the Thames is about 6000 square miles; this does not include that of the Medway, which can hardly be considered a tributary of the river.

The Thames is navigable for rowing-boats as far upwards as Cricklade, except in dry seasons, and for barges at all times as far as Lechlade, 18 miles below Thames Head. At Inglesham, three-quarters of a mile above Lechlade, the Thames and Severn Canal has its junction with the Thames. This canal is the necessary link between the two great rivers from which it takes its name, or, in other words, between the east and west of England. It was abandoned for years, but owing to the exertions of a joint-committee of the counties and other interests concerned, powers were obtained from Parliament for its restoration, and the works needful for its reopening have been carried out. Concurrently with the repair of the canal, the navigation works on the Thames were remodelled at a large cost, and barges drawing 3 feet 6 inches can now, even in the summer season, navigate from London to Inglesham.

Although the Thames, as one of the "great rivers of England," was always a navigable river, that is to say, one over which the public had the right of navigation, it was not until the last quarter of the 18th century that any systematic regulation of its flow in the upper reaches was attempted. Complaints of the obstructions in it are not uncommon, and early in the 17th century Taylor, the Water Poet, in a poem commemorating a voyage from Oxford to London, bewails the difficulties he found on the passage. No substantial measures to remedy this state of things were adopted till the year 1771, when an Act of Parliament was passed authorizing the construction of pound locks on the Thames above Maidenhead Bridge. In pursuance of the powers thus granted, the Thames Commissioners of that day caused locks to be built at various points above Maidenhead, and between 1810 and 1815 the Corporation of London carried out river works on the same lines as far down the river as Teddington. The character of these works is so well known that it is hardly necessary to explain that whilst they maintain an efficient head of water during the drier seasons of the year, they facilitate the escape of winter floods.

The canals communicating with the Thames, in addition to the Thames and Severn Canal already spoken of, are the Oxford Canal, the Wilts and Berks at Abingdon, the Kennet and Avon Canal at Reading, the Wey and Basingstoke Canals at Weybridge, the Grand Junction at Brentford, the Regent's Canal at Limehouse, and the Grand Surrey Canal at Rotherhithe. There is also a canal at Gravesend, but this is little, if at all, used. By means of these canals, and especially by means of the Grand Junction and Oxford Canals, constant communication is maintained between the Thames and the great industrial centres of England. The importance of the merchandise traffic on the upper Thames may be estimated from the fact that in the year 1900 the sum of £10,700 was paid for tolls on barges carrying goods on that part of the river.

But considerable as is the part the river thus plays in the national economy in distribution, its usefulness is greater still in the opportunities for exercise and recreation which it affords to the public, especially to Londoners. The scene at Henley at regatta time, or on any part of the river on public holidays, and on Saturdays and Sundays during the summer, would be sufficient to show how it contributes to the public enjoyment. But a further proof is in the fact that in the year 1900 as many as 11,284 rowing-boats, 541 steam launches, and 162 houseboats were registered for use on the Thames. It is only since about 1870 that this popularity has grown up. Ten years earlier even rowing-boats were but few and far between, excepting, of course, at Oxford, at Henley in regatta time, and at Putney on the tideway. Steam launches did not exist on the river before 1866 or 1867, and houseboats only in the form of college barges at Oxford. But by the year 1884 there were 217 launches; in 1887 they had increased to 268, and in 1900 there were 541. Houseboats increased from 98 in 1887 to 162 in 1900, and rowing-boats from 8926 in 1888, the first year of registration, to 11,284 in 1900. The growth of the popularity of river sports, as shown by these figures, has been encouraged by the facilities given by the Great Western railway and the London and South-Western railway for reaching stations on the river, as well as by the fact that the works carried out on the river since the year 1867 by the Conservators of the Thames have much improved the navigation for pleasure purposes as well as those of business. During the season regattas of importance take place at most of the towns and larger villages. Of these Henley Royal Regatta is preeminent by the number and importance of the entries, and by its comparative antiquity. The regattas at Molesey, Kingston, Reading, Marlow, and Oxford, as well as many others, attract numerous competitors and spectators.

The Thames is a favourite stream for the angler—indeed, up to 1860 the angler had comparatively undisturbed enjoyment of his sport. The introduction of steam launches and the growth of traffic generally have interfered with his pursuit, but there is no reason to apprehend that, as has often been alleged, the fishery has been injured. Indeed, in the opinion of those qualified to speak, the river has as good a supply as formerly of coarse fish such as pike, perch, roach, dace, and barbel. Of trout there are many fine specimens, especially at the weirs. Salmon are known to have existed at Maidenhead so recently as 1812, but they disappeared soon after that date. An association has been formed, under the presidency of Mr W. H. Grenfell, M.P., with the object of re-introducing this fish into the river, and in April 1901 a number of young salmon were placed at Teddington by way of experiment. The right of the public to take fish has been frequently in dispute, but a committee of the House of Commons, which took much evidence on the question in the year 1884, came to the conclusion that "it is impossible to recognize anything like a general public right to take fish as now existing." They added "that the public at large have only to know that their rights are imaginary to induce them also to be content with the extant system under which permission is very freely granted by owners of fisheries to the public for angling on the more frequented parts of the Thames." These conclusions are interesting in face of the fact that the question has arisen from time to time since 1884.

The fisheries are under the regulation of bye-laws made by the Conservators of the Thames, and apply to the riparian owners as well as to the public generally. These bye-laws are carried into effect by officers of the Conservators, assisted by the river keepers of the various fishing associations. The principal associations are those at Oxford, Reading, Henley, Maidenhead, and Windsor, and last but not least, the Thames Angling Preservation Society, whose district is from Staines to Brentford.

The Thames is the principal source of the water supply of London, and the water companies of the metropolis take in the summer, the season of their greatest requirements, as much as 130,000,000 gallons a day, under the statutory powers granted them by Parliament. The companies authorized to draw water from the Thames are the Chelsea, the East London, the Grand Junction, the Lambeth, the Southwark and Vauxhall, and West Middlesex, all of which have intakes at Hampton or in its immediate vicinity. In addition to these companies, there is a joint-committee of the New River Company, the Grand Junction Company, and the West Middlesex Company, which have power to draw water when the river is above a certain level. This committee is now constructing huge storage reservoirs at Staines Moor. Outside of London the corporation of Oxford and two small companies in the Staines district have power to draw water from the river, but not in any large quantities.

The flow of the Thames varies greatly, according to the season of the year. The average gaugings at Teddington for the summer months of the years 1883 to 1900 were in July 413,000,000 gallons a day, in August 395,000,000 gallons, and in September 375,000,000 gallons. At present the normal natural flow in ordinary summer weather is about 350,000,000 gallons a day, and of this, after the companies have taken 130,000,000, only 220,000,000 gallons are left to pass over Teddington Weir. After a long period of dry weather the natural flow has been known to fall to considerably below 200,000,000 gallons, whilst, on the other hand, in the rainy winter season, the flow in 1894 rose for a short time to as high a figure as 20,000,000,000 gallons, and the ordinary flow in winter months may be put down as 3,000,000,000 gallons. The importance of storage reservoirs, such as those at Staines, is manifest under such conditions of flow, especially bearing in mind the probable growth of population in the London district and of its increasing needs.

Whilst the flow of the river requires the most careful observation and regulation, as well in the interest of the traffic as of the water supply itself, the preservation of the purity of the stream calls for even more assiduous attention. Throughout the whole of the Thames watershed, and especially in the 3800 square miles above the intakes of the water companies, the Conservators have enforced the requirements of Parliament that no sewage or other pollution shall be allowed to pass into the Thames, into its tributary streams, or even into any water communicating with them. There is a large staff of inspectors constantly visiting the various parts of the watershed, and in spite of many difficulties arising from vested interests, the work of purification is attaining completion, with a correspondingly great improvement in the quality of the river water. So recently as 1890 the state of the river below London was such as to be dangerous to the public health. The metropolitan sewage was discharged untreated into the river, and the heavier solids deposited over the river-bed, while the lighter parts flowed backwards and forwards on the tide. The London County Council, directly after its establishment, took means to remedy this evil, and the solids are now separated from the sewage and taken to sea in large steam hoppers. The liquid effluent passed into the river does not now give rise to complaints, but the Council are, notwithstanding, carrying out works of magnitude to secure that the effluent shall be above suspicion.

While the points already dealt with are of very great interest, nothing has been said of the trade which constitutes the real importance of the Thames. Early in the 16th century the opulence of London, and the extent of the trade on the Thames, evoked the admiration of the ambassadors of Venice, and the port continued to hold its position in the following centuries. At the end of the 18th century the business of the port received a considerable impetus, due doubtless to the marked superiority of Great Britain at sea. The House of Commons in 1796 considered the growth of the trade in the port of London of such importance as to call for the appointment of a strong committee of the House to deal with the question of improvements to be made, and of this committee Mr Pitt, Mr Fox, and Mr Sheridan were members. Yet it is probable that at that date the trade of the port did not exceed 1,500,000 tons a year. The total foreign inward and outward trade of the port in the year 1816 amounted to only 1,240,000 tons; if to this be added as much again for coasting trade, we have a total trade of 2,500,000 tons. In 1850 the total trade, foreign and coasting, had grown to 7,494,815 tons; in 1870 to 11,169,746 tons; in 1890 to 20,962,334 tons; and in 1900 it approximated to 30,000,000 tons.

The greater part of this trade proceeds up the river to the various docks, of which the most important are the Tilbury Dock, the Albert Dock, and the Victoria Dock belonging to the London and India Docks Company, the Surrey Dock and the Commercial Dock, both belonging to the Surrey Commercial Dock Company, and the Millwall Docks. Ships of the largest draught can be docked in the Albert and Victoria Docks, in which the steamers belonging to the Peninsular and Oriental Companies, the Union-Castle Company, and other great lines load and discharge. The Surrey and Commercial Docks are mostly used for the timber and corn trades. The use of the river and the docks by the great ocean-going steamers has given rise to discussion as to the depth of the river and the necessity of dredging to a much greater extent than in the past. The river has been deepened to 26 feet up to Gravesend, and dredging to 22 feet is being carried out up to the Albert Docks. These depths are considered by the owners of large steamers to be insufficient, and they maintain that a depth of 30 feet at low water to Gravesend and of 26 feet to the Albert Dock is the least that should be afforded.

The regulation of the traffic below London is under the control of harbour-masters appointed by the Conservators, and it is part of their duty to see that the laws relating to explosives and to petroleum are duly observed. An important detail of the work in the river is the removal from the stream of sunken vessels. Of these forty or fifty are generally dealt with every year, many of them being large steamers. In most cases they are delivered to their owners on payment of the comparatively small expense incurred in raising.

There has existed from early times a special authority fôr the government of the Thames. A statute as far back as 1393, the 17th Richard II., cap. 9, recites that it had been granted to the citizens of London by the king's progenitors to remove all the weirs on the waters of Thames, and to leave the punishment thereof relating to the king, and it then grants to the Lord Mayor the enforcement of the particular provisions of the statute itself. The Lord Mayor for the next four centuries after the date of the statute enforced his powers through the medium of his water bailiffs, till, in 1771, a committee of the Corporation of London took under their charge the details of the work. This system continued till 1857, when an Act of Parliament was passed establishing the Thames Conservancy Board. The powers of this body have been enlarged by subsequent Acts of Parliament, and its constitution was varied in 1864 and 1866, and again in 1894, when it was greatly increased in numbers and placed on a more popular basis. The jurisdiction of the river above Staines was formerly under a very numerous body of commissioners, and was only transferred to the Conservancy Board in the year 1866.

A word should be added on the name of the Thames. Camden gave currency to the derivation of the word from the combination of the names Thame and Isis. Now it can be shown conclusively that the river has borne its present designation from the earliest times. We have the testimony of Cæsar (*B.G.*, v. 11) who says that at the time of his invasion of Britain it was called Tamesis. Dion Cassius (xl. 3) and Tacitus (*Ann.* xiv. 32) both call it Tamesa, and in no early authority is the name Isis used. In early Saxon times the river was called Thamis, as may be seen in a grant before A.D. 675 to Chertsey Abbey by the sub-king Frithwald. In the first statute passed for improving the navigation of the river near Oxford (21 Jac. I.) it is called the river of Thames, and it was only in a statute of George II. (1751) that the word Isis appears. The name Isis has indeed the authority of Spenser as applied to the Thames in its course above Dorchester (*Faerie Queen*, Bk. iv. canto xi. stanza 24), but there is ample evidence to show that long before his time the name of the river throughout its course was not Isis but Thames. The word Isis is probably an academic rendering of Ouse or Isca, a common British river name, but there is no reason to suppose that it ever had much vogue except in poetry or in the immediate neighbourhood of Oxford.

See *Ordnance Survey of England* for physical features; Report of the Select Committee of the House of Commons on Thames River Preservation, 1884; Reports of Royal Commissions of 1892 and 1898–99 on Metropolitan Water Supply; Evidence given before the Royal Commission on the Port of London, 1900; Annual Reports of the Conservators of the River Thames; Minutes of the London County Council. (J. H. GO.)

Thana, or TANNA (=a fort, or police-station), a town and district of British India, in the Konkan division of Bombay. The town is on the west of the Salsette creek or Thana river, just where the Great Indian Peninsula railway crosses to the mainland, 21 miles from Bombay city. Population (1881), 14,456; (1891), 17,455; (1901), 16,011.

The district of THANA, since the census of 1891, has been diminished by the transfer of about 200 villages to Kolaba. Present area, 3578 square miles; population, 819,580, showing an average density of 229 persons per square mile. In 1901 the population was 809,361, showing a decrease of 1 per cent. The land revenue and rates are Rs.15,08,077, the incidence of assessment being R.1.4.10 per acre; number of police, 1052; children at school (1897–98), 15,046, being 1·98 per cent. of the total population; registered death-rate (1897), 37·10 per 1000. Cultivated area (1897–98), 453,684 acres, of which 4593 were irrigated from wells. The staple crop is rice. Fishing supports many of the people, and the forests yield timber and other produce. Salt is largely manufactured by evaporation along the coast. At Kurla, in Salsette Island, there are 2 cotton mills, with 915 looms and 54,000 spindles, employing 4370 hands; 4 rice mills; 4 printing-presses, issuing 4 vernacular newspapers. The district is traversed throughout its length by the Bombay and Baroda railway, and also crossed by the two branches of the Great Indian Peninsula line.

Thann, a town of Germany, in Alsace-Lorraine, district of Upper Alsace, 16 miles by rail west-north-west of Mülhausen. It is the seat of cotton, calico, silk, machinery, and other industries. An excellent wine is made. The (Roman Catholic) church of St Theobald (1351) is an elegant specimen of the Gothic, and has a remarkably fine tower (1450–1516), 266 feet high. Above the town are the ruins of the castle of Engelburg, destroyed by Turenne in 1675. The town existed in the 10th century. Population (1885), 7464; (1900), 7618.

Thar and Parkar, a district of British India, in the Sind province of Bombay. Area, 2729 square miles; population (1881), 203,344; (1891), 298,203, showing an increase of 47 per cent., due to the extension of irrigation; average density, 23 persons per square mile, compared with 60 for Sind generally. In 1901 the population was 364,168, showing a further increase of 22 per cent.

The land revenue in 1897–98 was Rs.8,33,038, the incidence of assessment being R.1.7.3 per acre; cultivated area, 767,786 acres, of which 320,538 were irrigated from Government canals; number of police, 515; children at school, 3123, being 1·1 per cent. of the population; registered death-rate (1897), 19·54 per 1000. The principal crops are millet, rice, oil-seeds, and cotton. Cultivation largely depends upon the control of the water which comes down the canals and occasionally causes flood. Salt is found in two or three places. The western border of the district is entered by the railway from Haidarabad to Shadipalli, connected with the North-Western main line by a bridge across the Indus at Kotri, and with the Rajputana system at Jodhpur.

Umarkot, the administrative headquarters of the district, is on the edge of the desert. Population (1881), 2828; (1891), 3702. Historically interesting as the birthplace of the emperor Akbar in 1542, it is now a station on the railway from Haidarabad to Jodhpur, which has brought central India into direct connexion with the seaport of Karachi.

Tharandt, a town of Germany, romantically situated on the Wilde Weisseritz, 8¾ miles S.W. of Dresden, kingdom of Saxony, on the Dresden–Reichenbach railway. It has a Protestant church, a higher-grade girls' school, and the oldest academy of forestry in Germany, with about 90 students. Tharandt is a favourite summer resort of the Dresdeners, one of its principal charms being the magnificent beech woods which surround the little town. Population (1900), 2822.

Tharrawaddy, a district of the Pegu division of Lower Burma, lying to the north of Rangoon. Area, 2851 square miles; population (1891), 339,240, living in 1458 villages; (1901), 395,870. They paid in 1898–99 a revenue of Rs.13,15,648.

Of the population in 1891, 329,688 were Buddhists and Jains, 2843 were Hindus, 1674 Mahommedans, 1877 aborigines, mostly Karens, and 3158 Christians, 2722 of whom were natives, most of them Karens. Of the total area of 1,824,640 acres, 402,222 acres were cultivated in 1898–99. The remainder was made up of forest land, 616,669 acres; land not available for cultivation, 243,421 acres; cultivable waste, 544,918 acres; and current fallow, 17,410 acres. The rainfall in 1898–99 was 81·61 inches. The railway runs through the centre of the district, and there are ten railway stations. The chief villages, with their population in 1891, are Zigôn, 1256; Gyobingauk, 2960; Thonzè, 1653; Letpadan, 1575. The great bulk of the cultivation is rice.

Thatôn, a district in the Tenasserim division of Lower Burma. Area, 5089 square miles; population (1891), 266,620; (1901), 340,355. It was formerly a subdivision of the Amherst district, but was formed out of part of that and of the Shwegyin district which has now ceased to exist. There were 922 villages in 1898–99, and they paid a revenue of Rs.15,36,381.

The population was made up in 1891 of Buddhists and Jains, 247,662; aborigines, mostly Karens, 7338; Hindus, 6092; Mahommedans, 3814; and Christians, 1714, most of them natives. Of the total area of 3,256,890 acres, 529,826 acres were cultivated in 1898–99. Of the remainder 152,031 acres were forests, 1,750,703 were uncultivable, 811,590 were available for cultivation, and there were 12,740 acres of current fallow. The rainfall in 1898–99 was 181·84 inches. The headquarters town THATÔN had a population of 9683 in 1891. The great bulk of the cultivation is rice, but a good deal of tobacco also is grown.

Thaxter, Celia (1836–1894), American poet, was born at Portsmouth, New Hampshire, 29th June 1836. Her father, Thomas B. Laighton, became offended with some of his associates in state politics, and retired to the barren and isolated Isles of Shoals (ten miles off Portsmouth), where he was keeper of the lighthouse; and his daughter's girlhood was therefore spent in marine surroundings, which gave character to the best of the verse she afterwards wrote. Her poems, mainly in lyrical form, deal with the beacon-light, the sea-storm, the glint of sails, the sandpiper, the flower among the rocks, &c., in characteristic and sympathetic fidelity, constituting an interesting addition to American place literature. She wrote prose sketches of life and scenery, *Among the Isles of Shoals* (1873), stories and poems for children, and letters; but her best work is that described above, and contained in the complete (1896) edition of her poems, edited by Sarah Orne Jewett. She married Levi L. Thaxter, an interpreter of Browning's poetry, in 1851, spent most of her life on Appledore, one of the Isles of Shoals, and died 26th August 1894.

Thayetmyo, a district in the Minbu division of Upper Burma. It was formerly in the Irrawaddy division of Lower Burma, but was transferred to Upper Burma for administrative purposes in 1896. Area, 4750 square miles; population (1891), 250,161, living in 939 villages, and paying a revenue of Rs.4,03,504; (1901), 239,877.

The population was made up in 1891 of Buddhists and Jains, 226,732; aboriginal tribes, mostly Chins, 17,291; Hindus, 2524; Mahommedans, 2149; and Christians, 1465, of whom 545 were natives. The area is 1,534,080 acres. Of this in 1898–99 only 112,146 acres were cultivated, 296,320 acres were under forests, 564,928 acres were not available for cultivation, 544,535 acres were cultivable, and there were 16,151 acres of current fallow. The total rainfall in 1898–99 was 26·3 inches. The chief towns are Thayetmyo and Allanmyo, on opposite banks of the Irrawaddy. In 1891 Thayetmyo had 17,101 inhabitants, and Allanmyo 9012. There is now only a wing of a British regiment stationed here. There is a central gaol capable of containing 1214 prisoners. The bulk of the cultivation is rice, but in 1898–99 there were 3935 acres under tobacco. There are 256,256 acres of reserved forest. Three oil-wells were sunk in 1883 at Pedaukpin, but they were found unprofitable and abandoned.

Theinni, called by the Shans Hsenwi, and also officially so designated, but better known by the Burmanized name of Theinni. It was by far the largest of the cis-Salween Shan states, and at one time included not only all the territory of the present states of North and South Hsenwi, but also Kehsi Mansam, Möng Hsu, Möng Sang, and Möng Nawng, besides having a sort of protectorate over Mang Lön and other Wa states east of the Salween. These had, however, fallen away in Burmese times, and at the period before the British annexation Theinni was divided into five parts by name; but there was no central authority, and the whole state was in hopeless disorder. This continued until the appearance of British troops in March 1888, when it was divided into two states—North Theinni, which was assigned to a successful adventurer, Khun Hsang, of Tôn Hông, and South Theinni, which went to Nawmöng, of the old Shan ruling house. North Theinni has an approximate area of 6330 square miles, and a population estimated at 118,000 persons, living in 1500 villages, divided among 76 districts. South Theinni has an approximate area of 5000 square miles, and a population estimated in 1897 at 57,223.

The northern part of North Theinni is a mass of hills affected by the geological fault which has produced the rift that forms the Nam Tu or Myit-ngè valley, and has thrown up a series of parallel ranges which extend northwards to the Shweli (Lung Kiang), without altogether destroying the north and south trend which is the characteristic of the Shan hills as a whole. In the valleys between these hills are numerous tracts under rice cultivation, some circular or oval, some mere ribands along the river banks. The southern portion has much more flat land, along the line of the Nam Tu, its tributaries the Nam Yao and the Nam Nim, and the Nam Yek flowing into the Salween. This was formerly thickly populated, and still remains the most valuable portion of the state. A range running westwards from the Salween, and marking the southern border of the rift in the hills, divides North from South Theinni. Both north and south of the Nam Tu there are many peaks which rise to 6000 feet, and several over 7000 feet. The northern portion is almost consistent enough in its altitude of about 4000 feet to be called a plateau. It has large, grassy, upland downs. This part of the state has fallen almost entirely into the hands of the Kachins. The Shans are found in the Nam Mao (Shweli or Lung Kiang) valley, and in the Nam Tu and other valleys in the southern part of the state. The line of the Nam Mao is the lowest portion of North Theinni, being little over 2000 feet above sea-level. The southern valleys are about 500 or more feet higher. South Theinni is practically bisected by the huge mass of Loi Ling, nearly 9000 feet above sea-level, and by the spurs which that peak sends north and south. Apart from this it consists of broken hill-country of no great height, or open rolling downs, the latter chiefly in the eastern half of the state. It is watered by numerous streams, of which the chief is the Nam Pang, an affluent of the Salween. The chief river in the northern state, apart from the Salween, is the Nam Tu or Myit-ngè, which rises on the Irrawaddy–Salween watershed, not far from the latter river, and flows westwards through the state into Taungbaing or Thebaw, and eventually into the Irrawaddy at Amarapura. The Nam Mao or Shweli only skirts the state, but it receives a considerable tributary, the Nam Paw, which has its entire course in Theinni territory, and is large enough to be barely fordable in the dry weather, and only passable by boats in the rains. The deforestation caused by years of upland cultivation has dried up many of the springs, but as a whole North Theinni is very well watered. Considerable deposits of coal, or rather of lignite, exist in both North and South Theinni, but do not appear to be of high quality. Gold is washed in many of the streams in a fitful way. Limestone exists in large quantities. No valuable timber exists to any considerable extent. There is some teak in the Nam Yao valley, and scattered wood-oil trees exist. Pine forests cover some of the ranges, but, as elsewhere in the Shan states, varieties of the oak and chestnut are the commonest forest trees. The climate of the state as a whole is temperate. In the plains of the uplands there are yearly frosts in January, February, and March, but in the greater part of the state the thermometer rarely falls to freezing-point, and in the hot weather does not exceed ninety degrees for any length of time. The average rainfall seems to be about 60 inches yearly. After the disruption of the ancient Shan empire at Tali by Kublai Khan, Theinni seems to have been the centre of the independent Shan kingdom, with various capitals in the Shweli and Nam Tu valleys. This kingdom of Kawsampi was ended by the Burmese about 1738, and the country was divided into various states, with appointment orders from Ava. Numerous rebellions and civil wars have reduced Theinni from its position as the most powerful and populous Shan state to a condition of fearful desolation. It has regained much population since the British occupation in 1888, but is still far from its old prosperity. Much may be expected from the cart roads that have been made, and from the Mandalay–Kun Lông railway.

Hsenwi, the capital of North Theinni, contained 150 houses in 1898, with a population of about 800. It stands near the north bank of the Nam Tu. The ruins of the old capital lie at a short distance, and show it to have been a large and well-built town, with a number of houses variously estimated at from three to ten thousand. Möng Yai is the capital of South Theinni. It numbered 481 houses in 1897, with about 2000 inhabitants in the town and suburbs. Lashio, the headquarters of the Superintendent of the Northern Shan State, is in North Theinni. The races found in Theinni comprise Shans, Kachins, Chinese, Burmese, Lihsaws, Wa, Palaungs, and Yanglam. The Shans and Kachins vastly predominate, and are nearly equal in numbers. (J. G. SC.)

Theiss (Hungarian, *Tisza*), a large affluent of the Danube, next to which it is the greatest river of Hungary. It springs in the north-eastern part of the Carpathian Mountains, in the county of Máramaros, at a height of above 2000 metres. By a quick fall it soon reaches the great Hungarian plain (Alföld), where it becomes slow, somewhat muddy, and very tortuous. It flows into the Danube near Titel. Its length from source to mouth is, as the crow flies, only 455 kilometres, but its windings make its course about 1000 kilometres long. The floods formerly spread far and wide and caused immense damage; and in 1879 the town of Szegedin was almost destroyed by an inundation. Therefore the river is now strongly dammed. Formerly the Tisza and its tributaries were fabulously rich in fish, but these have considerably diminished. There are numerous water-mills on the stream, which is navigable for rafts almost everywhere, but for steamers only downwards from Szolnok for a length of 338 kilometres. Its chief tributaries are the Szamos, Körös, Maros, Latorcza, and the Sajó. In its lower course it is joined to the Danube by the Francis-Joseph canal crossing the county of Bács-Bodrog. A canal connecting Budapest with the Tisza is projected. As a purely Hungarian river, having its entire course within the frontiers of the country, the Tisza plays a considerable part in Hungarian literature and popular poetry.

Theodosia (formerly KAFFA), a seaport and watering-place of Russia, on the south-east coast of Crimea, 75 miles by branch line from Jankoi junction on the Sebastopol railway, and 181 miles from Sebastopol. Its roadstead is the best in Crimea after Sebastopol, and very seldom freezes in winter. It has gained much of the trade of Sebastopol since that town was made a military port in 1894, and the value of its exports, principally grain and animal products, is increasing year by year. Population (1897), 27,238.

THERAPEUTICS.

THERAPEUTICS is that branch of medicine which deals with the means employed to cure disease if possible, or to control and lessen its evil results when a cure is impossible. The cure which is sought for may either be symptomatic or radical. Various morbid conditions of the body generally may give rise to different symptoms. Thus a gouty condition may manifest itself in one man as eczema of the skin, giving rise to redness and intense itching; in another as neuralgia, causing most severe pain; in a third as bronchitis, producing a distressing cough; in a fourth as dyspepsia, giving rise to flatulence and intestinal disturbance; and in a fifth as inflammation of the great toe, accompanied by redness, swelling, and pain. The therapeutic measures employed in these different cases may be directed towards alleviating the symptoms, such as itching, pain, cough, and swelling, in which case the treatment will be merely *symptomatic;* or they may be directed towards removing the root of the disease, viz., the gouty condition underlying them all, and thus effecting a *radical* cure. It very frequently happens that we do not know what the underlying condition is, and we are forced simply to relieve as best we can the most prominent and most distressing symptoms. In symptomatic treatment we are frequently obliged to use remedies simply because we know they have done good before in similar cases, and we expect them to do so again without having the least idea of how they act. Thus in acute gout the most common and most trusted remedy for removing the pain is colchicum, but at present we do not know what action it has upon the system, or why it gives so much ease in the pain of gout while it has comparatively little effect upon pain due to other causes. This plan of treatment is termed *empirical.* It is a useful method, and is often very satisfactory, but it has the disadvantage that it admits of but little progress, and when a trusted empirical remedy fails we do not know precisely in what direction to look for a substitute. In contradistinction to empirical we have *rational* therapeutics, by which we mean the application of a remedy whose mode of action we know more or less perfectly in diseased conditions, the nature of which we also understand more or less fully. As an example may be taken the use of nitrite of amyl in angina pectoris. It has been found that in many cases of this disease the pressure of blood within the arteries becomes increased, probably from spasmodic contraction of the arteries themselves. Nitrite of amyl has the power of dilating the arteries; it has consequently been employed with much success in lowering the blood pressure and removing the pain in angina pectoris. But such rational knowledge as this not only enables us to remove pain at the time, but helps us to prevent its recurrence. For on the one hand knowledge of the fact that nitrite of amyl lessens blood pressure has led to the successful employment of other nitrites and bodies having a similar action, and on the other the knowledge that increased blood pressure tends to cause anginal pain leads to the prohibition of any strain, any food, any exposure to cold, and also of any medicines which would unduly raise the blood pressure. Here we notice one of the greatest advantages of rational over empirical therapeutics. In cases of angina, while the resistance opposed to the action of the heart by spasm in the vessels may be great, the heart itself may be feeble, and it may therefore be necessary to give some remedy which will increase the power of the heart. But if such a remedy were given alone it might, and probably would, act on the arteries as well as the heart, and by causing the contraction of the vessels do more harm than good. But if we know what remedies will increase the power of the heart and what will lessen resistance in the vessels, we may combine them and thus obtain the objects we desired, viz., removal of the pain, better action of the heart, and more perfect circulation.

Empirical and Rational treatment.

Harvey's successors.

The testing of ideas by observation and experiment which was begun in anatomy by Vesalius, and by Harvey in physiology, was applied by Morgagni to alterations in the organs produced by disease, by Bichat to the tissues, and by Virchow to the cell. The study of disease in the living body may be said to have been begun by John Hunter (*Ency. Brit.*, 9th edition, i. p. 815, xii. p. 385, xv. p. 816, xxii. p. 676), developed by Magendie, Claude Bernard, Brown-Séquard, and others. Of late years enormous impulse has been given to our knowledge of the causation of disease by microbes, through the works of Gaspard, who injected putrid matter into the veins of a living animal; by Villemin, who discovered that tuberculosis is infective; by Davaine; and especially by Pasteur, Koch, and others too numerous to mention, who have worked, and are still working, at the microbic causation of disease with marvellous success. The natural end of life is that all the organs should become old and gradually decay at the same time, so that at the last the individual should become less and less active, weaker and weaker, and finally die without any definite disease, without pain and without struggle. But this is exceptional, and generally one part gives way before another, either on account of one part being naturally weaker or of one part having been overtaxed or more severely attacked by some injurious external influence, or by some undue preponderance of another part of the body itself. For health consists in a due proportion between the action of all the different parts of the body, and if one part be unnaturally strong it may lead to injury or death. Thus

Disease by feebleness or excessive action of one part of the body.

a very strong heart, although it may be useful to its possessor for many years, driving the blood rapidly through the vessels, and supplying all his tissues with such abundant nutriment as to enable him to endure great exertion, mental or bodily, may in the end cause death by bursting a vessel in the brain, which might have resisted the pressure of a feebler circulation for years longer. On the other hand, a heart that is too feeble may cause its owner's death by its inability to carry on the circulation against increased resistance. This may occur suddenly, as when the resistance is increased in the arterial system by a sudden exertion or strain, and more slowly when the resistance is increased in the pulmonary circulation by inflammation of the respiratory passages. The thyroid gland, which is situated in front of the neck, yields a secretion which passes into the blood and there tends to maintain a state of moderate dilatation in the blood-vessels and of oxidization in the tissues, so that the circulation remains good and the body-heat and muscular activity remain well maintained. When this gland becomes enlarged, and its secretion consequently increases, the vessels dilate, the heart beats more rapidly, the skin becomes too hot, the nervous system becomes irritable, and tremors occur in the limbs. On the other hand, when it becomes atrophied the circulation becomes feeble, the face heavy and dull, the patient suffers from cold, the features grow lumpish, mental processes become sluggish, and bodily vigour diminishes.

Microbes.

Disease of the whole body may thus be produced by over-action or under-action of some part of it, but such causes of disease are slight as compared with the effect of external noxious influences, and more especially the effect of microbes. These enter the body through various channels, and once they have effected a lodgment they grow, multiply, and give rise to various poisons which attack and injure or destroy different tissues or organs in the body. Various safeguards are provided by Nature to prevent their entrance. On the skin we have a thick epidermis through which microbes cannot pass, although if an entrance is obtained for them by a prick or cut they may readily grow in the tissues below and spread from them throughout the whole body. They pass more readily through mucous membranes, but almost every one of these is provided not only with a coating of mucus, which obstructs their passage, but with some reflex mechanism which tends to remove them. Thus irritation of the eye causes winking and secretion of tears, by which the irritant is removed; irritation of the nose causes sneezing; of the air-passages, coughing; of the stomach, vomiting; and of the intestines, diarrhœa. Even when they have passed through the mucous membranes and enter the blood they are met, in some instances, by a toxic action of the blood itself upon them; and in others they are attacked by the white corpuscles, which destroy them, eat them up, and digest them, the process being known as phagocytosis. Moreover, the products of microbic secretion tend to produce fever. The high temperature characteristic of this condition is no doubt injurious to the body itself, but it is frequently more so to the microbe which has invaded the organism; and thus fever, instead of now being regarded as a morbid condition to be suppressed by every means in our power, is considered to be a reaction of the organism tending to protect it by destroying the infection. But it must be kept within limits, lest it should of itself cause death, and here again we see the difference between empirical and rational medicine.

Fever is not to be looked upon as an unmitigated evil, to be removed if possible, but rather as a defensive mechanism by which the organism may prevent invasion from noxious microbes. Nevertheless, as in a campaign the general's plan may be spoiled by too hasty or too eager action on the part of some of his troops, so the defensive arrangement carried to excess may prove injurious or fatal to the organism. Thus too great a rise of temperature in fever may kill the patient; and the aim of therapeutics is to restrain the temperature within proper limits, neither allowing it to rise too high nor to fall too low. The old plan of lowering it by means of cold baths was known to Musa, the physician of Augustus, and by it he saved the emperor's life; but the same treatment killed the emperor's nephew.

The introduction of the clinical thermometer, which allows us to ascertain exactly the amount to which the temperature rises in fever or to which it is reduced by antipyretic measures, is to the physician like the compass to the sailor, and allows him to steer safely between two extremes (HYDROPATHY, *Ency. Brit.*, 9th edition, vol. xii.). After the struggle between the organism and the microbes is over, even when it has ended victoriously for the former, injuries are left behind which require repair. Every one has noticed after prolonged fever how thin and weak the patient is, and both the muscular and nervous power throughout the whole body are sadly in want of repair. Where there has been local mischief due to inflammation the dead leucocytes must be removed, and this is done either by their being converted into pus in one mass (PATHOLOGY, vol. xviii. pp. 365 and 400), and making their way through the tissues to the nearest surface, whether of skin or mucous membrane, from which it can be discharged, or they may undergo a process of fatty degeneration and absorption, leaving behind in some cases cheesy matter, in others hard connective tissue.

Poisons formed by microbes are partly eliminated by the kidneys, partly by the mucous membrane of the stomach and intestines, and possibly also by the skin. In days of old free elimination by these channels was looked upon as a sign of returning health, and was termed a "critical" diuresis, diarrhœa, or sweating, according to the channel through which the eliminative act had occurred.

By therapeutic measures we strive to limit as far as possible the entry of injurious microbes into the organism, to expel or destroy them and their harmful products, and to maintain the strength of the organism itself. One of the influences which is most injurious to the body, and favours most the invasion of microbes, is chill. So much is this the case that some diseases which are now known to be due to infection were formerly attributed entirely to the effect of cold. Thus pneumonia is now known to be due to the diplococcus pneumoniæ, and yet its invasion occurs so frequently after a chill that it is almost impossible not to look upon chill and pneumonia as cause and effect. The reason of this appears to be that the diplococcus is frequently present in the mouth or air-passages without giving rise to any symptoms; but when the patient is exposed to chill, and the tissues of the respiratory passages are thereby weakened, the diplococcus grows, multiplies, and gives rise to inflammation of the lungs. Even what are known as common colds are probably due chiefly to microbic infection aided by a chill, just like pneumonia. Therapeutic measures which are commonly adopted in the treatment of a cold have for their object to destroy the microbes before they penetrate fairly into the organism, and to restore the balance of the circulation and increase the strength of the invaded parts. Thus carbolic acid or carbolized ammonia are sniffed into the nose to destroy the microbes there, or the nose is washed out by an antiseptic solution as a nasal douche; bismuth or morphine are insufflated, or zinc ointment is applied, to cover the mucous membrane, and protect it from further irritation; and various antiseptic gargles, paints, and powders applied to the pharynx in order to prevent the microbic inflammation from extending to the pharynx and down the trachea and bronchi, for many a severe bronchitis begins first by sneezing and nasal irritation. Sometimes the patient is put to bed and the circulation is encouraged, especially on the surface of the body, by the use of hot spirits and water, or opium and ipecacuanha (DIAPHORETICS, *Ency. Brit.*, 9th edition, vol. vii.), while the outside of the nose is protected to a certain extent from loss of heat, and consequent irritation, by smearing it with a tallow candle or rubbing some ointment over the skin. At the same time, if the throat has begun to show signs of being involved, a hot poultice or wet pack is applied to the neck.

Both inflammation and fever are protective processes calculated to defend the organism against the attacks of microbes. But protective processes misdirected or carried to excess may become injurious or even dangerous to the organism. As an instance of misdirection, we may take the irritation which remains in the eye after a particle of dust has been removed, or the itching of the skin which occurs in eczema. The irritation of the conjunctiva caused by dust leads to winking of the eyelids, lachrymation, and rubbing, which tend to remove it; but after the dust has been removed violent rubbing tends rather to keep up the irritation; and sometimes, if the particle of dust remains under the eyelid and is sharp and angular, the process of rubbing may cause it to injure the conjunctiva much more than if it were left alone. In the same way itching is often caused by the presence of insects or other irritants upon the skin, and it tends reflexly to cause rubbing, which is useful by removing the irritant. But when the irritation is situated in the skin itself, as in eczema, the scratching tends to increase inflammation, and makes the irritation worse. In the same way, the reflex act of coughing is useful in removing either foreign bodies or excessive secretion from the air-passages; but when the mucous membrane of the respiratory tract is irritated and inflamed, it produces a feeling of tickling and a desire to cough sometimes very violently; yet the coughing simply tends to exhaust the patient, because there is really little or nothing to bring up. The same is the case in inflammation of the lung substance itself. As an example of excessive action we may take sneezing, which is calculated to remove irritants from the nose, but when too powerful may cause the patient to burst a blood-vessel. In phthisis also, although there may be some expectoration to bring up, yet a good deal of the irritation is in the lung substance, and the efforts of coughing are far greater and more continuous than are required for the removal of expectoration, and they simply exhaust the patient. In inflammation of the stomach also such continuous vomiting occasionally occurs that the patient's life is in danger by his inability to retain food; and similar danger also occurs from inflammation of the intestines and consequent diarrhœa.

Defensive measures.

We will next take the various parts of the body, and consider more in detail the therapeutic measures most commonly employed in the treatment of their diseases. The defensive powers of the body against microbes, when actually on or in it, may be classed as means (1) of passive defence, (2) of active defence, and (3) of repair. Besides these, however, we must consider the protection of the whole body from injury caused by (*a*) inaction, (*b*) or over-action, or (*c*) weakness of any one of its parts. The means of passive and active defence are sometimes so closely associated that it is difficult to distinguish between them. Thus if a little diphtheritic sputum were coughed into a person's eye, or some blood containing anthrax bacilli were to touch a raw spot upon the hand, the removal of microbes in either case by washing with simple water might be regarded as a means of passive defence, whilst washing them away with an antiseptic lotion might be regarded as active defence, because the antiseptic would tend not only to remove but to destroy the microbes. In the same way, washing the skin with spirit would tend to harden the epidermis and thus prevent the entrance of microbes; and the application of an ointment to an abrasion would have a similar action. But by the addition of some antiseptic to the ointment its defensive action would be converted from passive to active, and its power to prevent infection would become greater; and if inflammation had already set up in the skin, the addition of opium, belladonna, or cocaine would lessen local pain; and an astringent, either metallic or organic, would restrain inflammation and accelerate repair. The thickening of the epidermis in the hands and feet, which occurs from constant use, is Nature's provision for meeting the extra wear to which these parts are subjected by much use; but pressure is apt to cause the defensive process to be carried too far, and to lead to corns, which give rise to much pain and annoyance. To remove these salicylic acid dissolved in flexible collodion is now generally employed. When this is painted upon the part the corn usually peels off in a day or two, and the patient is cured.

Principles of cure.

But the object of therapeutics is not merely to cure. It is, in the words of the old formula, "Curare, cito, tuto et jucunde," to cure quickly, safely, and pleasantly. There are therefore in most prescriptions (1) a basis or chief ingredient intended to cure (*curare*), (2) an adjuvant to assist its action and make it cure quickly (*cito*), (3) a corrective to prevent or lessen any undesirable effect (*tuto*), and (4) a vehicle or excipient to make it suitable for administration and pleasant to the patient (*jucunde*). In the remedy just mentioned the salicylic acid forms the basis; but sometimes chloride of zinc or lactic acid is added to it to make it act more quickly, and these are the adjuvants. Extract of belladonna is added to lessen the pain which might occur during the removal of the corn, and this acts as a corrective, while the flexible collodion forms a means of applying it conveniently, and constitutes the vehicle.

Inflammation.

The surface of the skin may be invaded by parasitic organisms and may exhibit spots, which are removed by something which will destroy the parasite, such as ointments containing mercurial salts. In psoriasis the epidermis separates in flakes at various spots which have not been subjected to pressure, and to cure it ointment containing tar or other products of the dry distillation of wood is employed. When the true skin is inflamed various appearances may arise, according to the intensity and extent of the inflammation, and the eruption may be papular, vesicular, pustular, tubercular, bulbous, or ulcerative. To lessen irritation the skin is protected by dusting powders, such as oxide of zinc, starch, fuller's earth, &c., or by ointments. Irritation is lessened by lotions containing substances that will diminish irritability of the nerve-endings and skin, such as carbolic acid, hydrocyanic acid, morphine or opium, cocaine, belladonna or atropine. Where the surface is ulcerated it may be protected from external violence and placed under favourable conditions for healing by covering it with lint moistened with water and with oil-silk over it to prevent evaporation. If the granulations tend to become too abundant, some astringent, such as sulphate of copper or sulphate of zinc, is added to the water. On the other hand, when the ulceration is old and the circulation through it poor, the aim of the therapeutist is to reawaken the normal reparative process, to bring about increased circulation and increased tissue change, and thereby insure healing. For this reason a blister is placed upon the callous ulcer, which heals with the fresh inflammation thus excited.

The treatment of inflammation of mucous membrane is based upon the same principles as inflammation of the skin, and there too we usually associate means (1) for removing microbes, (2) for destroying them, (3) for lessening the irritation they produce, and (4) for repairing any mischief they have done. Thus in the eye and ear, lotions containing an antiseptic, a sedative, and an astringent are very generally used. For inflammation of the mouth a similar combination is used as a mouth wash, in the throat as a gargle, and in the nose as a wash and sometimes as an ointment or spray, the ointment possessing the advantage of protecting the delicate nasal mucous membrane from irritation by stopping the entrance of irritant dust into the nasal cavities. In the stomach we aid the vomiting by which microbes or the products of decomposition of food are usually eliminated by giving to the patient repeated draughts of hot water so as to wash the stomach clean. Frequently this is sufficient; but if the stomach refuses to eject its objectionable contents, we may either give an emetic or wash it out by means of a stomach pump or syphon. Similar procedures are used for the intestine, and one of the best methods of treating the diarrhœa consequent upon the presence of irritating substances in the intestinal canal is to give a dose of castor-oil together with a few drops of laudanum. By means of the castor-oil the irritating substances are removed, and the laudanum which is mixed with the purgative soothes the intestine. Even in cases of very acute intestinal diseases similar treatment is now pursued, and instead of treating dysentery simply by sedatives or astringents, an eliminative treatment by means of sulphate of magnesia is largely employed. After the irritant has been removed either from the stomach or intestine, a feeling of irritation of the mucous membrane may remain, and sickness, diarrhœa, or pain may continue in the stomach and intestine although the irritant is no longer present within them, just as the flow of tears and desire to rub may remain in the eye after the piece of grit which has occasioned it may have been removed. The condition which remains after the irritant has been removed is one of inflammation more or less intense. The process of inflammation is a defensive one, but if carried too far may prove injurious.

For the purpose of checking the inflammatory processes and lessening discharge from mucous membranes astringents are employed. Some of these are of mineral and some of vegetable origin, but they almost all possess one chemical property in common, namely, they precipitate albumin. This power is possessed alike by a glass of brandy, by solution of lime, soluble salts of zinc, copper, or silver, by tannic and gallic acids, as well as vegetable juices and extracts which contain them. The strength of the astringent application and the mode of its administration are varied according to the delicacy and position of the mucous membrane affected. Thus to the eye we may use a solution of sulphate of zinc of half a grain to the ounce, while to the ear, urethra, or vagina a solution of four to eight grains or even more may be applied. For the stomach and intestines we employ the same drug in the form of a pill; and when it is desired to act especially upon the intestines, the pills are made of a harder consistence or less soluble preparation, or are covered with keratin, so that they may not act much, if at all, upon the stomach while passing through it before reaching the intestines. The heat which occurs in inflamed parts is chiefly due to the larger amount of blood circulating in the part on account of the dilatation of the vessels. The pain is due to stretching of the nerve fibrils or compression of them by the turgid vessels in the swollen tissues. This latter cause is chiefly observed when the tissues are of a very unyielding character; for example, when the inflammation occurs in a bone or under a thick fibrous and unyielding membrane. The swelling, heat, and pain may sometimes be relieved by mere change of position altering the flow of blood to the inflamed part. Thus when inflammation occurs in the finger, as in a whitlow, the pain is not only constantly severe, but it is increased by every pulsation of the heart, and thus has a throbbing character. By raising the hand nearly to a level with the head both the constant pain and the severity of the throbs may be relieved, as the blood is not sent with such great force into the arteries and returns more readily through the veins. In other parts of the body the same relief may be obtained by raising the inflamed part as high as possible. Relief is frequently given also both by heat and cold, and at first sight it seems strange that agents having such an opposite action should each produce a similar effect. The reason probably is that the application of cold causes contraction of the arteries leading to the inflamed part, while heat by dilating the vessels around forms a side channel through which the blood passes, the tension in the seat of inflammation being thus lessened in both cases. When the inflammation occurs in soft parts where the surrounding vessels can be readily dilated, heat often affords more relief to the pain than cold, but when the inflammation is in a bone or in unyielding fibrous tissues, cold generally gives more relief. For example, the pain of a gum-boil is generally relieved more by warmth, because the yielding tissues of the gum, mouth, and cheek can be readily relaxed by heat and their vessels dilated; but when the pain is dependent upon inflammation in the hard unyielding socket of a tooth, cold generally gives greater relief. The removal of blood, either by incision or by the application of leeches, sometimes gives considerable relief to the pain and tension of inflamed parts. Blisters applied at some distance from inflamed parts are also sometimes useful; and probably they produce this good effect by causing a reflex contraction of the arteries in the inflamed part, and thus acting like a cold application. Certain drugs have the power of relieving inflammation by slowing the heart and rendering its impulse more feeble. Amongst those are to be classed small doses of aconite and colchicum; the former especially tends to lessen the process of inflammation generally, when it is not too severe. There can be little doubt that the intensity of inflammation frequently depends very much on the condition of the blood, and that by altering the blood inflammation may be lessened. Thus free purgation, and especially purgation by cholagogues and salines, has long been recognized as a useful means of reducing the inflammatory process. For example, a mercurial pill at night, followed by salts and senna in the morning, will often relieve the pain in toothache or gum-boil, and lessen inflammation not only in the mouth, but other parts of the body as well. Such remedies are termed *antiphlogistic.* Venesection at one time was highly esteemed as an antiphlogistic measure, and while it is possible that it has not fallen too much into disuse, there can be no doubt that at one time it was very greatly abused, and was carried to such an excess as to kill many patients who would have recovered perfectly had they been let alone. Although the high temperature in an inflamed part is chiefly due to the increased circulation of blood in it, yet the presence of inflammation appears to cause increased formation of heat either in the inflamed part itself or in the body generally, because we rarely find inflammation exist to any extent without the temperature of the body being raised and a febrile condition produced. (See FEVER.)

Fever.

Two very old remedies for fever are acetate of ammonia and nitrous ether. These were formerly given empirically, simply because they had been found to do good. Now we can see the reason for their administration, because the nitrous ether, consisting chiefly of ethyl nitrite, dilates the superficial vessels and thus allows greater escape of heat from the surface; while acetate of ammonia, by acting as a diaphoretic and stimulating the secretion of sweat, increases the loss of heat by evaporation. When a patient is covered with several blankets, loss of heat from the surface both by radiation and evaporation is to a great extent prevented, but if a cradle be placed over him, so as to raise the bedclothes and allow of free circulation of air around his body, both radiation and evaporation will be increased and the temperature consequently lowered. If his body be left uncovered except by the sheet or blanket thrown over the cradle, the loss of heat is still greater, and it may be much increased by sponging the surface with either hot or cold water so as to leave it slightly moist and increase evaporation. The temperature may be still further reduced by placing vessels filled with ice inside the cradle. When the patient is very restless, so that cradling is impossible, a wet pack may be employed, a sheet wrung out of cold water being wrapped round him, and over this a blanket. The pack has the double effect of restraining his movements and thus lessening the production of heat, while at the same time it dilates the vessels of the skin and produces loss of heat. The restraint which it imposes and the equal distribution of heat over the surface frequently cause sleep quickly in patients who have previously been wildly delirious and entirely sleepless. When the temperature continues to rise in spite of wet sponging and cradling, recourse must be had to the cold bath. The bath should be brought to the bedside and the patient, wrapped in a sheet, should be lifted into it by two attendants. The water should be at the temperature of 90° and gradually reduced by the removal of hot water and displacement by cold, until the temperature of the patient as taken in the mouth is reduced to about 99½° or 99°. After this the patient should be taken out and again put into bed. It is inadvisable to lower the temperature quite to the normal while the patient is in the bath, as frequently it falls after his removal, and may fall so far as to induce collapse. In cases where no bath is available a large mackintosh sheet may be spread upon the bed under the patient, the sides and top may be raised by pillows, and cold water may be applied to the surface of the body with large sponges. The mackintosh sheet forms a shallow bath, and the water may afterwards be run off from it at the lower end of the bed. Another way of applying cold is to dip an ordinary sheet into cold water, apply it for three or four minutes to the surface of the body, then remove it and replace it by another sheet while the first one is being dipped in water. By the alternate use of the two sheets, or by the use of one quickly wrung out of cold water as soon as it becomes warm, the patient's temperature may be rapidly reduced.

There are a number of drugs which have a very powerful action in lowering temperature. Most of these belong to the aromatic group of bodies, although one of them, antipyrin, belongs rather to the furfurol group. Carbolic acid has an antipyretic action, but on account of its poisonous properties it cannot be employed as an antipyretic. Salicylic acid has a strong antipyretic action, and is most commonly used in the form of its sodium salt, which is much more soluble than the acid itself. Amongst other antipyretics, the most important are quinine, phenacetin, and antifebrin. These probably lessen fever by their action upon the nerve centres which regulate the temperature of the body, and partly by their peripheral action in causing the secretion of sweat. Very high fever in itself will cause death, the fatal temperature in rabbits being 114.6°. Before death occurs the pulse and respiration become exceedingly rapid and weak, and complete unconsciousness sets in. That these symptoms are simply due to heat is shown by the fact that if the temperature be quickly reduced by the application of cold the symptoms at once subside. But the delirium which is common in fever, although it may be partly due to rise of temperature, is very often due to poisons in the blood, for in some cases it occurs with quite a low temperature, 101° or 102°, whereas in others the temperature rises to 104° and 105° with no delirium whatever. The presence of toxins in the blood not only affects the brain, causing delirium, but also other organs, the heart and lung, and may cause fatal syncope or respiratory failure.

Anti-toxins and anti-serums.

Many years ago Dr S. L. Mitchell, father of the well-known neurologist, Dr Weir Mitchell, pointed out the close resemblance which exists between symptoms of poisoning by snake venom and infective fevers.[1] Weir Mitchell and others have shown that serpent venom consists chiefly of albumoses, and the toxins formed by infective bacilli have a somewhat similar chemical nature. Calmette and Fraser found that when small doses of snake venom, insufficient to cause death, are injected into an animal, temporary disturbance is produced; but after a few days the animal recovers, and a larger dose is then required to produce any symptoms. By gradually increasing the dose the animal becomes more and more resistant, until at last a dose fifty times as great as that which would at first have produced immediate death can be injected without doing the animal any harm. If a horse be chosen for the experiment, a considerable quantity of blood may be withdrawn without injuring the animal. When this is clotted the serum is found to act as an anti-venin, so that when mixed with the venom of a snake it renders it harmless. Although this result is best obtained when the venom and serum are mixed in a glass before injection, yet if they be injected at the same time in different parts of the body the animal will still be protected and the poison will not produce its usual deadly results. What occurs with snake venom takes place also when the toxins are formed by microbes, and a new method of treatment by anti-toxic serums has been introduced of late years with great success. This is most commonly and successfully used in the treatment of diphtheria. This disease depends upon the presence of a bacillus which grows rapidly at the back of the throat and in the air-passages of children, causing the formation of a membrane which, by plugging the windpipe, causes suffocation and death. At the same time it produces a poison which causes inflammation of the nerves, leading to paralysis, which sometimes proves fatal. By growing this bacillus in broth a toxin is formed which remains in solution and can be separated from the bacilli themselves by filtration. This toxin-containing broth is injected into a horse in increasing doses, just as in the case of the serpent venom, and after the resistance of the horse has been much increased it is bled into sterilized vessels and the blood is allowed to coagulate. The serum is then removed and its anti-toxic power tested by ascertaining the amount necessary to counteract a given amount of active toxin in a guinea-pig of a certain size, the standard weight being three hundred grammes. The serum, the strength of which has thus been ascertained, is distributed in bottles and injected in the proper quantity under the skin of children suffering from diphtheria. If used at an early stage of the disease, and in sufficient quantity, the results are wonderful. The same method of serum therapeutics has been used in other infective diseases, but not with the same success.

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[1] Quoted by Weir Mitchell, "Researches on the Venom of the Rattlesnake," *Smithsonian Contributions*, 1860, p. 97.

Inoculation.

Another therapeutic method which is historically much older than that of serum therapeutics is that of inoculation. The virulence of infective diseases varies in different epidemics, and at different times in the same epidemic. It had been noted that many infective diseases did not attack an individual a second time, the first attack appearing to protect from subsequent ones. The idea of inoculation, therefore, was to infect an individual with a mild form of the disease, so that he should escape infection by a more virulent one. This was tried largely in the case of smallpox, and once at least by Dr Erasmus Darwin in the case of scarlet fever. The worst of this method was that the disease thus inoculated did not always prove of a mild character, and in the case of Dr Erasmus Darwin's son the scarlet fever was exceedingly severe and very nearly proved fatal. To Jenner we owe the discovery that vaccination protects against smallpox, and it is now generally acknowledged that smallpox and vaccine are probably the same disease, the virus of which is modified and its virulence lessened by passing through the body of the cow. Pasteur found that the germs of anthrax could be cultivated outside the body and their virulence weakened either by growing them at too high a temperature or in an unsuitable medium. By inoculating first with a weak virus and then with others which were stronger and stronger, he was able completely to protect oxen either from the effects of inoculation with the strongest virus or from infection through contact with other animals suffering from the disorder. On the other hand, he found the weakened virus could be again strengthened by inoculating a feeble animal such as a guinea-pig a day or two old with it, and then inoculating stronger and stronger animals: an increase in strength was gained with each inoculation, until at last the virus could attack the strongest. A similar increase in virulence appears to occur in plague, where animals, especially rats and mice, seem to be affected before human beings, and not only increase the virulence of the microbes, but convey the infection. Two methods of protective inoculation have been used. In one, Haffkine employs the toxins obtained by growing plague bacilli in broth for five or six weeks, and then heating the whole to 65° or 70° C. so as to destroy the bacilli. This preparation is prophylactic, but does not seem to be curative. Yersin has prepared a serum from horses in the same way as diphtheria anti-toxin, and this is said to have a curative action during the attack. In the same way sterilized cultures of typhoid bacilli have been used to protect against attacks of typhoid fever, and an anti-typhoid serum has been employed with intent to cure. Protection does seem to be afforded, but the curative action of the serum is still somewhat doubtful. Although the anti-toxins which are used in the cure of infective diseases are not dangerous to life, yet they sometimes cause unpleasant consequences, more especially an urticarial eruption almost exactly like that which follows eating mussels or other shell-fish. Sometimes the swelling of the skin is much more general, so that the whole body may be so swollen and puffy as exactly to resemble that of a person suffering from advanced kidney disease. These disagreeable results, however, are not to be compared with the benefits obtained by the injection of anti-toxic serum, and this method of treatment is likely to maintain its place in therapeutics.

Organo-therapeutics.

For many years pepsine has been used as a remedy in dyspepsia to supplement the deficiency of digestive juice in the stomach, and it has been used popularly in dyspepsia for a still longer period. From time immemorial savages have been accustomed to eat the hearts of lions and other wild animals, under the belief that they will thereby obtain courage and strength like that of the animal from which the heart had been taken, but in 1889 Brown-Séquard proposed to use testicular juice as a general tonic and stimulant. Observations were made on the connexion between thyroid gland and myxœdema, which appeared to show that this disease was dependent upon atrophy of the gland. Accordingly the liquid extracts of the gland, or the gland substance itself compressed into tablets, have become largely used in the treatment of the disorder. The success which has been achieved has led to the use of many other organs in a raw or compressed form, or as extracts, in other diseases; *e.g.*, of suprarenal capsule in Addison's disease, of bone marrow in pernicious anæmia, of thymus and suprarenal capsule in exophthalmic goître, of kidney in renal disease, and of pituitary body in acromegaly. To this method of treatment the name of organo-therapeutics has been given. The first scientific attempt to employ portions of raw organs in the treatment of disease was made by Lauder Brunton in diabetes in 1873, sixteen years before Brown-Séquard's paper on the effect of testicular juice. From considering the nature of diabetes, he had come to the conclusion that many cases were due to imperfect oxidation of sugar in the body; that this oxidation was normally carried out by a ferment in the muscles, and that probably the disease was in some cases dependent upon absence of the ferment. He tried to supply this by giving raw meat and glycerine extract of meat, but although he seemed to get some benefit from the treatment, it was not sufficiently marked to attract general attention. His attempts to isolate a glycolytic ferment from flesh were also only partially successful. One of the great difficulties in the way of applying this treatment is that in all probability many of the ferments or enzymes are altered during the process of absorption in the same way as the normal ferments of digestion, and unless the tissue enzymes can be isolated and injected subcutaneously the desired results will not be obtained. The most striking of all the results of organo-therapy are those obtained in myxœdema. In this disease the face is heavy, puffy, and expressionless, the lips thick, the speech slow, the hands shapeless and spade-like, the patient apathetic, the circulation slow, and the extremities cold. Under the influence of thyroid gland these symptoms all disappear, and the patient is frequently restored to a normal condition. When the thyroid gland is absent in children, not only is the expression of the face dull and heavy as in the adult, but the growth both of body and mind is arrested, and the child remains a stunted idiot. The effect of thyroid gland in such cases is marvellous, the child growing in body and becoming healthy and intelligent. In the case of the thyroid the function of the gland appears to be to prepare a secretion which is poured out into the blood and alters tissue-change. When the thyroid tablets or extract of thyroid are given in too large quantities to patients suffering from myxœdema, the symptoms of myxœdema disappear, but in their place appear others indicative of increased metabolism and accelerated circulation.

The pulse-rate becomes very rapid, the extremities become warm, so that the patient is obliged to wear few clothes, the temper becomes irritable, the patient nervous, and a fine tremor is observed in the hands. On stopping the administration of thyroid these symptoms again disappear. When the thyroid is hypertrophied, as in Graves's disease, the same symptoms are observed, and these are probably due to increased secretion from the thyroid. At the same time other symptoms, such as exophthalmos, may appear, which have an independent origin and are not due to the secretion of the gland. The whole of the secretion here is poured into the blood and not at all on to a mucous surface, and herein the thyroid gland differs largely from such glands as the pancreas or peptic and intestinal glands. But it seems now probable that all glands which have what may be termed an external secretion like the pancreas, stomach, intestine, skin, and kidneys have also an internal secretion, so that while they are pouring out one secretion from the ducts into the intestine or external air, they are also pouring into the lymphatics, and thus into the blood, an internal secretion. In fact, a splitting appears to take place in the process of secretion somewhat resembling that which takes place in the formation of a toxin and anti-toxin. The secretion of some digestive glands would prove poisonous if absorbed unchanged. For example, the trypsin of the pancreas (*vide* Digestive Organs) digests albuminous bodies in neutral or alcoholic solution, and if the whole of that which is secreted in the pancreas for the digestion of meat in the intestine were absorbed unchanged into the circulation, it would digest the body itself and quickly cause death. The secretion of trypsin by the pancreas may therefore be looked upon as the formation of a toxin. We do not know at present if any corresponding anti-toxin or anti-trypsin, as we may term it, is returned into the lymphatics or blood from the gland, but the pancreas, which in addition to secreting trypsin secretes a diastatic ferment forming sugar from starch, pours this into the intestine and secretes at the same time a glycolytic ferment which breaks up sugar, and this latter passes into the blood by way of the lymphatics. Thus the gland not only breaks up starch into sugar in the intestine, but breaks up the sugar thus formed after it has been absorbed into the blood. It is by no means improbable that all glands have a double function, and that sometimes the external may be even less important than the internal secretion. On this point, however, we have but little definite knowledge, and a great field is open for future research. At the same time, there are many indications of the importance of an internal secretion in popular treatment. For example, there are many people who feel very much better after profuse perspiration, and as sweat appears to contain little but water and a few salts, it is not improbable that the improvement in their condition is due rather to the internal secretion from the skin than to the elimination effected by the sweat. It is probable that the kidneys also have an internal secretion, and that the great œdema sometimes found in kidney disease (*vide* Kidneys) is rather due to the action of some proteid body resembling in its effects the streptococcus anti-toxin, rather than to accumulation of water due to imperfect action of the kidney. Similarly the beneficial effects of purgation may be due not only to the elimination which takes place through the bowel, but also to the internal secretion from the intestinal glands.

Nutrition and elimination.

The health of the body depends upon the proper kind and supply of food, upon its proper digestion and absorption, on the proper metabolism or tissue-change in the body, and the proper excretion of waste. We have considered how these may be disturbed by microbes from without and from within. We have also considered in a general way the treatment of local diseases by a passive protection, active protection, and repair of waste; but both maintenance of health and repair of waste depend very largely upon the condition of the blood. When this is healthy the attacks of microbes are resisted, wounds heal readily, and patients recover from serious diseases which in persons of debilitated constitution would prove fatal. In order to keep the blood in a satisfactory condition it must be well supplied with fresh nutriment, and the products of waste freely eliminated. The food required for the body may be divided into five kinds (*vide* Dietetics)—carbohydrates, such as starches and sugars; fats; proteids, such as meat and eggs; salts; and last, but not least, water. Water forms almost three-fifths of the weight of the body, so that it amounts to more than all the other constituents put together. Without it life would be impossible, and it is well recognized that death from thirst is more awful than death from hunger. The healthy organism can adapt itself to great varieties both in regard to the quality and quantity of food; but when health begins to fail much care may be required, and many ailments arise from dyspepsia. Imperfect digestion is very often caused by defective teeth or by undue haste in eating, so that the food is bolted instead of being sufficiently masticated and insalivated (*vide* Digestive Organs). The food thus reaches the stomach in large lumps which cannot be readily digested, and either remain there till they decompose and give rise to irritation in the stomach itself, or pass on to the intestine, where digestion is likewise incomplete, and the food is ejected without the proper amount of nourishment having been extracted from it; while at the same time the products of its decomposition may have been absorbed and acted as poisons, giving rise to lassitude, discomfort, headache, or perhaps even to irritablility and sleeplessness. Much dyspepsia would be avoided by attention to the condition of the teeth, by artificial teeth when the natural ones are defective, and by obedience to one or two simple rules: (1) to eat slowly; (2) to masticate thoroughly; (3) to take no liquid with meals excepting breakfast, but sip half a pint of hot water on rising in the morning, on going to bed at night, and again about an hour before luncheon and dinner. The object of taking no liquid with meals is that it ensures mastication being more complete, because persons cannot wash the unmasticated food down by drinking, and it prevents the gastric juice from being greatly diluted, and so allows it to digest more rapidly. Should these rules be insufficient, then (4) proteid and farinaceous food should be taken in separate meals—farinaceous food at breakfast, proteid alone at lunch; farinaceous in the afternoon, and proteid again in the evening. The reason for this is that farinaceous foods are digested in the intestine and not in the stomach, where they may undergo fermentation, whereas proteid foods are to a great extent digested in the stomach. When the secretion of gastric juice is deficient it may be excited by gastric tonics, such as ten grains of bicarbonate of soda and a drachm of compound tincture of gentian in water shortly before meals, and may be supplemented by the administration of pepsin and hydrochloric acid after meals. When the nervous system is below par, and both secretion and movements are deficient in the stomach, nervine tonics, such as nux vomica or strychnine, are most useful.

High tension in the arteries is often associated with sleeplessness, the pressure of blood being such that the circulation in the brain is constantly maintained at a high

Sleeplessness.

rate of speed and the brain is unable to obtain rest. The means of producing sleep may be divided into two classes: those (1) which lessen the circulation, and which (2) diminish the excitability of the brain cells. The circulation in the brain may be lessened by warmth to the feet, cold to the head, warm food in the stomach, warm poultices or compresses to the abdomen, antipyretics, which reduce the temperature and consequently slow the beats of the heart in fever, and cardiac or vascular tonics, which slow the heart and tend to restore tone to the blood-vessels, so that the circulation in the brain may be more efficiently regulated. Amongst those which lessen excitability of the brain-cells, are opium, morphine, hyoscyamus, chloral, sulphonal, trional, paraldehyde, chloralamide, chloralose, hop, and many others. A combination of the two kinds of remedy is sometimes useful, and chloral sometimes succeeds when other things fail, because it depresses the circulation as well as lessens the activity of the brain-cells.

Pain.

Irritation of sensory nerves tends to cause contraction of the vessels and to raise the blood pressure, and where pain is present opium or morphine is the most efficient sedative. The sensation of pain is felt in the brain, and the cause of it may be in the sensory centres of the brain alone, as in cases of hysterical pain, with no lesion to cause it. Ordinarily, however, it is due to some peripheral irritation which is conducted by sensory nerves to the spinal cord and thence up to the sensory centre in the brain. Pain may be stopped by removing the cause of irritation, as, for example, by the extraction of a carious tooth or by rendering the nerve-endings insensitive to irritation, as by the application of cocaine; by preventing its transmission along the spinal cord by antipyrin, phenacetin, acetanilide, cocaine, &c.; or by dulling the perceptive centre in the brain by means of opium or its alkaloids, by anæsthetics, and probably also, to a certain extent, by antipyrin and its congeners.

Flatulence.

Deficient nervous action also leads to defective secretion and movement in the intestine, sometimes with flatulent accumulation and sometimes with constipation. In such cases nux vomica or strychnine is useful. Flatulent distension in the stomach or bowels is partly due to air which has been swallowed and partly to gas which has been formed by the decomposition of food. The stomach may become distended with gas on account of acid fermentation leading to the frequent swallowing of saliva, and both this form of flatulence and that caused by the actual formation of gas are much diminished by such drugs as tend to prevent fermentation. Amongst the best of these are carbolic acid in doses of one or two grains, creosote in one or two drops, and sulpho-carbolate of soda in doses of ten grains. Others which may be mentioned are salicylate of bismuth, salol, β-naphthol, and naphthalene. By preventing fermentation in the intestine these also tend to prevent or check diarrhœa, and they may do good after the irritant has been removed by castor oil. After the irritant has been removed and fermentation stopped, the irritation still remaining in the intestinal wall may be soothed by chalk mixture and bismuth, to which if necessary small quantities of opium may be added. In cases where diarrhœa is very obstinate and lasts for weeks, sulphuric acid is sometimes more efficacious than alkalis; and in chronic colics it may be necessary to treat the mucous membrane by local application of astringent solutions. For this purpose solutions of sulphate of copper or of nitrate of silver may be gently introduced into the bowel in quantities of a quart at a time. It is essential that a large quantity should be used, as otherwise the seat of irritation may not be reached by the astringent.

Constipation.

Constipation is so common that it may be almost looked upon as the normal condition in civilized countries. Two of its chief causes probably are (1) improvement in cookery, whereby the harder and more irritating parts of the food are softened or removed; and (2) improvement in grinding machinery, whereby the harder and more stimulating parts of the grain are separated from the finer flour which is used for bread. In consequence of the absence of mechanical stimulant the bowels act more slowly, and constipation is the result. It may be considerably diminished by a return to a more natural system of feeding, as by using brown bread instead of white, by taking oatmeal porridge, and by eating raw or cooked fruits, such as apples, oranges, prunes, and figs, or preserves made of fruit, such as raspberry and strawberry jam, marmalade, &c., or by vegetables. Should these means fail, aperients may be used. The commonest are senna in the form of compound liquorice powder, sulphur in the form of lozenges, cascara sagrada, either in tablets or in the form of liquid or dry extract, rhubarb, colocynth, and especially aloes. The last acts chiefly upon the lower bowel, and forms a constituent of nearly every purgative pill. The medicines above mentioned may be taken either in a moderate dose at bedtime or in the form of a dinner pill, or they may be taken in small doses three times a day just before or after meals. Some sufferers from constipation find that they get greater relief from salts dissolved in water, or from natural aperient water taken on rising in the morning, and others again find that the best way of opening the bowels is to inject one or two drachms of glycerine into the rectum, or use it as a suppository. If these means fail, exercise, massage, and electricity may help a cure.

Diseases of malassimilation.

The most common diseases of malassimilation are gout, rheumatism, and diabetes. In health most of the nitrogenous waste in the body is eliminated as urea, but in gout uric acid is either formed in too great quantity or too little is eliminated, so that it tends to be deposited as urate of soda in the joints and other tissues. Two means of treating it by diet have been proposed. One is to put the patient on an almost complete vegetarian diet, so as to limit both the amount of uric acid introduced into the body as well as its formation in the body. The other plan is to use an exclusively meat diet, combined with the ingestion of a large quantity of hot water, so as to cause free elimination. Where neither method is strictly pursued it is usual to forbid to gouty patients sugar, pastry, and pickles, and to forbid heavy wines, especially Burgundy and port. During an attack of acute gout nothing relieves so much as colchicum, but during the intervals potash or lithia salts taken in water are advisable, as tending to prevent the deposits of urate of soda. In true diabetes, which probably originates in the central nervous system, as well as in the glycosuria common in gouty patients, sugar in every form should be entirely forbidden, and starchy food restricted to within narrow limits. The remedy most trusted to in this disease is opium and its alkaloids, morphine and codeine. In acute attacks of rheumatism the remedy *par excellence* is salicylate of soda, which reduces the temperature, relieves the pain, and removes the swellings from the joints. Rest in bed should be insisted upon for a longer time than appears actually required, because acute rheumatism tends to bring on cardiac changes, and is more likely to do this when the heart is excited than when the patient is kept at rest. In chronic rheumatism the chief remedies are salicylate of soda, iodide of potassium, guaiacum, and sulphur, while massage, liniments, and baths are beneficial as local applications.

Elimination of waste-products is one of the most important points in regard to health, and when this is interfered with by disease of the kidneys, the life of the patient is rendered more or less uncertain and the health frequently seriously impaired. In some cases of chronic inflammation of the kidneys, where the disease is not extensive, the patient may continue in fair health for a number of years, provided attention be paid to the following rules:—(1) The body must be kept warm, and chills must be scrupulously avoided; (2) the digestion must be attended to carefully, so that no excess of poisonous bodies is formed in the intestine or absorbed from it; (3) eliminating channels such as the skin and bowel must be kept active. It is usual to reduce the quantity of proteid food to a minimum, in order to lessen the amount of nitrogenous waste to be excreted by the kidneys. Sometimes an entirely milk diet is useful, but in others it does not agree, and a more liberal diet is essential. Alcohol should be avoided as much as possible. The small contracted kidney, which is so common in elderly gouty people, is usually associated with a very large secretion of urine containing only a minute trace of albumin. The tension within the blood-vessels is generally high, and the patients run a risk of anginal attacks or of apoplexy. A nearly vegetarian diet and a complete abstinence from alcoholic stimulants is the ideal in such cases, but it must be modified to suit individuals, as sometimes very strict limitations prove injurious. The daily use of potash, and especially nitrate of potash, tends to reduce the tension and increase the patients' safety, but if pushed too far may sometimes render them very weak and depressed.

Diets and "cures."

It has already been mentioned that water is absolutely necessary for the body: by taking it hot it does not lie like a weight on the stomach, and by taking it an hour before meals it washes out the remnants of the previous meal; and being absorbed into the blood, it probably renders the secretion of gastric juice freer and accelerates digestion, instead of diluting it and interfering with the digestive processes. Where the stomach and bowels are irritable, all food likely to cause mechanical irritation should be avoided, such as skins, bones, fibres, and seeds. In some cases of diarrhœa an entirely milk diet has to be prescribed, and in the diarrhœa of children it is sometimes necessary to alternate a diet of barley water with one of beef juice or white of egg and water, or to give whey instead of milk. The drinking of large quantities of whey is used as a means of cure for dyspepsia in adults, and also in cases of chronic bronchitis. The whey is drunk warm, and for this cure it is usual to go to some Alpine resort where pasturage is abundant and fresh milk can be had at all times of the day. The cure is greatly helped by the fresh air and sunshine of such places, among which are Gais, Heiden, Interlaken, Rorschach, Rigi-Scheideck, and Weggis in Switzerland; Ischl and Meran in Austria; Harzburg, Kreuth, Partenkirchen, Rehburg, Reichenhall, Sankt Blasien, Salzbrunn, and Streitberg in Germany. Another therapeutic method is the so-called "grape cure," in which, along with a regulated diet, five or six pounds of grapes are eaten daily. As the grapes contain a quantity of water and of salts, they tend to lessen the amount of food taken, to increase the action of the bowels, and to stimulate the kidneys. The "grape cure" is used both in chronic disease of the stomach and intestines with or without constipation, and also in cases of gout or ailments depending upon a gouty constitution. The chief places where it is carried on are in the neighbourhood of the Rhine, on the Lake of Geneva, and in the Tirol. Amongst places in the Rhine and its vicinity may be mentioned Cannstadt, Dürkheim, Gleisweiler, Kreuznach, Neustadt, Rüdesheim, St Goar, and Weinheim; on the Lake of Geneva are Montreux and Vevey; and in the Tirol Gries and Meran. The so-called "Salisbury" cure consists of living entirely upon minced beef and hot water. It sometimes answers very well in persons troubled with flatulence, since meat does not give rise to the same amount of gas in the intestines as carbohydrates. During its continuance fat is absorbed from the subcutaneous tissue, and patients become very much thinner, so that it not only lessens flatulence, but reduces obesity. It is, in fact, very much the same system as that proposed a number of years ago by Banting. It is very important for those who are trying this diet to bear in mind the necessity of abundance of water, because sometimes they may be tempted to lessen the water on account of the inconvenience produced either by frequent micturition or too profuse sweats. If the meat diet be continued with too small a proportion of water, a gouty condition may be brought on. This diet has been recommended in gout, and no doubt the essential part of it is the hot water, but there can be little doubt that in fat gouty people it is often useful. An entirely opposite dietary is that in which butcher's meat is completely excluded and proteids reduced to a minimum, as advocated by Dr Haig. This dietary also is very useful in gout, but it answers better in thin gouty people than in fat ones.

The dietaries already mentioned, the whey cure, the grape cure, the meat cure, and the vegetarian cure, are all more or less systems of starvation, one or other article of ordinary diet being either reduced to a minimum or omitted altogether. In three of them at least—the whey cure, the grape cure, and the meat cure—a diminution in one or other of the solid constituents of food is associated with the ingestion of an unusually large quantity of water. In visiting the most famous watering-places, it is curious to note how one finds, in the various waters, here some chloride, there some sulphate, here some potash, there some magnesium, but in all of them we find water. In watching the troops of patients who go to the wells we notice that most of them do more early rising, take more regular exercise, and drink more water in the course of a month at the well than they would do in the rest of the year at home. The watering-places divide themselves, according to the temperature of the waters, into cold and thermal, and according to the composition of the waters, into purgative saline, indifferent saline, sulphur, and iron. Amongst the most celebrated saline waters are those of Carlsbad, which contain sulphate of soda and bicarbonate of soda. These salts crystallize out when the water is partially evaporated and may be used with hot water at home, the best imitation of the Carlsbad water being obtained by mixing with hot water the powdered Carlsbad salts (*pulverförmig*), which contain all the constituents of the natural water. Where it is impossible for the patient to visit Carlsbad, half a teaspoonful or a teaspoonful of salts may be taken in a large tumbler of hot water on rising every morning; but when taken at home the treatment is not so effective as at Carlsbad, because at the wells sipping water is associated with early rising, considerable exercise, and a very carefully regulated diet. It is, indeed, the care with which the diet of patients is regulated and the difficulty that patients find in obtaining forbidden foods at hotels and restaurants, that make Carlsbad better for the liver than any other watering-place. Amongst other places having a similar action are Marienbad, Franzensbad, and Tarasp. The waters just mentioned contain free alkali as well as sulphates, and are employed more especially in cases of hepatic disorder, such as congestion of the liver, jaundice, gall-stone, and diabetes. A number of other waters containing sulphides and chlorides are powerfully purgative, and are more often drunk at home than at the springs. Amongst these are the Hungarian waters, Æsculap, Apenta, Franz Josef, and Hunyadi Janos; and the Rubinat and Condal waters of Spain. Waters which have a similar composition are drunk at the springs of Leamington and Cheltenham in England, Brides Salins and St Gervais in France, for chronic constipation, dyspepsia, gout, and hepatic disorders of a milder character than those usually treated at Carlsbad. The waters in which chlorides form the purgative principle are those of Homburg, Kissingen, Wiesbaden, and Baden Baden in Germany, and Bridge of Allan in Scotland. Similar waters, but much weaker, are found at Innerleithen and Pitkeithly. Sulphur waters are chiefly used for painful and stiff joints, chronic skin disease, and chronic catarrhal affections. The most important are Aix-les-Bains, and a number of springs in the Pyrenees in France, Aachen in Germany, Harrogate in England, Strathpeffer and Moffat in Scotland. Iron waters are used in anæmia and the affections which are frequently associated with it. The most important are Spa in Belgium, Schwalbach in Germany, St Moritz and Tarasp in Switzerland. Iron waters are, however, common, and are generally found at all those places which have sulphur waters. Simple alkaline waters, containing carbonates, chiefly of sodium along with some magnesium and calcium, are drunk for their utility in gastric and intestinal disorders as well as in rheumatism and gout. They are also employed locally as sprays and douches to the nose, throat, vagina, and rectum, for catarrhal conditions of the mucous membranes. The most important are Vichy and Vals in France and Neuenahr in Germany. Alkaline waters, containing a little common salt, are perhaps even more important than the pure alkaline, as the salt lessens the depressing effect of the alkali. They are therefore used largely in chronic gout, rheumatism, and in calculous affections of the kidney. Amongst the most important are Ems and Wildungen in Germany, Contrexéville and Royat in France.

Baths.

Simple thermal waters are those which contain only a very small quantity of solids, and owe their efficacy chiefly to their temperature. They are used partly for drinking, but even more so for baths. Bath, Buxton, and Matlock in England; Mallow in Ireland; Wildbad, Schlangenbad, and Badenweiler in Germany; Gastein and Teplitz in Austria; Ragatz and Senkerbad in Switzerland; Plombières and Dax in France; and Bormio in Italy are amongst the best known. When water is dashed against the body with more or less violence, its effects are more powerful than when the body is simply immersed in it. Thus the stimulating effect of sea-bathing is more marked than simple salt-water baths, for in addition to the effect upon the skin produced by the salt and by the temperature of the water, we have the quicker removal of heat by the continual renewal of the water as the waves dash over the body, and mechanical stimulus from its weight and impetus. Somewhat similar effects are produced by so-called wave-baths, and at Nauheim, although the fresh movement of the water against the surface of the body is much less than in the sea, yet its stimulating effect is greatly increased by the presence of carbonic acid in it. Douches have a still more powerful action than waves. They are generally given in the air, but at Plombières very simple douches are given under water. These form a more powerful wave-bath, and are used very successfully for the treatment of abdominal disorders. Douches to the spine are much employed for nervous debility, and good effects are also obtained in such cases from the so-called needle-bath, where small streams of water at high pressure are driven against the whole surface of the body. In the treatment of stiffened joints, massage under water is very serviceable, and in the so-called Aix douche a nozzle from which water continuously streams is fastened to the wrist of the masseur, so that a current of water is constantly playing upon the joint which he is rubbing. While water containing much saline matter, and more especially water containing free carbonic acid, has a very stimulating action upon the skin, mud has a sedative effect, so that in a mud-bath one feels a pleasant soothing sensation as if bathing in cream. These mud-baths are chiefly employed at Marienbad, Franzensbad, and Homburg. Sulphur-baths and sulphur waters are chiefly used in combination for rheumatism and gout, and massage, especially under water, is frequently combined most advantageously with baths and drinking water to effect a cure.

Exercise.

Exercises, passive and active, are also used in diseases of the joints, as well as massage and baths, but exercises and training are even more important in cases of cardiac disease. In very bad cases of heart disease, where the patient is unable to go about, the best plan of treatment usually is to make him stay absolutely quiet in bed and have massage, which aids the circulation, tends to remove waste, and increases the appetite. To this is added gentle exercise, beginning with the fingers at first. At Meran walks have been arranged according to Oertel's system, and at Llangammarch in Wales both Oertel's and Schott's systems are employed, and baths according to the Nauheim system are also to be found in London, Sidmouth, Leamington, Buxton, Strathpeffer, &c. Many people who have sedentary employments are unable to get as much exercise as they require because they have not either the time or the opportunity. Such persons may sometimes get a good deal of exercise in a short time by the use of dumb-bells, of elastic cords, or of cords running over pulleys and weighted at one end. The whole system of methodical exercises was started by Ling in Sweden, but it has been developed to a large extent for the purpose of increasing muscular strength by the professional athlete Sandow. Fencing, boxing, wrestling, and the use of a punching-ball may also be resorted to. Walking on the flat is of comparatively little use as a mode of exercise, and has become supplanted to a considerable extent by bicycling. Ascending mountains, however, is very different, because in walking up a steep ascent all the muscles of the body are thrown into action, and not only those of the legs. In addition the purer and rarefied air of the Swiss mountains seems to produce a sense of exhilaration which is not felt nearer the sea-level. For those who suffer from nervous depression, exercise in the Swiss mountains is useful, and even living at a height of about 6000 feet above the sea-level seems to have an exhilarating influence. The nature of this is not very easy to analyse, but as mental depression is closely associated with irritation of the vagus nerve and weakening of the circulation, it seems not at all unlikely that mountain air acts by accelerating the pulse and quickening the circulation, and thus creating a sense of well-being. Indeed many patients liken its effect to that of drinking champagne. In some persons rarefied air is too stimulating, so that they find difficulty in sleeping, and for those who suffer from insomnia a warm moist air nearer the sea-level is preferable.

It sometimes happens, however, that people cannot sleep at the seaside itself, although they do so perfectly well a mile or two inland. Where the nervous system is exhausted, such warm and moist climates as Malaga, Madeira, Tenerife, and Grand Canary are suitable. In these places not only is the air moist, but the temperature is particularly equable, and they are therefore suitable places also for persons suffering from kidney disease. Many such persons also do well in dry, warm places, such as the higher reaches of the Nile, Egypt, Mentone, St Raphaël, and other sheltered places on the Riviera. The places mentioned are all suitable for persons suffering from chronic bronchitis, who should avoid any irritation of the larynx, trachea, or bronchi by air which is too dry or which is liable to great changes of temperature. Some cases of phthisis, therefore, do better in warmer and moist climates, and especially those where the larynx has become affected by the disease. Such patients are apt to suffer much from cough and laryngeal irritation in the cold, dry air of the Alps, whereas they live in comparative comfort on the Riviera, in the Canary Islands, Madeira, or at Capri. But warm, moist climates rather favour sedentary habits and tend to lessen appetite, so that the nutrition of the patient is apt to suffer; and although phthisical patients may live in comparative comfort in such climates, their tendency to recovery in them is small. At the Swiss health resorts, on the contrary, during the winter the air is very pure, and has just sufficient coldness to make exercise agreeable to patients. They are thus induced to be out the whole day, and to take food with an appetite which greatly improves their nutrition and aids their restoration to health. The best-known Alpine health resorts are St Moritz and Davos, to which lately Grindelwald has been added. St Moritz is, upon the whole, better for less advanced cases, while Davos is more sheltered and better for cases which are severe. It is a mistake, however, to send those in whom the disease is very far advanced away from home and friends, because when there is no hope of cure it is better for them to die in comfort at home. At the health resorts just mentioned the amount of food taken is regulated by the appetite of the patient himself, but a system of cure has been inaugurated by Dr Brehmer at Görbersdorf, by Dr Dettweiler at Falkenstein, and by Dr Walther at Nordrach, in the Black Forest. The most important point in this treatment consists in forced feeding, the want of appetite which is so prominent in many cases of phthisis being regarded as an abnormal sensation not to be regarded; and under the forced feeding, combined with open-air life, many marvellous recoveries are recorded. Numerous other institutions have been started in imitation of Dr Walther's, but their success or failure must depend very much on the doctor who directs them. In the well-known "rest" cure, which we owe to Weir Mitchell, forced feeding takes a prominent part. The essence of this cure is to give to the patient rest, bodily and mental, by confinement to bed and isolation from the outside world. While this treatment by itself would aid recovery from nervous exhaustion, it would lessen appetite and thus interfere with nervous repair; but the want of exertion is supplied by means of massage, which stimulates the circulation and increases the appetite, so that the patient gets all the benefit of exercise without any exhaustion. Where nervous exhaustion is less marked and the Weir Mitchell treatment is not appropriate—for example, in men who are simply overworked or broken down by anxiety or sorrow—a sea voyage is often a satisfactory form of "rest" cure. The lack of posts and telegrams prevents much of the excitement which they would have upon shore, the space for exercise is limited, food is abundant and appetite is supplied by the stimulus of constant exposure in the open air. In order that the voyage should be satisfactory, however, it must be sufficiently long, and the weather must be sufficiently warm to allow the patient to stay in the open air the whole day long. During the heat of summer voyages to the North Cape are suitable, and during the spring and autumn to the Mediterranean, but in the colder months of the year the West Indies, India, Cape Town, Australia, or New Zealand forms the best objective. (T. L. B.)

Health resorts.

Theresienstadt (Czech, *Terezin*), a royal free town and important garrison in the government district of Leitmeritz, Bohemia, Austria, situated on the Eger river, near its confluence with the Elbe, in a district known as the "Bohemian Paradise," from its wealth of fruit trees. The fortress erected here by the Empress Maria Theresa in 1780 was abandoned in 1882; but the place remains one of considerable strategic importance, owing to its position on both banks of the Eger in the midst of a broad plain. It lies on the border between the Czech and German portions of Bohemia, and its inhabitants belong to both nationalities. The basaltic cones of the Mittelgebirge are visible from the town. Population (1890), 7215; (1900), 7046, including garrison of 3998 men.

Therezina, a town of Brazil, and capital of the state of Piauhy. It was formerly called Chapada do Corisco, and has several fine churches and public buildings. Among the manufacturing industries are a large factory for making cotton and thread, an iron foundry, a soap factory, and machines for assorting and pressing cotton. Population, 22,000.

Thermochemistry. — Thermochemistry is a branch of Energetics, and treats of the thermal phenomena which are associated with chemical change.

§ 1. That vigorous chemical action is accompanied by a brisk evolution of heat is evident from such familiar examples as the combustion of fuel or the explosion of gunpowder. The heat attendant on these actions, and on the vital processes of the animal organism, naturally first attracted attention. Boyle, Crawford, Lavoisier and Laplace, Dulong, Davy, Rumford, all concerned themselves with thermochemical investigations of such processes. Their quantitative experiments were, however, too rough to permit of accurate generalization; and although Lavoisier and Laplace stated the principle that the same amount of heat must be supplied to decompose a compound as would be produced on its formation, the statement was not based on exact experiment, and only received experimental confirmation much later.

The beginnings of modern thermochemistry, though made independently of the doctrine of the Conservation of Energy, are practically contemporaneous with the recognition of that law, and without it the science could scarcely have reached the degree of development which it rapidly attained. Thomas Andrews and, especially, G. H. Hess (1840) were the first who systematically investigated thermochemical effects in solution, and arrived at conclusions from their experimental data which still possess validity. Andrews, for example, found that when a series of acids were under similar conditions used to neutralize a given amount of a base, the quantity of heat evolved on the neutralization was the same in all cases. Hess, from his work, arrived at the converse conclusion, that when a series of bases were used to neutralize a given amount of an acid, the heat of neutralization was always the same. Both of these statements are correct when the powerful mineral acid and bases are considered, exceptions only arising when weak acids and bases are employed. Again, Andrews discovered that when one metal displaces another from solution of its salts (*e.g.*, zinc with solutions of copper salts), the thermal effect is practically independent of the nature of the acid radical in the salt employed. Andrews likewise found that when the heat evolved on the displacement from its salts of a metal M′ by a metal M is added to the heat of displacement of another metal M″ by M′, the sum is equal to the heat which is evolved on the direct displacement of M″ from its salts by M. This affords an example of a principle which had been stated by Hess in a very general form under the name of the *Law of Constant Heat Sums*—namely, that the thermal effect of a given chemical action is the same, independently of the character and number of the stages in which it takes place. Thus, in the above example, it is immaterial whether M displaces M″ from its salt directly, or whether M first displaces M′, which is then used to displace M″. This important principle is a direct consequence of the Law of the Conservation of Energy, but was discovered independently by Hess from accurate experiment.

Hess employed this principle to determine indirectly the *heat of formation* of compounds from their elements, when this magnitude, as is generally the case, was inaccessible to direct measurement. Thus the heat of formation of anhydrous zinc sulphate, $ZnSO_4$, which cannot be determined directly, may be arrived at by summation (in Hess's units) as follows:—

Oxidation of Zn to ZnO	5291	units
,, S ,, SO_3	6384	,,
Dissolution of SO_3 in much water	2566	,,
,, ZnO in the resulting aqueous H_2SO_4	1609	,,
	15850	,,
Deduct heat of dissolution of anhydrous $ZnSO_4$.	1193	,,
Heat of formation of $ZnSO_4$ from Zn, S, and 4O =	14657	,,

Heats of formation are still determined for the most part in a precisely similar manner.

Hess also stated another principle on empirical grounds, which, although admitting of many exceptions, is of considerable utility and significance. It had been known long before his time that when solutions of neutral salts were mixed, and no precipitate resulted, the mixed solution was also neutral. Hess now observed that in the process of mixing such neutral solutions no thermal effect was produced—that is, neutral salts in aqueous solution could apparently interchange their radicals without evolution or absorption of heat. These experimental results were generalized by him under the title of the *Law of Thermoneutrality.*

After the investigations of Hess and Andrews, a great deal of excellent experimental work was performed by Favre and Silbermann, whose chief theoretical achievement was the recognition that the heat of neutralization of acids and bases was additively composed of two constants, one determined by the acid and the other by the base. This deduction harmonized the observations of Andrews and of Hess previously alluded to, and also accounted satisfactorily for the Law of Thermoneutrality.

The Danish chemist, Julius Thomsen (born 1826), was the first investigator who deliberately adopted the principle of the Conservation of Energy as the basis of a thermochemical system. His thermochemical work was begun in 1853, but most of his experiments were performed in the years 1869–82, the whole being published collectively, under the title *Thermochemische Untersuchungen*, in four volumes. Somewhat later than Thomsen, the distinguished French chemist, Marcellin Berthelot, began (in 1873) a series of thermochemical determinations, which by the hands of himself and his pupils have been continued to the present day (1902). It is to these two investigators that most of our exact thermochemical data are due.

Thomsen and Berthelot independently enunciated a generalization (commonly known as Berthelot's *Third Principle*, or *Principle of Maximum Work*), which may be stated in brief as follows:—Every pure chemical reaction is accompanied by *evolution* of heat. Whilst this principle is undoubtedly applicable to the great majority of chemical actions under ordinary conditions, it is subject to numerous exceptions, and cannot therefore be taken (as its authors originally intended) as a secure basis for theoretical reasoning on the connexion between thermal effect and chemical affinity. The existence of reactions which are reversible on slight alteration of conditions at once invalidates the principle, for if the action proceeding in one direction evolves heat, it must absorb heat when proceeding in the reverse direction. As the principle has now been abandoned even by its authors, it is at the present time only of historical importance, although for many years it exerted considerable influence on thermochemical research.

§ 2. From the standpoint of the Law of the Conservation of Energy, the relation between chemical and thermochemical action bears the following aspect:—A given amount of any substance under given conditions possesses a perfectly definite amount of intrinsic energy, and, no matter what chemical and physical transformations the substance may undergo, it will, when it returns to its original state, possess the original amount of intrinsic energy. If we consider now the transformation of one system of chemical substances into another system under specified conditions, we shall find that in general the intrinsic energy of the second system is different from the intrinsic energy of the first. Let us assume, as is commonly the case, that the intrinsic energy of the initial system is greater than that of the final system. When the first system then is transformed into the second, the excess of energy which the former possesses must appear in the shape of heat, light, electrical energy, mechanical energy, &c. It is for the most part a simple matter to obtain the excess of energy entirely in the form of heat, the amount of which is easily susceptible of measurement, and thus the existence of thermochemistry as a practical science is rendered possible. Since the intrinsic energies of the two systems under given conditions are invariable, the difference between them is constant, so that the heat evolved when the first system is converted into the second is equal to that absorbed when the second system is retransformed into the first (cf. Lavoisier and Laplace, *ante*, § 1). The total thermal effect too, which is associated with the transformation, must be the same, whether the transformation is conducted directly or indirectly (Hess's *Law of Constant Heat Sums*), since the thermal effect depends only on the intrinsic energies of the initial and final systems.

Since the intrinsic energy of a substance varies with the conditions under which the substance exists, it is necessary, before proceeding to the practical application of any of the laws mentioned above, accurately to specify the conditions of the initial and final systems, or at least to secure that they shall not vary in the operations considered. It is also a necessary condition for the application of the preceding laws that no form of energy except heat and the intrinsic energy of the substances should be ultimately involved. For example, when metallic zinc is dissolved in dilute sulphuric acid with production of zinc sulphate (in solution) and hydrogen gas, a definite quantity of heat is produced for a given amount of zinc dissolved, provided that the excess of energy in the initial system appears entirely as heat. This provision may not always be fulfilled, since by placing the zinc in electrical contact with a piece of platinum, likewise immersed in the sulphuric acid, we can generate a current of electricity through the solution and the metallic part of the circuit. The reaction as before is completely expressed by the chemical equation

$$Zn + H_2SO_4 = ZnSO_4 + H_2,$$

the initial and final systems being exactly the same as in the first case; yet the amount of heat generated by the action is much smaller, a quantity of the intrinsic energy having been converted into electrical energy. This electrical energy, however, is equivalent to the heat which has disappeared, for it has been shown experimentally that if it is converted into heat and added to the heat actually evolved, the total quantity of heat obtained is exactly equal to that produced by the direct dissolution of the zinc in the absence of platinum.

§ 3. The following conditions have to be considered as affecting in a greater or less degree the intrinsic energy of the initial and final systems:—

(1) Dilution of solutions.
(2) Physical state.
(3) Change of volume.
(4) Allotropic modifications.
(5) Temperature.

(1) Generally speaking, there is a considerable thermal effect when a substance is dissolved in water, and this effect varies in magnitude according to the amount of water employed. It is only, however, when we deal with comparatively concentrated solutions that the heat-effect of diluting the solutions is at all great, the heat-change on diluting an already dilute solution being for most practical purposes negligible. In dealing, therefore, with dilute solutions, it is only necessary to state that the solutions are dilute, the exact degree of dilution being unimportant. It occasionally happens that a change in dilution affects the chemical action that occurs. Thus if concentrated instead of dilute sulphuric acid acts upon zinc, the action takes place to a great extent not according to the equation given above, but according to the equation

$$Zn + 2H_2SO_4 = ZnSO_4 + SO_2 + 2H_2O,$$

sulphur dioxide and water being produced instead of hydrogen. Here we have a different final system with a different amount of intrinsic energy, so that the thermal effect of the action is altogether different.

(2) The physical state of the reacting substances must be considered, since comparatively large amounts of heat are absorbed on fusion and on vaporization. Thus the heat of fusion of ice (for $H_2O = 18$ g) is 1440 cal., and the heat of vaporization of water at 100°, for the same quantity, 9670 cal.

(3) The effect of change of volume against external pressure (due to production or consumption of mechanical energy) may be neglected in the case of solids, liquids, or solutions, but must usually be taken into account when gases are dealt with. Each gramme-molecule of a gas which appears under constant pressure during a chemical action (*e.g.*, hydrogen during the action of zinc on dilute sulphuric acid) performs work equivalent to 580 cal. at the ordinary temperature, which must be allowed for in the thermo-chemical calculation. A similar correction, of opposite sign, must be made when a gramme-molecule of gas disappears during the chemical action.

(4) When a substance—*e.g.*, carbon, phosphorus, sulphur—exists in more than one allotropic modification, the particular variety employed should always be stated, as the conversion of one modification into another is frequently attended by a considerable thermal effect. Thus the conversion of yellow into red phosphorus evolves about one-sixth of the heat of combustion of the latter in oxygen, and so the knowledge of which variety of phosphorus has been employed is of essential importance in the thermochemistry of that element.

(5) The influence of temperature on the thermal effect of a chemical action is sometimes considerable, but since the initial and final temperatures, which alone determine the variation in the thermal effect, are in almost all cases within the ordinary laboratory range of a few degrees, this influence may in general be neglected without serious error.

§ 4. *Methods.*—In order to estimate the thermal effect of any chemical process, use is made of the ordinary methods of calorimetry, the particular method being selected according to the nature of the chemical action involved. In almost every case the method of mixture (CALORIMETRY, *Ency. Brit.*, vol. xxvi. p. 505) is employed, the method of fusion with Bunsen's ice-calorimeter (*ibid.*) being only used in special and rarely occurring circumstances.

As a very great number of important chemical actions take place on mixing solutions, the method for such cases has been thoroughly studied. When the solutions employed are dilute, no water is placed in the calorimeter, the temperature-change of the solutions themselves being used to estimate the thermal effect brought about by mixing them. Known quantities of the solutions are taken, and the temperature of each is accurately measured before mixing, the solutions having been allowed as far as possible to adjust themselves to the same temperature. The change of temperature of the solutions after the mixing has taken place is then observed with the usual precautions. It is of course in such a case necessary to know the specific heat of the liquid in the calorimeter. Thomsen by direct experiment found that the heat-capacity of a dilute aqueous solution diverged in general less than 1 per cent. from the heat-capacity of the water contained in it, the divergence being sometimes in one sense, sometimes in the other. He therefore abstained from determining for each case the specific heats of the solutions he employed, and contented himself with the above approximation. Berthelot, on the other hand, assumed that the heat-capacity of an aqueous solution is equal to that of an equal volume of water, and calculated his results on this assumption, which involves much the same uncertainty as that of Thomsen. Since thermochemical measurements of this type may be frequently performed with an error due to other causes of much less than 1 per cent., the error introduced by either of these assumptions is the chief cause of uncertainty in the method.

The calorimeter used for solutions is usually cylindrical, and made of glass or a metal which is not attacked by the reacting substances. The total quantity of liquid employed need not in general exceed half a litre if a sufficiently delicate thermometer is available. The same type of calorimeter is used in determining the heat of solution of a solid or liquid in water.

Combustion calorimeters are employed for observing the heat generated by the brisk interaction of substances, one of which at least is gaseous. They are of two kinds. In the older type the combustion chamber (of metal or glass) is sunk in the calorimeter proper, tubes being provided for the entrance and exit of the gaseous substances involved in the action. These tubes are generally in the form of worms immersed in the water of the calorimeter. In the newer type (which was first proposed by Andrews for the combustion of gases) the chemical action takes place in a completely closed combustion chamber of sufficient strength to resist the pressure generated by the sudden action, which is often of explosive violence. The steel combustion chamber is of about 250 c.c. capacity, and is wholly immersed in the calorimeter. To withstand the chemical action of the gases, the "calorimetric bomb" is lined either with platinum, as in Berthelot's apparatus, or with porcelain, as in Mahler's. For ordinary combustions compressed oxygen is used, so that the combustible substance burns almost instantaneously, the action being induced by means of some electrical device which can be controlled from without the calorimeter. The accuracy of heats of combustion determined in the closed calorimeter is in favourable cases about one-half per cent. of the quantity estimated.

§ 5. *Units and Notation.*—The heat-units employed in thermochemistry have varied from time to time. The following are those which have been in most general use:—

Small calorie or gramme calorie	cal.
Large or kilogramme calorie	Cal.
Centuple or "rational" calorie	K.

The centuple calorie is the amount of heat required to raise 1 g. of water from 0° C. to 100° C., and is approximately equal to 100 cal. The large calorie is equal to 1000 cal. In view of the not very great accuracy of thermochemical measurements, the precise definition of the heat-unit employed is not a matter of special importance. It has lately been proposed to adopt the *joule*, with the symbol j, as thermochemical unit for small quantities of heat, large amounts being expressed in terms of the *kilojoule*, Kj = 1000 j. (For the exact relation between these heat-units, see CALORIMETRY, vol. xxvi. p. 509.) For ordinary thermochemical work we may adopt the relation 1 cal. = 4·18 j, or 1 Cal. = 4·18 Kj.

Except for technological purposes, thermochemical data are not referred to unit quantity of matter, but to chemical quantities—*i.e.*, to the gramme-equivalents or gramme-molecules of the reacting substances, or to some multiples of them. The notation which Julius Thomsen employed to express his thermochemical measurements is still extensively used at the present day, and is as follows:—The chemical symbols of the reacting substances are written in juxtaposition and separated by commas; the whole is then enclosed in brackets and connected by the sign of equality to the number expressing the thermal effect of the action. The chemical symbols stand for quantities measured in grammes, and heat-evolution is reckoned as positive, heat-absorption as negative. Thus

$$[\mathrm{S}, 2\mathrm{O}] = 71100 \text{ cal.}$$

indicates that 71100 calories are evolved when 32 grammes of sulphur react with 2 × 16 grammes of free oxygen to form sulphur dioxide. It is of course necessary in accurate work to state the conditions of the reaction. In the above instance the sulphur is supposed to be in the solid rhombic modification, the oxygen and sulphur dioxide being in the gaseous state, and the initial and final systems being at the ordinary temperature. Again, the equation

$$[2\mathrm{N}, \mathrm{O}] = -18500 \text{ cal.}$$

indicates that if 28 grammes of nitrogen could be made to unite directly with 16 grammes of oxygen to form nitrous oxide, the union would cause the absorption of 18500 calories. When substances in solution are dealt with, Thomsen indicates their state by affixing Aq to their symbols. Thus

$$[\mathrm{NaOH\,Aq}, \mathrm{HNO_3Aq}] = 13680 \text{ cal.}$$

represents the heat of neutralization of one gramme-equivalent of caustic soda with nitric acid, each in dilute aqueous solution before being brought into contact. One drawback of Thomsen's notation is that the nature of the final system is not indicated, although this defect in general causes no ambiguity.

Berthelot's notation defines both initial and final systems by giving the chemical equation for the reaction considered, the thermal effect being appended, and the state of the various substances being affixed to their formulæ after brackets. Ostwald has proposed a modification of Berthelot's method which has many advantages, and is now commonly in use. Like Berthelot, he writes the chemical equation of the reaction, but in addition he considers the chemical formula of each substance to express not only its material composition, but also the (unknown) value of its intrinsic energy. To the right-hand member of the equation he then adds the number expressing the thermal effect of the reaction, heat-evolution being as before counted positive, and heat-absorption negative. The mass equation then becomes an energy equation. He thus writes

$$\mathrm{S} + \mathrm{O_2} = \mathrm{SO_2} + 71100 \text{ cal.},$$

which expresses the fact that the intrinsic energy of the quantities of sulphur and oxygen considered exceeds that of the sulphur dioxide derived from them by 71100 cal. when thermal units are employed. The equation

$$\mathrm{H_2} + \mathrm{I_2} = 2\mathrm{HI} - 12200 \text{ cal.}$$

expresses that under certain conditions the intrinsic energy of hydriodic acid is greater than the intrinsic energy of its component elements by 12200 cal., *i.e.*, that hydriodic acid is formed from its elements with absorption of this amount of heat. Energy equations, such as the above, may be operated with precisely as if they were algebraic equations, a property which is of great advantage in calculation. Thus by transposition we may write the last equation as follows:—

$$2\mathrm{HI} = \mathrm{H_2} + \mathrm{I_2} + 12200 \text{ cal.},$$

and thus express that hydriodic acid when decomposed into its elements evolves 12200 cal. for the quantity indicated by the equation.

Ostwald has made the further proposal that the formulæ of solids should be printed in heavy type (or within square brackets), of liquids in ordinary type, and of gases in italics (or within curved brackets), so that the physical state of the substances might be indicated by the equation itself. Thus the equation

$$\mathit{Cl}_2 + 2\mathrm{KI}, \mathrm{Aq} = 2\mathrm{KCl}, \mathrm{Aq} + \mathbf{I}_2 + 52400 \text{ cal.},$$

or

$$(\mathrm{Cl_2}) + 2\mathrm{KI}, \mathrm{Aq} = 2\mathrm{KCl}, \mathrm{Aq} + [\mathbf{I}_2] + 52400 \text{ cal.},$$

would express that when gaseous chlorine acts on a solution of potassium iodide, with separation of solid iodine, 52400 calories are evolved. These suggestions have not as yet been widely adopted.

§ 6. *Heat of Formation.*—For thermochemical calculations it is of great importance to know the heat of formation of compounds from their elements, even when the combination cannot be brought about directly. As an example of the use of Ostwald's energy-equations for the indirect determination we may take the case of carbon monoxide.

The following equations give the result of direct experiment:—

$$\mathrm{C} + 2\mathrm{O} = \mathrm{CO_2} + 94300 \text{ cal.}$$
$$\mathrm{CO} + \mathrm{O} = \mathrm{CO_2} + 68000 \text{ cal.}$$

If now it is required to find the heat of formation of the compound CO, which cannot be directly ascertained, we have merely to subtract the second equation from the first, each symbol representing constant intrinsic energy, and thus we obtain

$$\mathrm{C} + \mathrm{O} - \mathrm{CO} = 26300 \text{ cal.},$$

or

$$\mathrm{C} + \mathrm{O} = \mathrm{CO} + 26300 \text{ cal.},$$

that is, the heat of formation of a gramme-molecule of carbon monoxide is 26300 cal.

As has already been stated, the heat of formation of a compound is the amount (expressed in thermal units) by which its intrinsic energy exceeds or falls short of that of the elements which enter into its composition. Now of the absolute values of intrinsic energy we know nothing; we can only estimate differences of intrinsic energy when one system is compared with another into which it may be directly or indirectly converted. But since the elements cannot under any circumstances be converted one into the other, we are absolutely without knowledge of the relative values of their intrinsic energy. This being the case, we are at liberty to make the assumption that the intrinsic energy of each element (under specified conditions) is zero, without thereby introducing any risk of self-contradiction in thermochemical calculations. This assumption has the great advantage, that the intrinsic energy of a compound relatively to its elements now appears as the heat of formation of the compound with its sign reversed. Thus if we consider the energy equation

$$C+O_2=CO_2+94300 \text{ cal.},$$

and replace the symbols by the values of the intrinsic energy, viz., zero for carbon and oxygen, and x for carbon dioxide, we obtain the equation

$$0+0=x+94300 \text{ cal.}$$

or

$$x=\ -94300 \text{ cal.}$$

With knowledge then of the heats of formation of the substances involved in any chemical action, we can at once calculate the thermal effect of the action, by placing for each compound in the energy-equation its heat of formation with the sign reversed, *i.e.*, its heat of decomposition into its elements. Thus if we wish to ascertain the thermal effect of the action

$$Mg+CaO=MgO+Ca,$$

we may write, knowing the heats of formation of CaO and MgO to be 131000 and 146000 respectively,

$$0-131000=0-146000+x$$
$$x=15000 \text{ cal.}$$

Since heats of formation afford such convenient data for calculation on the above method, they have been ascertained for as many compounds as possible.

Substances with positive heats of formation are termed *exothermic;* those with negative heats of formation are termed *endothermic.* The latter, which are not very numerous, give out heat on decomposition into their elements, and are more or less unstable. Amongst endothermic compounds may be noted hydriodic acid, HI, acetylene, C_2H_2, nitrous oxide, N_2O, nitric oxide, NO, azoimide, N_3H, nitrogen trichloride, NCl_3. Some of these pass into their elements with explosive violence, owing to the heat generated by their decomposition and the gaseous nature of the products.

§ 7. *Heat of Combustion.*—The thermochemical magnitude which is universally determined for organic compounds is the heat of combustion, usually by means of the calorimetric bomb. The relation between the heat of combustion of a hydrocarbon and its heat of formation may be readily seen from the following example. The hydrocarbon methane, CH_4, when completely burned to carbon dioxide and water, generates 213800 cal. We may therefore write

$$CH_4+4O=CO_2+2H_2O+213800.$$

Now we know the heats of formation of carbon dioxide (from diamond) and of liquid water to be 94300 cal. and 68300 cal. respectively. The above equation may consequently be written, if x is the heat of formation of methane,

$$-x+0=-94300-(2\times 68300)+213800$$
$$x=17000 \text{ cal.}$$

This heat of formation, like that of most hydrocarbons, is comparatively small: the heat of formation of saturated hydrocarbons is always positive, but the heat of formation of unsaturated hydrocarbons is frequently negative. For example, ethylene, C_2H_4, is formed with absorption of 16200 cal., acetylene, C_2H_2, with absorption of 59100 cal., and liquid benzene, C_6H_6, with absorption of 9100 cal. Since the heat of combustion of a hydrocarbon is equal to the heat of combustion of the carbon and hydrogen it contains minus its heat of formation, those hydrocarbons with positive heat of formation generate less heat on burning than the elements from which they were formed, whilst those with a negative heat of formation generate more. Thus the heat generated by the combustion of acetylene, C_2H_2, is 316000 cal., whereas the heat of combustion of the carbon and hydrogen composing it is only 256900 cal., the difference being equal to the negative heat of formation of the acetylene.

For substances consisting of carbon, hydrogen, and oxygen, a rule was early devised for the purpose of roughly calculating their heat of combustion (Welter's rule). The oxygen contained in the compound was deducted, together with the equivalent amount of hydrogen, and the heat of combustion of the compound was then taken to be equal to the heats of combustion of the elements in the residue. That the rule is not very accurate may be seen from the following example. Cane-sugar has the formula $C_{12}H_{22}O_{11}$. According to Welter's rule, we deduct 11 O with the equivalent amount of hydrogen, namely, 22 H, and are left with the residue 12 C, the heat of combustion of which is 1131600 cal. The observed heat of combustion of sugar is, however, 1354000, so that the error of the rule is here 20 per cent. A much better approximation to the heat of combustion of such substances is obtained by deducting the oxygen together with the amount of carbon necessary to form CO_2, and then ascertaining the amount of heat produced by the residual carbon and hydrogen. In the above case we should deduct with 11 O the equivalent amount of carbon 5·5 C, thus obtaining the residue 6·5 C and 22 H. These when burnt would yield $(6{\cdot}5\times 94300)+(11\times 68300)=1364250$ cal., an amount which is less than 1 per cent. different from the observed heat of combustion of sugar. Neither of the above rules can be applied to carbon compounds containing nitrogen.

§ 8. *Heat of Neutralization.*—It has already been stated that the heats of neutralization of acids and bases in aqueous solution are additively composed of two terms, one being constant for a given base, the other constant for a given acid. In addition to this, the further regularity has been observed that when the powerful monobasic acids are neutralized by the powerful monacid bases, the heat of neutralization is in all cases the same. The following table gives the heats of neutralization of the commoner strong monobasic acids with soda:—

Hydrochloric acid	HCl	137400 cal.
Hydrobromic acid	HBr	137500 ,,
Hydriodic acid	HI	136800 ,,
Nitric acid	HNO_3	136800 ,,
Chloric acid	$HClO_3$	137600 ,,
Bromic acid	$HBrO_3$	137800 ,,

Within the error of experiment these numbers are identical.

It was at one time thought that the greater the heat of neutralization of an acid with a given base, the greater was the strength of the acid. It is now known, however, that when weak acids or bases are used, the heat of neutralization may be either greater or less than the normal value for powerful acids and bases, so that there is no proportionality, or even parallelism, between the strengths of acids and their heats of neutralization.

§ 9. *Heat of Solution.*—When substances readily combine with water to form hydrates, the heat of solution in water is usually positive; when, on the other hand, they do not readily form hydrates, or when they are already hydrated, the heat of solution is usually negative. The following examples show the effect of hydration on heat of solution in a large quantity of water:—

	Heat of Solution.	Heat of Hydration.
I. Sodium carbonate—		
Na_2CO_3 . .	+5640 cal.	...
Na_2CO_3, H_2O .	+2250 ,,	+3390 cal.
Na_2CO_3, $2H_2O$.	+20 ,,	+5620 ,,
Na_2CO_3, $10H_2O$.	−16160 ,,	+21800 ,,
II. Sodium sulphate—		
Na_2SO_4 . .	+460 cal.	...
Na_2SO_4, H_2O .	−1900 ,,	+2360 cal.
Na_2SO_4, $10H_2O$.	−18760 ,,	+19200 ,,

§ 10. *Application of the Second Law of Thermodynamics to Thermochemistry.*—What is commonly understood by thermochemistry is based entirely on the first law of thermodynamics, but of recent years great progress has been made in the study of chemical equilibrium by the application of the second law. For an account of work in this direction the reader may consult the last two books given in the short bibliography subjoined.

See Julius Thomsen. *Thermochemische Untersuchungen.* Leipzig, 1882–86.—M. Berthelot. *Essai de Mécanique Chimique fondée sur la Thermochimie*, Paris, 1879; *Thermochimie, Données et Lois numériques*, Paris, 1897.—W. Ostwald. *Lehrbuch der allgemeinen Chemie*, 2nd ed., vol. ii. part 1, pp. 1–517. Leipzig, 1893.—Muir and Wilson. *Elements of Thermal Chemistry.* London, 1885.—P. Duhem. *Traité de Mécanique Chimique.* Paris, 1897–99.—J. J. van Laar. *Lehrbuch der mathematischen Chemie.* Leipzig, 1901. (J. Wal.)

Thermodynamics.—The name Thermodynamics is given to that branch of the general science of Energetics which deals with the relations between thermal and mechanical energy, and the transformations of heat into work, and *vice versâ*. Other transformations of heat (see Energetics) are often included under the same title, but they cannot be considered here. A discussion of some of the fundamental principles and equations of thermodynamics has been given under the same title in *Ency. Brit.* vol. xxiii., p. 283. The object of the present article is to explain more fully the applications of the theory to imperfect gases and vapours under conditions which occur in practice, and to develop certain equations which are interesting in themselves and are required for reference in cognate subjects. (See Thermometry, Fusion, Vaporization.) An alphabetical index of the symbols employed will be found at the end of the article.

1. *Introductory.*—The modern science of thermodynamics dates from about the year 1850, in which Rankine and Clausius independently and simultaneously published the correct interpretation of Carnot's principle on the basis of the law of the conservation of energy, which had already won general acceptance through the work of Joule and Thomson and of Helmholtz. It was in the same year that Joule's principal paper on the mechanical equivalent of heat was published in the *Philosophical Transactions.* About the same time Thomson devised the absolute or thermodynamic scale of temperature, without which no scientific treatment of the subject was possible, and developed the fundamental equations of the subject in the most general manner. The previous work of Carnot and others had been founded on the assumption that heat, like a material substance, possessed the property of remaining invariable in quantity through any transformation. Carnot, in the proof of his principle that the efficiency of a reversible heat engine is a maximum, assumed that the case of a heat engine receiving a quantity of heat, H', from a source at a temperature, θ', and giving up a quantity of heat, H'', to a sink at a lower temperature, θ'', was exactly analogous to that of a water engine taking water from a high level and letting it down to a lower level. In the latter case, the maximum work that could be done by any kind of water-wheel would be equal to the product of the difference of level and the weight of water transferred. This maximum output could be attained only by a perfectly reversible water-wheel, capable, if driven backwards, of restoring the water to its original level by the expenditure of a like amount of work. For if there were any more efficient engine, A, capable of doing more work with the same quantity of water and the same difference of level, it would be possible to obtain a balance of work without any expenditure of water power by employing A to drive a reversible engine backwards and return the water to its original level. On Carnot's assumption with regard to the indestructibility of heat, it follows by exactly similar reasoning that the efficiency W/H (the ratio of work done, W, to heat transferred, H) of a perfectly reversible heat engine is the maximum attainable, and cannot be exceeded by any other engine working between the same limits of temperature. The fallacy of Carnot's proof became evident when it was admitted that heat was a form of energy, and therefore capable of transformation. The adoption of the principle of the conservation of energy in place of that of the conservation of heat made it necessary to suppose (as was experimentally proved by Hirn and others at a later date) that part of the heat, H', taken from the source was transformed into work and disappeared, ceasing to exist as heat. The quantity of heat, H'', given up to the sink was therefore less than H'. The simple proof given by Carnot on the basis of the conservation of heat no longer held good, and it became necessary to devise some other axiom on which to found the proof of Carnot's principle. Either of the axioms chosen for this purpose by Clausius and Thomson (Lord Kelvin) may be stated as the second law of thermodynamics, but as they are equivalent to Carnot's principle, and may be deduced from it, it is more convenient in practice to take Carnot's principle itself as the second law.

2. *Application of the First Law.*—The complete transformation of mechanical energy into heat by friction, or some analogous process of degradation, is always possible, and is made the basis of experiments for the determination of the mechanical equivalent of the heat unit. (See Calorimetry.) The converse process of the transformation of heat into mechanical work or other forms of energy is subject to limitations. When a quantity of heat, H, is supplied to a body, part is expended in raising the temperature of the body, or in expanding the volume against molecular forces, and is represented by an increase in the total quantity of energy contained in the body, which is generally called its *Intrinsic Energy*, and will be denoted by the symbol E. The remainder is equivalent to the external work, W, done *by* the body in expanding or otherwise, which can be utilized for mechanical purposes, and ceases to exist as heat in the body. The application of the first law leads immediately to the equation,

$$H = E - E_0 + W, \quad . \quad . \quad . \quad (1)$$

in which E_0 represents the quantity of energy originally present in the body, and all the quantities are supposed, as usual, to be expressed in mechanical units. This equation is generally true for any series of transformations, provided that we regard H and W as representing the *algebraic sums* of all the quantities of heat supplied to, and of work done *by* the body, heat taken *from* the body or work done *on* the body being reckoned negative in the summation. $E - E_0$, then, represents the total increase of the intrinsic energy of the body in its final state, which may be determined by measuring H and W. If after any series or cycle of transformations the body is restored to its initial state, we must have $E = E_0$, whence it follows that $H = W$. But this simple relation is only true of the net balances of heat and work in a complete cyclical process, which must be adopted for theoretical purposes if we wish to eliminate the unknown changes of intrinsic energy. The balance of work obtainable in such a cycle depends on the limits of temperature in a manner which forms the subject of the second law.

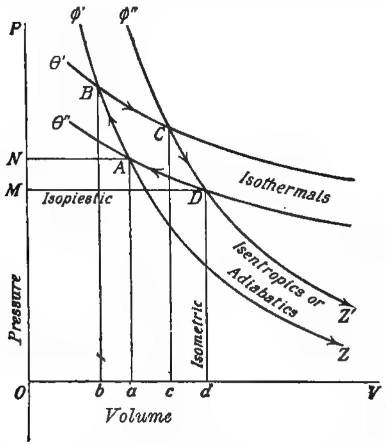

Fig. 1.

3. *Indicator or p.v. Diagram.*—The significance of relation (1) is best appreciated by considering the graphic representation of quantities of heat and energy on a work-diagram. On the familiar indicator diagram the state of the working substance is represented by the position of a point called the "state-point," defined by the values of the pressure p and volume v of *unit mass*, as ordinate and abscissa respectively (Fig. 1). Any line ("path" or "graph") on the diagram, such as BCD, represents an "operation" or "process," *i.e.*, a continuous series of states through which the substance may be made to pass in any transformation. It is tacitly assumed that the motion is relatively so slow that the pressure and temperature of the substance are practically uniform throughout its mass at any stage of the process. Otherwise the transformation could not be fully represented on the diagram, and would not be reversible. The area BCD*db* under the path represents the external work done *by* the substance in expanding from B to D, which is analytically represented by the integral of *pdv* taken along the given path. Any closed path or figure, such as ABCD, represents a complete cycle or series of operations, in the course of which the substance is restored to its original state with respect to temperature, intrinsic energy, and other properties. The area DAB*bd* under the return path (v diminishing) represents work done *on* the substance, or against the back-pressure, and is negative. The area of the cycle, viz., that enclosed by the path BCDA, represents the balance of external work done by the substance in one cycle, and is positive if the cycle is described clockwise as indicated by the arrows. The simplest types of process or operation are:—(1), heating or cooling *at constant volume*, represented by vertical lines such as B*b*, called *Isometrics*, in which the pressure varies, but no external work is done. (2) Heating or cooling *at constant pressure*, represented by horizontal lines such as NA, called *Isopiestics*, in which the external work done is the product of the pressure p and the expansion $v'' - v'$. (3) Expansion or compression *at constant temperature*, represented by curves called *Isothermals*, such as BC, AD, the form of which depends on the nature of the working substance. The isothermals are approximately equilateral hyperbolas ($pv =$ constant), with the axes of p and v for asymptotes, for a gas or unsaturated vapour, but coincide with the isopiestics for a saturated vapour in presence of its liquid. (4) Expansion or compression under the condition of *heat-insulation*, represented by curves called *Adiabatics*, such as BAZ or CDZ′, which are necessarily steeper than the isothermals.

A cycle such as ABCD enclosed by parts of two isothermals, BC, AD, and two adiabatics, AB, CD, is the simplest form of cycle for theoretical purposes, since all the heat absorbed, H', is taken in during the process represented by one isothermal at the temperature θ', and all the heat rejected, H'', is given out during the process represented by the other at the temperature θ''. This is the cycle employed by Carnot for the establishment of his fundamental principle of reversibility as the criterion of perfect efficiency in a heat engine. The area ABCD, representing the work, W, per cycle, is the difference $(H' - H'')$ of the quantities of heat absorbed and rejected at the temperatures θ' and θ''. As the temperature θ'' is lowered, the area of the cycle increases, but since W can never exceed H', there must be a zero limit of temperature at which the pressure would vanish and the area of the cycle become equal to the whole heat absorbed at the higher temperature. Taking this ideal limit as a theoretical or absolute zero, the value of H' may be represented on the diagram by the whole area included between the two adiabatics BAZ, CDZ′ down to the points where they intersect the isothermal of absolute zero, or the zero isopiestic OV asymptotically at infinity.

If the substance in any state such as B were allowed to expand adiabatically ($dH = 0$) down to the absolute zero, at which point it contains no heat and exerts no pressure, the whole of its intrinsic heat energy might theoretically be recovered in the form of external work, represented on the diagram by the whole area BAZ*cb* under the adiabatic through the state-point B, bounded by the isometric B*b* and the zero isopiestic *b*V. The change of the intrinsic energy in passing from one state to another, as from B to C, is represented by the addition of the heat-area $H =$ BCZZ′, and the subtraction of the work-area $W =$ BC*cb*. It follows from the first law that the intrinsic energy of a substance in a given state must always be the same, or that the change of E in any transformation must depend only on the initial and final states, and not on the path or process. It will be observed that the areas representing H and W both depend on the form of the path BC, but that the difference of the areas representing the change of intrinsic energy dE is independent of BC, which is a boundary common to both H and W. This is mathematically expressed by the statement that dE is an exact differential of a function of the co-ordinates defining the state of the body, which can be integrated between limits without reference to the relation representing the path along which the variations are taken.

4. *Application of the Second Law.*—The limitations of the transformation of heat into work in a cyclical process, such as is necessarily involved in the working of any form of heat engine, form the subject of the second law, and are most conveniently stated in terms of the absolute scale of temperature devised by Lord Kelvin on the basis of Carnot's principle. Since the efficiency of all perfectly reversible engines working between the same two limits of temperature in a cycle of the kind illustrated in Fig. 1 must be the same, it follows that it can depend only on the limits of temperature, and not on the mechanism of the engine, or on the nature of the working substance employed. Any scale of temperature defined in terms of the ratios of the quantities of heat absorbed and rejected by a reversible engine will be *absolute* in the sense of being independent of the properties of any particular substance. The scale proposed by Lord Kelvin, and now

universally adopted, is obtained by taking the ratio θ'/θ'' of the temperatures of the source and the sink to be the same as the ratio H'/H'' of the quantities of heat absorbed and rejected at those temperatures in a simple Carnot cycle. Since $H'-H''=W$, we thus obtain the simple relations,

$$W/(\theta'-\theta'')=H'/\theta'=H''/\theta'' \quad . \quad (2)$$

The scale of temperature so defined leads to the simplest thermodynamical relations, and has the great advantage of being in the closest possible agreement with the scales of the mercury and gas-thermometers. The size of the degree of temperature is determined by the system of graduation employed (Centigrade, or Fahrenheit, or Réaumur) with reference to the freezing and boiling points of water, but this does not affect the ratios involved in (2), and is immaterial for theoretical purposes. Having due regard to the meaning of the symbols employed, the relations (2) may also be interpreted as the formula of the simple reversible engine, or as the symbolic statement of Carnot's principle, since the assertion that the efficiency depends only on the temperature limits is implicitly involved in the form of the equations.

5. *Thermodynamical Relations.*—The most important and most useful of the relations between the thermodynamical properties of a substance may be very simply deduced from a consideration of the indicator diagram by a geometrical method, which is in many respects more instructive than the analytical method generally employed. Referring to Fig. 2, let BC be a small portion of any isothermal corresponding to the temperature θ', and AD a neighbouring isothermal θ''. Let BE be an isometric through B meeting AD in E, and EC an isopiestic through E meeting BC in C. Let BA, CD be adiabatics through B and C meeting the isothermal θ'' in A and D. Then by relations (2) the heat, H, absorbed in the isothermal change BC, is to the work, W, done in the cycle ABCD in the ratio of θ' to $(\theta'-\theta'')$. If the difference of temperature $(\theta'-\theta'')$ is small, the figure ABCD may be regarded as a parallelogram, and its area W as equal to the rectangle BE × EC. This is accurately true in the limit when $(\theta'-\theta'')$ is infinitesimal, but in practice it is necessary to measure specific heats, &c., over finite ranges of temperature, and the error involved is generally negligible if the range does not exceed a few degrees. BE is the increase of pressure $(p'-p'')$ produced by the rise of temperature $(\theta'-\theta'')$ if the volume is kept constant. EC is the expansion $(v''-v')$ produced by the same rise of temperature if the pressure is kept constant. Substituting these symbols in the expression for the area, the relation becomes

$$H=\theta(p'-p'')(v''-v')/(\theta'-\theta'') \quad . \quad . \quad . \quad (3)$$

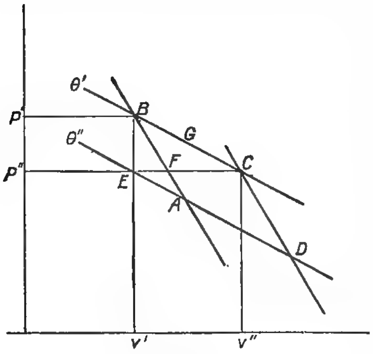

Fig. 2.

This relation may be interpreted in two ways, according as we require the heat absorbed in terms of the change of pressure or volume. (1) The heat, H, absorbed in isothermal expansion (latent heat of expansion) from p' to p'' is equal to the diminution of pressure $(p'-p'')$ multiplied by the absolute temperature and by the expansion per degree $(v''-v')/(\theta'-\theta'')$ at constant pressure. (2) The heat, H, absorbed in isothermal expansion from v' to v'' is equal to the increase of volume $(v''-v')$ multiplied by the absolute temperature, and by the increase of pressure per degree $(p'-p'')/(\theta'-\theta'')$, at constant volume. In the notation of the calculus the relations become

$$\left.\begin{aligned}-dH/dp\ (\theta \text{ const})&=\theta dv/d\theta\ (p \text{ const})\\ dH/dv\ (\theta \text{ const})&=\theta dp/d\theta\ (v \text{ const})\end{aligned}\right\} \quad . \quad . \quad (4)$$

The negative sign is prefixed to dH/dp because absorption of heat $+dH$ corresponds to diminution of pressure $-dp$. The utility of these relations results from the circumstance that the pressure and expansion coefficients are familiar and easily measured, whereas the latent heat of expansion is difficult to determine.

The most instructive example of the application of relations (1) and (2) is afforded by the change of state of a substance at constant temperature and pressure. Starting with unit mass of the substance in the first state (*e.g.*, liquid) possessing volume v' at a temperature θ'' and pressure p'' represented by the point A in Fig. 3, the heat absorbed in raising the temperature to θ' and the pressure to p' without change of state may be written $s'(\theta'-\theta'')$, where s' is the specific heat of the substance in the first state at saturation pressure. If now the substance in the state B is entirely converted at constant temperature and pressure into the second state (*e.g.*, saturated vapour), in which it occupies a volume v'', the line BC represents the change of volume $(v''-v')$. The heat absorbed in this change is called the latent heat of change of state, and may be represented by the symbol L'. The substance is then cooled to the lower temperature θ'' along the path CD, keeping it in the saturated state. The heat evolved in this process may be represented by $s''(\theta'-\theta'')$, where s'' is the specific heat of the substance in the second state at saturation pressure. Finally, the substance is reconverted into the first state at the temperature θ'', completing the cycle by the abstraction of a quantity of heat L''. By the application of the first law, the difference of the quantities of heat absorbed and evolved in the cycle must be equal to the work represented by the area of the cycle, which is equal to $(p'-p'')(v''-v')$ in the limit when the difference of pressure is small. By the application of the second law, relations (2), the same work area is equal to $(\theta'-\theta'')L'/\theta'$. Dividing by $(\theta'-\theta'')$, and writing $dp/d\theta$ and $dL/d\theta$ for the limiting values of the ratios $(p'-p'')/(\theta'-\theta'')$ and $(L'-L'')/(\theta'-\theta'')$, we obtain the important relations

$$s'-s''+dL/d\theta=(v''-v')dp/d\theta=L/\theta, \quad . \quad . \quad . \quad (5)$$

in which $dp/d\theta$ is the rate of change of pressure with temperature when the two states are in equilibrium, and not necessarily at constant volume, as in the previous example.

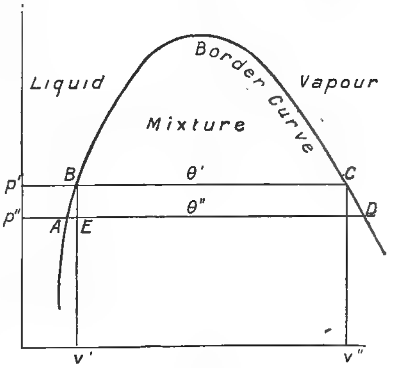

Fig. 3.

6. *Ratio and Difference of Specific Heats.*—If we take unit mass of the substance at B, Fig. 2, and cool it at constant volume to E, through an interval of temperature $(\theta'-\theta'')$, the amount of heat abstracted may be written $h=s(\theta'-\theta'')$, where s is the specific heat *at constant volume.* If, starting from E, *the same* amount of heat h is restored *at constant pressure*, we should arrive at the point F on the adiabatic through B, since the substance has been transformed from B to F by a reversible path without loss or gain of heat on the whole. In order to restore the substance to its original temperature θ' *at constant pressure*, it would be necessary to supply a further quantity of heat, H, represented by the area between the two adiabatics from FC down to the absolute zero. This quantity of heat is the same as that already found in equation (3), but for the small area BFC, which is negligibly small in the limit compared with H. The whole quantity of heat required to raise the temperature from θ'' to θ' at constant pressure along the path EC is $H+h$, which is equal to $S(\theta'-\theta'')$, where S is the specific heat at constant pressure. Since $h=s(\theta'-\theta'')$, the difference $S-s$ between the specific heats at constant pressure and volume is evidently $H/(\theta'-\theta'')$. Substituting for H its value from (3), and employing the notation of the calculus, we obtain the relation

$$S-s=\theta(dp/d\theta)(dv/d\theta), \quad . \quad . \quad . \quad . \quad (6)$$

in which the partial differential coefficients have the same meaning as in (4).

Since the amounts of heat supplied at constant pressure from E to F and from E to C are in the limit proportional to the expansions EF and EC which they produce, the ratio S/s is equal to the ratio EC/EF. EF is the change of volume corresponding to a change of pressure BE when no heat is allowed to escape and the path is the adiabatic BF. EC is the change of volume for *the same* change of pressure BE when the path is the isothermal BC. These changes of volume are directly as the compressibilities, or inversely as the elasticities. If we write K for the adiabatic elasticity, and k for the isothermal elasticity, we obtain

$$S/s=\text{EC}/\text{EF}=K/k \quad . \quad . \quad . \quad . \quad (7)$$

The value of the specific heat S at constant pressure can always be determined by experiment, and in practice is one of the most important thermodynamical properties of a substance. The value of the specific heat s at constant volume can also be measured in a few cases, but it is generally necessary to deduce it from that at constant pressure by means of relation (6). It is often impossible to observe the pressure-coefficient $dp/d\theta$ directly, but it may be deduced from the isothermal compressibility by means of the geometrically obvious relation, BE=(BE/EC)×EC. The ratio BE/EC of the diminution of pressure to the increase of volume at constant temperature, or $-dp/dv$, is readily observed.

The amount of heat absorbed in any small change of state, as from E to G in Fig. 2, may be found by adding to the heat required for the change of temperature at constant volume, $sd\theta$, or at constant pressure, $Sd\theta$, the heat absorbed in isothermal expansion as given by relations (4). We thus obtain the expressions

$$dH = sd\theta + \theta(dp/d\theta)dv = Sd\theta - \theta(dv/d\theta)dp \quad . \quad . \quad (8)$$

The first is equivalent to measuring the heat along the path EBG, the second along the path ECG. The two differ by the area BEC, which can be neglected if the change is small. For a finite change it is necessary to represent the path by a series of small steps, which is the graphic equivalent of integration along the path represented by the given relation between v and θ, or p and θ. If we put $dH=0$ in equations (8), we obtain the relations between dv and $d\theta$, or dp and $d\theta$, under the condition of no heat-supply, *i.e.*, along the adiabatic, which can be integrated, giving the equations to the adiabatics, provided that the values of the specific heats and expansion-coefficients are known.

6. *Intrinsic Energy.*—The change of intrinsic energy E along any path is found by subtracting the work pdv from either of the expressions for dH. Since the change of energy is independent of the path, the finite change between any two given states may be found by integration along *any* convenient path. It is generally convenient to divide the path into two steps, isothermal and isometric, or isothermal and isopiestic, and to integrate along each separately. The change of energy at constant volume is simply $sd\theta$, the change at constant temperature is $(\theta dp/d\theta - p)dv$, which may be written

$$dE/d\theta \ (v \text{ const}) = s, \quad dE/dv \ (\theta \text{ const}) = \theta dp/d\theta - p \quad . \quad . \quad (9)$$

These must be expressed as functions of v and θ, which is theoretically possible if the values of s, p, and $dp/d\theta$ are known. Since the two expressions (9) are the partial differential-coefficients of a single function E of the independent variables v and θ, we shall obtain the same result, namely $d^2E/d\theta dv$, if we differentiate the first with respect to v and the second with respect to θ. We thus obtain the relation

$$ds/dv(\theta \text{ const}) = \theta d^2p/d\theta^2 \ (v \text{ const}), \quad . \quad . \quad . \quad (10)$$

which is useful for calculating the variation of the specific heat s with variation of density at constant temperature. A similar expression for the variation of the specific heat S at constant pressure is obtained from the second expression in (8), by taking p and θ as independent variables; but it follows more directly from a consideration of the variation of the function $(E+pv)$.

7. *Total Heat.*—The function $F=(E+pv)$, like E itself, has a value depending only on the state of the body. It may conveniently be called the *Total Heat*, by a slight extension of the meaning of a term which has been for a long time in use as applied to vapours (see VAPORIZATION). Since $dE=dH-pdv$, we have evidently for the variation of the total heat from the second expression (8),

$$dF = d(E+pv) = dH + vdp = Sd\theta - (\theta dv/d\theta - v)dp \quad . \quad (11)$$

This expression shows that the rate of variation of the total heat with temperature at constant pressure is equal to the specific heat at constant pressure. To find the total heat of a substance in any given state defined by the values of p and θ, starting from any convenient zero of temperature, it is sufficient to measure the total heat required to raise the substance to the final temperature under a constant pressure equal to p. For instance, in the boiler of a steam engine the feed water is pumped into the boiler against the final pressure of the steam, and is heated under this constant pressure up to the temperature of the steam. The total heat with which we are actually concerned in the working of a steam engine is the total heat as here defined, and not the total heat as defined by Regnault, which, however, differs from $(E+pv)$ only by a quantity which is inappreciable in ordinary practice.

Observing that F is a function of the co-ordinates expressing the state of the substance, we obtain for the variation of S with pressure at constant temperature

$$dS/dp \ (\theta \text{ const}) = d^2F/d\theta dp = -\theta d^2v/d\theta^2 \ (p \text{ const}) \quad . \quad (12)$$

If the heat supplied to a substance which is expanding reversibly and doing external work, pdv, is equal to the external work done, the intrinsic energy, E, remains constant. The lines of constant energy on the diagram are called *Isenergics*. The equation to these lines in terms of v and θ is obtained by integrating

$$dE = sd\theta + (\theta dp/d\theta - p)dv = 0 \quad . \quad . \quad . \quad (13)$$

If, on the other hand, the heat supplied is equal to $-vdp$, we see from (11) that F remains constant. The equation to the lines of constant total heat is found in terms of p and θ by putting $dF=0$ and integrating (11).

8. *Ideal Gases.*—The simplest and most instructive illustration of the foregoing principles is afforded by a consideration of the properties of an ideal gas, and of the manner in which actual gases deviate from the ideal state. According to the elementary kinetic theory, an ideal monatomic gas is imagined to consist of a number of very small and perfectly elastic particles, each of mass m, moving in all directions with a velocity u, depending on the temperature. In the state of equilibrium of a mixture of different gases the mean kinetic energy $mu^2/2$ of each kind of molecule must be the same. This mean kinetic energy is the natural measure of the temperature, since the energy is assumed to be wholly kinetic, and equal increments of heat produce equal increments of energy. The specific heat at constant volume is constant and equal to $u^2/2\theta$. The pressure p due to the molecular impacts is $u^2/3v$. We thus obtain the ideal characteristic equation

$$pv = R\theta/M = u^2/3 = 2s\theta/3, \quad . \quad . \quad . \quad . \quad (14)$$

in which R is a constant, the same for all ideal gases, and M is the molecular weight relative to the standard for which the value of R is calculated. It is assumed in establishing these relations that the molecules themselves are so small that the space which they occupy is a negligible fraction of that occupied by the gas, and that the duration of an intermolecular collision may be neglected in comparison with the time between two consecutive encounters of the same molecule with another. It is also assumed that there are no forces of attraction or repulsion between molecules, so that no work is done against molecular forces in change of volume. The change of energy in isothermal expansion is zero, and the heat absorbed is equal to the external work. This assumption gives $\theta dp/d\theta = p$, by relations (4), which are equivalent to (2). But by (14) $\theta dp/d\theta = p$, hence the scale of temperature given by the ideal gas coincides with the scale defined by (2). The difference of the specific heats, $(S-s)=R/M$, and the ratio S/s is constant, being equal to 5/3 for a monatomic gas. The adiabatic elasticity is Sp/s, and the adiabatic equation $pv^{S/s}=$ constant.

9. *Deviations of Actual Gases from the Ideal State.*—Since no gas is ideally perfect, it is more important for practical purposes to discuss the deviations of actual gases from the ideal state, and to consider how their properties may be thermodynamically explained and defined. The most natural method of procedure is to observe the deviations from Boyle's law by measuring the changes of pv at various constant temperatures. But this procedure in itself is not sufficient, because, although it would be highly probable that a gas obeying Boyle's law at all temperatures was practically an ideal gas, it is evident that Boyle's law would be satisfied by any substance having the characteristic equation $pv=f(\theta)$, where $f(\theta)$ is any arbitrary function of θ, and that the scale of temperatures given by such a substance would not necessarily coincide with the absolute scale. An ideal gas is often defined as one which obeys the law of Boyle, and also that of Charles. But the latter does not afford a practical test, as the gas thermometer itself is the only available standard for measuring temperature. A sufficient test, in addition to Boyle's law, is the condition $dE/dv=0$ at constant temperature, which is assumed in the elementary kinetic theory. This gives by equation (9) the condition $\theta dp/d\theta = p$, which is satisfied by any substance possessing the characteristic equation $p/\theta = f(v)$, where $f(v)$ is any arbitrary function of v. In order that a substance of this nature may also satisfy Boyle's law, it is necessary that its characteristic equation should be that of the ideal gas. In that case its specific heat must be constant, and its temperature scale must coincide with the absolute scale. This test was applied by Joule in the well-known experiment in which he allowed a gas to expand from one vessel to another in a calorimeter without doing external work. Under this condition the increase of intrinsic energy would be equal to the heat absorbed, and would be indicated by fall of temperature of the calorimeter. Joule failed to observe any change of temperature in his apparatus, and was therefore justified in assuming that the increase of intrinsic energy of a gas in isothermal expansion was very small, and that the absorption of heat observed in a similar experiment in which the gas was allowed to do external work by expanding against the atmospheric pressure was equivalent to the external work done. But owing to the large thermal capacity of his calorimeter, the test, though sufficient for his immediate purpose, was not delicate enough to detect and measure the small deviations which actually exist.

10. *Method of Joule and Thomson.*—William Thomson (Lord Kelvin), who was the first to realize the importance of the absolute scale in thermodynamics, and the inadequacy of the test afforded by Boyle's law or by experiments on the constancy of the specific

heat of gases, devised a more delicate and practical test, which he carried out successfully in conjunction with Joule. A continuous stream of gas, supplied at a constant pressure and temperature, is forced through a porous plug, from which it issues at a lower pressure through an orifice carefully surrounded with non-conducting material, where its temperature is measured. If we consider any short length of the stream bounded by two imaginary cross-sections A and B, unit mass of the fluid in passing A has work, $p'v'$, done on it by the fluid behind and carries its energy, $E'+U'$, with it into the space AB, where U' is the kinetic energy of flow. In passing B it does work, $p''v''$, on the fluid in front, and carries its energy, $E''+U''$, with it out of the space AB. If there is no external loss or gain of heat through the walls of the pipe, and if the flow is steady, so that energy is not accumulating in the space AB, we must evidently have the condition $E'+U'+p'v'=E''+U''+p''v''$ at any two cross-sections of the stream. It is easy to arrange the experiment so that U is small and nearly constant. In this case the condition of flow is simply that of constant total heat, or in symbols, $d(E+pv)=0$. We have therefore, by equation (11),

$$Sd\theta=(\theta dv/d\theta-v)dp, \quad . \quad . \quad . \quad (15)$$

where $d\theta$ is the fall of temperature of the fluid corresponding to a diminution of pressure dp. If there is no fall of temperature in passing the plug, $d\theta=0$, and we have the condition $\theta dv/d\theta=v$. The characteristic equation of the fluid must then be of the form $v/\theta=f(p)$, where $f(p)$ is any arbitrary function of p. If the fluid is a gas also obeying Boyle's law, $pv=f(\theta)$, then it must be an ideal gas. As the result of their experiments on actual gases (air, hydrogen, and CO_2), Joule and Thomson (*Phil. Trans.* 1854, 1862) found that the cooling effect, $d\theta$, was of the same order of magnitude as the deviations from Boyle's law in each case, and that it was proportional to the difference of pressure, dp, so that $d\theta/dp$ was nearly constant for each gas over a range of pressure of five or six atmospheres. By experiments at different temperatures between 0° and 100° C., they found that the cooling effect per atmosphere of pressure varied inversely as the square of the absolute temperature for air and CO_2. Putting $d\theta/dp=A/\theta^2$ in equation (15), and integrating on the assumption that the small variations of S could be neglected over the range of the experiment, they found a solution of the type, $v/\theta=f(p)-SA/3\theta^3$, in which $f(p)$ is an arbitrary function of p. Assuming that the gas should approximate indefinitely to the ideal state $pv=R\theta$ at high temperatures, they put $f(p)=R/p$, which gives a characteristic equation of the form

$$v=R\theta/p-SA/3\theta^2\,. \quad . \quad . \quad . \quad (16)$$

An equation of a similar form had previously been employed by Rankine (*Trans. Roy. Soc. Ed.* 1854) to represent Regnault's experiments on the deviations of CO_2 from Boyle's law. This equation is practically identical for moderate pressures with that devised by Clausius (*Phil. Mag.* 1880) to represent the behaviour of CO_2 up to the critical point. Experiments by Natanson on CO_2 at 17° C. confirm those of Joule and Thomson, but show a slight increase of the ratio $d\theta/dp$ at higher pressures, which is otherwise rendered probable by the form of the isothermals as determined by Andrews and Amagat. More recent experiments by Grindley (*Proc. Roy. Soc.* 1899) and Callendar (*Proc. Roy. Soc.* 1900) on steam confirm this type of equation, but give much larger values of the cooling effect than for CO_2, and a more rapid rate of variation with temperature.

11. *Modified Joule–Thomson Equation.*—Hirn (*Théorie Mec. de la Chaleur*, ii. p. 211, Paris, 1869) proposed an equation of the form $(p+p_0)(v-b)=R\theta$, in which the effect of the size of the molecules is represented by subtracting a quantity b, the "covolume," from the volume occupied by the gas, and the effect of the mutual attractions of the molecules is represented by adding a quantity p_0, the internal pressure, to the external pressure, p. This type of equation was more fully worked out by van der Waals, who identified the internal pressure, p_0, with the capillary pressure of Laplace, and assumed that it varied directly as the square of the density, and could be written a/v^2. This assumption represents qualitatively the theoretical isothermal of James Thomson (see VAPORIZATION) and the phenomena of the critical state (see CONDENSATION OF GASES); but the numerical results to which it leads differ so widely from experiment that it is necessary to suppose the constant, a, to be a function of the temperature. Many complicated expressions have been suggested by subsequent writers in the attempt to represent the continuity of the gaseous and liquid states in a single formula, but these are of a highly empirical nature, and beyond the scope of the present inquiry. The simplest assumption which suffices to express the small deviations of gases and vapours from the ideal state *at moderate pressures* is that the coefficient a in the expression for the capillary pressure varies inversely as some power of the absolute temperature. Neglecting small terms of the second order, the equation may then be written in the form

$$v-b=R\theta/p-c_0(\theta_0/\theta)^n=V-c, \quad . \quad . \quad . \quad (17)$$

in which c is a small quantity (expressing the defect from the ideal volume $V=R\theta/p$ due to co-aggregation of the molecules) which varies inversely as the nth power of θ, but is independent of p to a first approximation at moderate pressures. The constant c_0 is the value of c at some standard temperature θ_0. The value of the index, n, appears to be different for different types of molecule. For CO_2 at ordinary temperatures $n=2$, as in the Joule–Thomson equation. For steam between 100° and 150° C. it approaches the value 3·5. It is probably less than 2 for air and the more perfect gases. The introduction of the covolume, b, into the equation is required in order to enable it to represent the behaviour of hydrogen and other gases at high temperatures and pressures according to the experiments of Amagat. It is generally taken as constant, but its value at moderate pressures is difficult to determine. According to van der Waals, assuming spherical molecules, it should be four times; according to O. E. Meyer, on slightly different assumptions, it should be $4\sqrt{2}$ times, the actual volume of the molecules. It appears to be a quantity of the same order as the volume of the liquid, or as the limiting volume of the gas at very high pressures. The value of the co-aggregation volume, c, at any temperature, assuming equation (17), may be found by observing the deviations from Boyle's law and by experiments on the Joule–Thomson effect. Differentiating equation (17) at constant pressure to find $dv/d\theta$, and observing that $dc/d\theta=-nc/\theta$, we find by substitution in (15) the following simple expression for the cooling effect $d\theta/dp$ in terms of c and b,

$$Sd\theta/dp=(n+1)c-b \quad . \quad . \quad . \quad (18)$$

Experiments at two temperatures suffice to determine both c and n if we assume that b is equal to the volume of the liquid. But it is better to apply the Boyle's law test in addition, provided that errors due to surface condensation can be avoided. The advantage of this type of equation is that c is a function of the temperature only. Other favourite types of equation for approximate work are (1) $p=R\theta/v+f(v)$, which makes p a linear function of θ at constant volume, as in van der Waals's equation; (2) $v=R\theta/p+f(p)$, which makes v a linear function of θ at constant pressure. These have their advantages in special cases as empirical formulæ (*e.g.*, Zeuner's formula for steam), but they cannot be made to represent with sufficient approximation the deviations from the ideal state at moderate pressures. In the modified Joule–Thomson equation (17), both c and n have simple theoretical interpretations, and it is possible to express the thermodynamical properties of the substance in terms of them by means of reasonably simple formulæ.

12. *Application of the Modified Equation.*—We may take equation (17) as a practical example of the thermodynamical principles already given. The values of the partial differential coefficients in terms of n and c are as follows—

$$dv/d\theta\ (p\ \text{const})=(R/p)(1+nc/V) \quad . \quad . \quad (19)$$
$$d^2v/d\theta^2 \quad ,, \quad = -n(n+1)c/\theta^2 \quad . \quad . \quad (20)$$
$$dp/d\theta\ (v\ \text{const})=(R/V)(1+nc/V) \quad . \quad . \quad (21)$$
$$d^2p/d\theta^2 \quad ,, \quad =Rnc(1-n+2nc/V)/\theta V^2 \quad . \quad (22)$$
$$-dp/dv\ (\theta\ \text{const})=p/V\,. \quad . \quad . \quad . \quad . \quad (23)$$

Substituting these values in equations already given, we find,

$$\text{from (6)} \qquad S-s=R(1+nc/V)^2 \quad . \quad . \quad . \quad (24)$$
$$,, \ (9) \quad dE/dv\ (\theta\ \text{const})=ncp/V \quad . \quad . \quad . \quad . \quad (25)$$
$$,, \ (11) \quad dF/dp \quad ,, \quad =(n+1)c-b \quad . \quad . \quad . \quad (26)$$
$$,, \ (10) \quad ds/dv \quad ,, \quad =(1-n+2nc/V)Rnc/V^2 \quad . \quad (27)$$
$$,, \ (12) \quad dS/dp \quad ,, \quad =n(n+1)c/\theta \quad . \quad . \quad . \quad (28)$$

In order to deduce the complete variation of the specific heats from these equations, it is necessary to make some assumption with regard to the variation of the specific heats with temperature. The assumption usually made is that the total kinetic energy of the molecules, including possible energy of rotation or vibration if the molecules consist of more than one atom, is proportional to the energy of translation in the case of an ideal gas. In the case of imperfect gases, all the available experimental evidence shows that the specific volume tends towards its ideal value, $V=R\theta/p$, in the limit, when the pressure is indefinitely reduced and the molecules are widely separated so as to eliminate the effects of their mutual actions. We may therefore reasonably assume that the *limiting* values of the specific heats at zero pressure do not vary with the temperature, provided that the molecule is stable and there is no dissociation. Denoting by S_0, s_0, these constant limiting values at $p=0$, we may obtain the values at any pressure by integrating the expressions (27) and (28) from ∞ to v and from 0 to p respectively. We thus obtain

$$S=S_0+n(n+1)pc/\theta \quad . \quad . \quad . \quad . \quad (29)$$
$$s=s_0+(n-1-nc/V)ncp/\theta\,. \quad . \quad . \quad . \quad (30)$$

In working to a first approximation, the small term nc/V may be omitted in the expression for s.

The expression for the change of intrinsic energy E between any given limits $p_0\theta_0$ to $p\theta$ is readily found by substituting these values of the specific heats in equations (11) or (13), and integrating between the given limits. We thus obtain

$$E - E_0 = s_0(\theta - \theta_0) - n(pc - p_0c_0) \quad . \quad . \quad (31)$$

The energy is less than that of an ideal gas by the term npc. If we imagine that the defect of volume c is due to the formation of molecular aggregates consisting of two or more single molecules, and if the kinetic energy of translation of any one of these aggregates is equal to that of one of the single molecules, it is clear that some energy must be lost in co-aggregating, but that the proportion lost will be different for different types of molecules and also for different types of co-aggregation. If two monatomic molecules, having energy of translation only, equivalent to 3 degrees of freedom, combined to form a diatomic molecule with 5 degrees of freedom, the energy lost would be $pc/2$ for co-aggregation, c, per unit mass. If two diatomic molecules, having each 5 degrees of freedom, combine to form a molecule with 6 degrees of freedom, we should have $n=2$, or the energy lost would be $2pc$ per unit mass. If the molecules and molecular aggregates were more complicated, and the number of degrees of freedom of the aggregates were limited to 6, or were the same as for single molecules, we should have $n = s_0/\mathrm{R}$. The loss of energy could not be greater than this on the simple kinetic theory, unless there were some evolution of latent heat of co-aggregation, due to the work done by the mutual attractions of the co-aggregating molecules.

It is not necessary to suppose that the co-aggregated molecules are permanently associated. They are continually changing partners, the ratio c/V representing approximately the ratio of the time during which any one molecule is paired to the time during which it is free. At higher densities it is probable that more complex aggregates would be formed, so that as the effect of the collisions became more important c would cease to be a function of the temperature only; experiment, indeed, shows this to be the case.

13. *Entropy.*—It follows from the definition of the absolute scale of temperature, as given in relations (2), that in passing at constant temperature θ from one adiabatic ϕ' (Fig. 1) to any other adiabatic ϕ'', the quotient H/θ of the heat absorbed by the temperature at which it is absorbed is the same for the same two adiabatics whatever the temperature of the isothermal path. This quotient is called the change of entropy, and may be denoted by $(\phi'' - \phi')$. In passing along an adiabatic there is no change of entropy, since no heat is absorbed. The adiabatics are lines of constant entropy, and are also called *Isentropics*. In virtue of relations (2), the change of entropy of a substance between any two states depends only on the initial and final states, and may be reckoned along any reversible path, not necessarily isothermal, by dividing each small increment of heat, dH, by the temperature, θ, at which it is acquired, and taking the sum or integral of the quotients, dH/θ, so obtained.

The expression for the change of entropy between any two states is found by dividing either of the expressions for dH in (8) by θ and integrating between the given limits, since dH/θ is a perfect differential. In the case of a solid or a liquid, the latent heat of isothermal expansion may often be neglected, and if the specific heat, s, be also taken as constant, we have simply $\phi - \phi_0 = s \log_e \theta/\theta_0$. If the substance at the temperature θ undergoes a change of state, absorbing latent heat, L, we have merely to add the term L/θ to the above expression. In the case of an ideal gas, $dp/d\theta$ at constant volume $= R/v$, and $dv/d\theta$ at constant pressure $= R/p$; thus we obtain the expressions for the change of entropy $\phi - \phi_0$ from the state $p_0\theta_0v_0$ to the state $p\theta v$,

$$\begin{aligned}\phi - \phi_0 &= s \log_e \theta/\theta_0 + R \log_e v/v_0 \\ &= S \log_e \theta/\theta_0 - R \log_e p/p_0 \qquad (32)\end{aligned}$$

In the case of an imperfect gas or vapour, the above expressions are frequently employed, but a more accurate result may be obtained by employing equation (17) with the value of the specific heat, S, from (29), which gives the expression

$$\phi - \phi_0 = S_0 \log_e \theta/\theta_0 - R \log_e p/p_0 - n(cp/\theta - c_0p_0/\theta_0) \qquad (33)$$

The state of a substance may be defined by means of the temperature and entropy as co-ordinates, instead of employing the pressure and volume as in the indicator diagram. This method of representation is applicable to certain kinds of problems, and has been developed by Macfarlane, Gray, and other writers in its application to the steam engine. (See ENGINES, vol. xxviii. p. 175 of this work; also Ewing, *Steam Engine;* Perry, *Steam Engine.*) Areas on the temperature-entropy or θ, ϕ diagram represent quantities of heat in the same way as areas on the indicator diagram represent quantities of work. The θ, ϕ diagram is useful in the study of heat waste and condensation, but from other points of view the utility of the conception of entropy as a "factor of heat" is limited by the fact that it does not correspond to any directly measurable physical property, but is merely a mathematical function arising from the form of the definition of absolute temperature. Changes of entropy must be calculated in terms of quantities of heat, and must be interpreted in a similar manner. The majority of thermodynamical problems may be treated without any reference to entropy, but it affords a convenient method of expression in abstract thermodynamics, especially in the consideration of irreversible processes and in reference to the conditions of equilibrium of heterogeneous systems.

14. *Irreversible Processes.*—In order that a process may be strictly reversible, it is necessary that the state of the working substance should be one of equilibrium at uniform pressure and temperature throughout. If heat passes "of itself" from a higher to a lower temperature by conduction, convection, or radiation, the transfer cannot be reversed without an expenditure of work. If mechanical work or kinetic energy is directly converted into heat by friction, reversal of the motion does not restore the energy so converted. In all such cases there is necessarily, by Carnot's principle, a loss of efficiency or available energy, accompanied by an increase of entropy, which serves as a convenient measure or criterion of the loss. A common illustration of an irreversible process is the expansion of a gas into a vacuum or against a pressure less than its own. In this case the work of expansion, pdv, is expended in the first instance in producing kinetic energy of motion of parts of the gas. If this could be co-ordinated and utilized without dissipation, the gas might conceivably be restored to its initial state; but in practice violent local differences of pressure and temperature are produced, the kinetic energy is rapidly converted into heat by viscous eddy friction, and residual differences of temperature are equalized by diffusion throughout the mass. Even if the expansion is adiabatic, in the sense that it takes place inside a non-conducting enclosure and no heat is supplied from external sources, it will not be isentropic, since the heat supplied by internal friction must be included in reckoning the change of entropy. Assuming that no heat is supplied from external sources and no external work is done, the intrinsic energy remains constant by the first law. The final state of the substance, when equilibrium has been restored, may be deduced from this condition, if the energy can be expressed in terms of the co-ordinates. But the line of constant energy on the diagram does not represent the path of the transformation, unless it be supposed to be effected in a series of infinitesimal steps between each of which the substance is restored to an equilibrium state. An irreversible process which permits a more complete experimental investigation is the steady flow of a fluid in a tube already referred to in section 10. If the tube is a perfect non-conductor, and if there are no eddies or frictional dissipation, the state of the substance at any point of the tube as to E, p, and v, is represented by the adiabatic or isentropic path, $dE = -pdv$. As the

section of the tube varies, the change of kinetic energy of flow, dU, is represented by $-vdp$. The flow in this case is reversible, and the state of the fluid is the same at points where the section of the tube is the same. In practice, however, there is always some frictional dissipation, accompanied by an increase of entropy and by a fall of pressure. In the limiting case of a long fine tube, the bore of which varies in such a manner that U is constant, the state of the substance along a line of flow may be represented by the line of constant total heat, $d(E+pv)=0$; but in the case of a porous plug or small throttling aperture, the steps of the process cannot be followed, though the final state is the same.

In any small reversible change in which the substance absorbs heat, dH, from external sources, the increase of entropy, $d\phi$, must be equal to dH/θ. If the change is not reversible, but the final state is the same, the change of entropy, $d\phi$, is the same, but it is no longer equal to dH/θ. By Carnot's principle, in all irreversible processes, dH/θ must be algebraically less than $d\phi$, otherwise it would be possible to devise a cycle more efficient than a reversible cycle. This affords a useful criterion (see ENERGETICS) between transformations which are impossible and those which are possible but irreversible. In the special case of a substance isolated from external heat supply, $dH=0$, the change of entropy is zero in a reversible process, but must be positive if the process is not reversible. The entropy cannot diminish. Any change involving decrease of entropy is impossible. The entropy tends to a maximum, and the state is one of stable equilibrium when the value of the entropy is the maximum value consistent with the conditions of the problem. This is the theorem of Clausius, but it cannot be usefully applied in practice on account of the difficulty of realizing experimentally the condition of heat-isolation, and because the equations to which it leads would often be difficult or impossible of solution.

15. *Heterogeneous Equilibrium.*—In a *system*, as distinguished from a homogeneous substance, consisting of two or more states or phases in equilibrium, a similar condition of equilibrium applies. In any spontaneous irreversible change, if the system is heat-isolated, there must be an increase of entropy. The total entropy of the system is found by multiplying the entropy per unit mass of the substance in each state by the mass existing in that state, and adding the products so obtained. The simplest case to consider is that of equilibrium between solid and liquid, or liquid and vapour. The more general case is discussed in the article ENERGETICS, and in the original memoirs of Willard Gibbs and others. Since the condition of heat-isolation is impracticable, the condition of maximum entropy cannot be directly applied, and it is necessary to find a more convenient method of expression. If dW is the external work done, dH the heat absorbed from external sources, and dE the increase of intrinsic energy, we have in all cases by the first law, $dH-dE=dW$. Since $\theta d\phi$ cannot be less than dH, the difference $(\theta d\phi-dE)$ cannot be less than dW. This inequality holds in all cases, but cannot in general be applied to an irreversible change, because $\theta d\phi$ is not a perfect differential, and cannot be evaluated without a knowledge of the path or process of transformation. In the special case, however, in which the transformation is conducted in an isothermal enclosure, a common condition easily realized in practice, the temperature at the end of the transformation is reduced to its initial value throughout the substance. The value of $\theta d\phi$ is then the same as $d(\theta\phi)$, which is a perfect differential, so that the condition may be written $d(\phi\theta-E)=dW$. The condition in this form can be readily applied provided that the external work dW can be measured. There are two special cases of importance:—(*a*) If the volume is constant, or $dW=0$, the value of the function $(\theta\phi-E)$ cannot diminish, or $(E-\theta\phi)$ cannot increase, if the temperature is kept constant. This function may be represented, for each state or phase of the system considered, by an area on the indicator diagram similar to that representing the intrinsic energy, E. The product $\theta\phi$ may be represented at any point such as D in Fig. 1 by the whole area θ''DZ′VO under the isothermal θ''D and the adiabatic DZ′, bounded by the axes of pressure and volume. The intrinsic energy, E, is similarly represented by the area DZ′Vd under the adiabatic to the right of the isometric Dd. The difference $\theta\phi-E$ is represented by the area θ''DdO to the left of the isometric Dd under the isothermal θ''D. The increment of this area (or the decrement of the negative area $E-\theta\phi$) at constant temperature represents the external work obtainable from the substance in isothermal expansion, in the same way that the decrement of the intrinsic energy represents the work done in adiabatic expansion. The function $J=E-\theta\phi$, has been called the "free energy" of the substance by Helmholtz, and $\theta\phi$ the "bound energy." These functions do not, however, represent energy existing in the substance, like the intrinsic energy; but the increment of $\theta\phi$ represents heat supplied to, and the decrement of $(E-\theta\phi)$ represents work obtainable from, the substance when the temperature is kept constant. The condition of stable equilibrium of a system at constant temperature and volume is that the total J should be a minimum. This function is also called the "thermodynamic potential at constant volume" from the analogy with the condition of minimum potential energy as the criterion of stable equilibrium in statics.

As an example, we may apply this condition to the case of change of state. If J', J'' represent the values of the function for unit mass of the substance of specific volumes v' and v'' in the two states at temperature θ and pressure p, and if a mass m is in the state v', and $1-m$ in the state v'', the value of J for unit mass of the mixture is $mJ'+(1-m)J''$. This must be a minimum in the state of equilibrium at constant temperature. Since the volume is constant, we have the condition $mv'+(1-m)v''=$constant. Since $dJ=-\phi d\theta-pdv$, we have also the relations $dJ'/dv'=-p=dJ''/dv''$, at constant temperature. Putting $dJ/dm=0$ at constant volume, we obtain as the condition of equilibrium of the two states $J'+p'v'=J''+p''v''$. This may be interpreted as the equation of the border curve giving the relation between p and θ, but is more easily obtained by considering the equilibrium at constant pressure instead of constant volume.

(*b*) The second case, which is of greater practical utility, is that in which the external pressure, p, is kept constant. In this case $dW=pdv=d(pv)$, a perfect differential, so that the external work done is known from the initial and final states. In any possible transformation $d(\theta\phi-E)$ cannot be less than $d(pv)$, or the function $(E-\theta\phi+pv)=G$ cannot increase. The condition of stable equilibrium is that G should be a minimum, for which reason it has been called the "thermodynamic potential at constant pressure." The product pv for any state such as D in Fig. 1 is represented by the rectangle MDdO, bounded by the isopiestic and the isometric through D. The function G is represented by the negative area θ''DM under the isothermal, bounded by the isopiestic DM and the axis of pressure. The increment of $\theta\phi$ is always greater than that of the total heat $F=E+pv$, except in the special case of an equilibrium change at constant temperature and pressure, in which case both are equal to the heat absorbed in the change, and the function G remains constant. This is geometrically obvious from the form of the area representing the function on the indicator diagram, and also follows directly from the first law. The simplest application of the thermodynamic potential is to questions of change of state. If ϕ', E', v'; and ϕ'', E'', v'', refer to unit mass of the substance in the first and second states respectively in equilibrium at a temperature θ and pressure p, the heat absorbed, L, per unit mass in a change from the first to the second state is, by definition of the entropy, equal to $\theta(\phi''-\phi')$, and this by the first law is equal to the change of intrinsic energy, $E''-E'$, plus the external work done, $p(v''-v')$, *i.e.*, to the change of total heat, $F''-F'$. If G' and G'' are the values of the function G for the two states in equilibrium at the same pressure and temperature, we must have $G'=G''$. Assuming the function G to be expressed in terms of p and θ, this condition represents the relation between p and θ corresponding to equilibrium between the two states, which is the solution of the relation $(v''-v')dp/d\theta=L/\theta$, (5). The direct integration of this equation requires that L and $v''-v'$ should be known as functions of p and θ, and cannot generally be performed. As an example of one of the few cases where a complete solution is possible, we may take the comparatively simple case equation (17), already considered, which is approximately true for the majority of vapours at moderate pressures.

Writing formulæ (31) and (33) for the energy and entropy with indeterminate constants A and B, instead of taking them between limits, we obtain the following expressions for the thermodynamic functions in the case of the vapour :—

$$\phi''=S_0\log_e\theta-R\log_e p-ncp/\theta+A'' \quad . \quad . \quad . \quad . \quad (34)$$
$$E''=s_0\theta-ncp+B'' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (35)$$
$$F''=S_0\theta-(n+1)cp+bp+B'' \quad . \quad . \quad . \quad . \quad . \quad (36)$$
$$G''=S_0\theta(1-\log_e\theta)+R\theta\log_e p-(c-b)p-A''\theta+B'' \quad . \quad (37)$$
$$J''=s_0\theta-S_0\theta\log_e\theta+R\theta\log_e p-A''\theta+B'' \quad . \quad . \quad (38)$$

The function J'' may be expressed in terms of θ and v by writing for p its value, namely, $R\theta/(v+c-b)$. We have also in any case the relations

$$dG''/d\theta\ (p\ \text{const})=\phi''=dJ''/d\theta\ (v\ \text{const}) \quad . \quad . \quad (39)$$
$$dG''/dp\ (\theta\ \text{const})=v,\ dJ''/dv\ (\theta\ \text{const})=p \quad . \quad . \quad (40)$$

And all the properties of the substance may be expressed in terms of G or J and their partial differential coefficients. The values of the corresponding functions for the liquid or solid cannot be accurately expressed, as the theoretical variation of the specific heat is unknown, but if we take the specific heat at constant pressure s' to be approximately constant, and observe the small residual variation dh of the total heat, we may write

$$F'=s'\theta+dh+B' \quad . \quad . \quad . \quad . \quad . \quad . \quad (41)$$
$$\phi'=s'\log_e\theta+d\phi+A' \quad . \quad . \quad . \quad . \quad . \quad (42)$$
$$G'=s'\theta(1-\log_e\theta)+(dh-\theta d\phi)-A'\theta+B' \quad . \quad . \quad (43)$$

where $d\phi$ is the corresponding residual variation of ϕ', and is easily calculated from a table of values of h.

To find the border curve of equilibrium between the two states, giving the saturation pressure as a function of the temperature, we have merely to equate the values of G' and G''. Rearranging the terms, and dividing throughout by θ, we obtain an equation of the form

$$R\log_e p=A-B/\theta-(s'-S_0)\log_e\theta+(c-b)p/\theta+(dh/\theta-d\phi) \quad . \quad (44)$$

in which $B=B''-B'$, and $A=A''-A'+s'-S_0$. The value of A is determined by observing the value of θ_0 at some known pressure p_0, *e.g.*, at the boiling-point. The value of B is determined by observing the latent heat, $L_0=F''_0-F'_0$, which gives

$$B=B''-B'=L_0+(s'-S_0)\theta_0+(n+1)c_0p_0-bp_0+dh_0 \quad . \quad (45)$$

This constant may be called the absolute latent heat, as it expresses the thermal value of the change of state in a manner independent of temperature.

The term $(dh/\theta-d\phi)$ depending on the variation of the specific heat of the liquid may be made very small in the case of water by a proper choice of the constant s'. It is of the same order as the probable errors of observation, and may be neglected in practice. (See VAPORIZATION, § 12.) The expression for $R\log p$ for an imperfect gas of this type differs from that for a perfect gas only by the addition of the term $(c-b)p/\theta$. This simple result is generally true, and the corresponding expressions for G'' and J'' are valid, provided that $c-b$ in formula (17) is a function of the temperature only. It is not necessary to suppose that c varies inversely as the nth power of the temperature, and that b is constant, as assumed in deducing the expressions for ϕ, E, and F.

Although the value of G in any case cannot be found without that of ϕ, and although the consideration of the properties of the thermodynamic potential cannot in any case lead to results which are not directly deducible from the two fundamental laws, it affords a convenient method of formal expression in abstract thermodynamics for the condition of equilibrium between different phases, or the criterion of the possibility of a transformation. For such purely abstract purposes, the possibility of numerical evaluation of the function is of secondary importance, and it is often possible to make qualitative deductions with regard to the general nature of a transformation without any knowledge of the actual form of the function. A more common method of procedure, however, is to infer the general relations of the thermodynamic potential from a consideration of the phenomena of equilibrium.

It is often possible to heat a liquid at atmospheric pressure considerably above its boiling-point, especially if it be not exposed to vapour or gas. It is similarly possible to cool a vapour considerably below its condensing-point, in the absence of nuclei, without condensation occurring. Under such conditions, boiling of the liquid or condensation of the vapour may be induced, if they are brought in contact or in various other ways, but is an irreversible process involving local differences of pressure and temperature, which cannot be fully represented on the indicator diagram, since the condition is not one of equilibrium throughout the substance. In such cases there is always dissipation of available energy in friction and diffusion before the equilibrium state is reached, and the value of the function G for the mixture is diminished. The direction of the change of state which occurs may be determined by observing whether G' is greater than G'', or *vice versâ*.

As it would be impossible within the limits of this article to illustrate or explain adequately all the applications which have been made of the principles of thermodynamics, it has been necessary to select such illustrations only as are required for other reasons, or could not be found elsewhere. For fuller details and explanations of the elements of the subject, the reader must be referred to general treatises such as Baynes's *Thermodynamics* (Oxford), Tait's *Thermodynamics* (Edinburgh), Maxwell's *Theory of Heat* (London), Parker's *Thermodynamics* (Cambridge), Clausius's *Mechanical Theory of Heat* (translated by Browne, London), and Preston's *Theory of Heat* (London). One or two chapters on the subject are also generally included in treatises on the steam engine, or other heat engines, such as those of Rankine, Perry, or Ewing. Of greater interest, particularly from a historical point of view, are the original papers of Joule, Thomson, and Rankine, some of which have been reprinted in a collected form. A more complete and more elaborate treatment of the subject will be found in foreign treatises, such as those of Clausius, Zeuner, Duhem, Bertrand, Planck, and others.

Alphabetical Index of Symbols employed.

θ, Thermodynamic or absolute temperature.
ϕ, Entropy. Section 13.
b, Covolume of molecules of gas. Equation (17).
c, c_0, Co-aggregation volume per unit mass. Equation (17).
e, Base of Napierian logarithms.
E, Intrinsic energy per unit mass. Section 2.
$F=E+pv$, Total heat. Section 7.
G, J, Thermodynamic potential functions. Section 15.
H, Quantity of heat (in mechanical units). Section 2.
K, k, Adiabatic and isothermal elasticities. Equation (7).
L, Latent heat of fusion or vaporization. Equation (5).
M, Molecular weight. Section 8.
m, Mass of substance or molecule.
n, Index in expression for c. Equation (17).
p, Pressure of fluid. p_0, Initial pressure.
$R=S_0-s_0$, Constant in gas-equation (17).
S, Specific heat of gas at constant pressure.
S_0, Limiting value of S when $p=0$. Section 12.
s, Specific heat of gas at constant volume.
s_0, Limiting value of s when $p=0$. Section 12.
s', s'', Specific heat under other conditions. Equation (5).
U, Kinetic energy of flow of fluid. Section 10.
u, Mean velocity of gaseous molecules. Section 8.
$V=R\theta/p$, Ideal volume of gas per unit mass. Equation (17).
v, Specific volume of fluid, reciprocal of density.
W, External work done by fluid.

(H. L. C.)

Thermoelectricity.—The account of this subject given in the article Electricity, *Ency. Brit.*, vol. viii. p. 94, brings our knowledge of the phenomena down to the epoch of Tait's theory and experiments. The present article gives a summary of the results of the older work, in order to make the discussion of later theories and researches intelligible.

§ 1. *Fundamental Phenomena.*—Volta (1801) showed that although a separation of the two electricities was produced by the contact of two different metals (*Volta Effect*), which could be detected by a sensitive electrometer, a continuous current of corresponding magnitude could not be produced in a purely metallic circuit without the interposition of a liquid, because the electromotive force at one junction was exactly balanced by an equal and opposite force at the other. Seebeck (1822), employing a galvanometer then recently invented, which was more suited for the detection of small electromotive forces, found that a current was produced if the junctions of the two metals were at different temperatures. He explained this effect by supposing that the Volta contact E.M.F. varied with the temperature, so that the exact balance was destroyed by unequal heating. The intensity of the current, C, for any given pair of metals was found to vary directly as the difference of temperature, $t-t'$, between the hot and cold junctions, and inversely as the resistance, R, of the circuit. We conclude by applying Ohm's law that the electromotive force, E, of the thermocouple may be approximately represented for small differences of temperature by the formula

$$E=CR=p\,(t-t') \quad . \quad . \quad . \quad . \quad (1)$$

§ 2. *Thermoelectric Power, Series, Inversion.*—The limiting value, dE/dt, of the coefficient, p, for an infinitesimal difference, dt, between the junctions is called the *Thermoelectric Power* of the couple. One metal (A) is said to be thermoelectrically positive to another (B), if positive electricity flows from A to B across the cold junction when the circuit is completed. The opposite convention is sometimes adopted, but the above is the most convenient in practice, as the circuit is generally broken at or near the cold junction for the insertion of the galvanometer. Seebeck found that the metals could be arranged in a *Thermoelectric Series*, in the order of their power when combined with any one metal, such that the power of any thermocouple p, composed of the metals A and B, was equal to the algebraic difference $(p'-p'')$ of their powers when combined with the standard metal C. The order of the metals in this series was found to be different from that in the corresponding Volta series, and to be considerably affected by variations in purity, hardness, and other physical conditions. Cumming shortly afterwards discovered the phenomenon of *Thermoelectric Inversion*, or the change of the order of the metals in the thermoelectric series at different temperatures. Copper, for instance, is negative to iron at ordinary temperatures, but is positive to it at 300° C. or above. The E.M.F. of a copper-iron thermocouple reaches a maximum when the temperature of the hot junction is raised to 270° C., at which temperature the thermoelectric power vanishes and the metals are said to be *neutral* to one another. Beyond this point the E.M.F. diminishes, vanishing and changing sign when the temperature of the hot junction is nearly as much above the neutral point as the temperature of the cold junction is below it. Similar phenomena occur in the case of many other couples, and it is found that the thermoelectric power p is not in general a constant, and that the simple linear formula (1) is applicable only for small differences of temperature. More accurately it may be stated that the thermo-E.M.F. in any given circuit containing a series of different metals is a function of the temperatures of the junctions only, and is independent of the distribution of the temperature at any intermediate points, provided that each of the metals in the series is of uniform quality. This statement admits of the simple mathematical expression

$$E=\int_{t_0}^{t'} p'dt+\int_{t'}^{t''} p''dt+\&c. \quad . \quad . \quad . \quad (2);$$

where p', p'', &c., are the thermoelectric powers of the metals, and t_0, t', t'' &c., the temperatures of the junctions. There are some special cases of sufficient practical importance to be separately stated.

§ 3. *Homogeneous Circuit. Strain Hysteresis.*—In a circuit consisting of a single metal, no current can be produced by variations of temperature, provided that the metal is not thereby strained or altered. This was particularly demonstrated by the experiments of Magnus. The effects produced by abrupt changes of temperature or section, or by pressing together pieces of the same metal at different temperatures, are probably to be explained as effects of strain. A number of interesting effects of this nature have been investigated by Thomson, Le Roux, Tait, and others, but the theory has not as yet been fully developed. An interesting example is furnished by an experiment due to Trouton (*Proc. R. S. Dub.*, 1886). A piece of iron or steel wire in the circuit of a galvanometer is heated in a flame to bright redness at any point. No effect is noticed so long as the flame is stationary, but if the flame be moved slowly in one direction a current is observed, which changes its direction with the direction of motion of the flame. The explanation of this phenomenon is that the metal is transformed at a red heat into another modification, as is proved by simultaneous changes in its magnetic and electrical properties. The change from one state to the other takes place at a higher temperature on heating than on cooling. The junctions of the magnetic and the non-magnetic steel are therefore at different temperatures if the flame is moved, and a current is produced just as if a piece of different metal with junctions at different temperatures had been introduced into the circuit. Other effects of "hysteresis" occur in alloys of iron, which have been recently studied by Barrett (*Trans. R. S. Dub.*, Jan. 1900).

§ 4. *Law of Successive Temperatures.*—The E.M.F. of a given couple between any temperatures t' and t'' is the algebraic sum of the E.M.F. between t' and any other temperature t and the E.M.F. between t and t''. A useful result of this law is that it is sufficient to keep one junction always at some convenient standard temperature, such as 0° C., and to tabulate only the values of the E.M.F. in the circuit corresponding to different temperatures of the other junction.

§ 5. *Law of Intermediate Metals.*—A thermoelectric circuit may be cut at any point and a wire of some other metal introduced without altering the E.M.F. in the circuit, provided that the two junctions with the metal introduced are kept at the same temperature. This law is commonly applied in connecting a thermocouple to a galvanometer with coils of copper wire, the junctions of the copper wires with the other metals being placed side by side in a vessel of water or otherwise kept at the same temperature. Another way of stating this law, which, though apparently quite different, is really equivalent in effect, is the following. The E.M.F. of any couple, AB, for any given limits of temperature is the algebraic sum of the E.M.F.s between the same limits of temperature of the couples BC and CA formed with any other metal C. It is for this reason unnecessary to tabulate the E.M.F.s of all possible combinations of metals, since the E.M.F. of any couple can be at once deduced by addition from the values given by its components with a single standard metal. Different observers have chosen different metals as the standard of reference. Tait and Fleming select lead on account of the smallness of the Thomson effect in it, as observed by Le Roux. Noll adopts mercury because it is easily purified, and its physical condition in the liquid state is determinate; there is, however, a discontinuity involved in passing from the liquid to the solid state at a temperature of −40° C., and it cannot be used at all with some metals, such as lead, on account of the rapidity with which it dissolves them. Both lead and mercury have the disadvantage that they cannot be employed for temperatures much above 300° C. Of all metals, copper is the most generally convenient, as it is always employed in electrical connexions and is easily obtained in the annealed state of uniform purity. For high temperature work it is necessary to employ platinum, which would be an ideal standard for all purposes on account of its constancy and infusibility, did not the thermoelectric properties of different specimens differ considerably.

§ 6. *Thermoelectric Formulæ.*—On the basis of the principles stated above, the most obvious method of tabulating the observations would be to give the values E_t of the E.M.F. between 0° C. and t for each metal against the standard. This involves no assumptions as to the law of variation of E.M.F. with temperature, but is somewhat cumbrous. In the majority of cases it is found that the observations can be represented within the limits of experimental error by a fairly simple empirical formula, at least for moderate ranges of temperature. The following formulæ are some of those employed for this purpose by different observers:—

$E_t = bt + ct^2$ . . . . (Avenarius, 1863.)
$E_t = at + bt^2 + ct^3$ . . . (General type.)
$\log E = a + b/T + c \log T$ . . (Becquerel, 1863.)
$E_{(t-t')} = c(t-t')(2t^\circ - (t+t'))$. (Tait, 1870.)
$E_t + E_{t^\circ} = 10^{a+bt} + 10^{a'+b't^\circ}$. (Barus, 1889.)
$t = aE + bE^2 + cE^3$ . . . (Holborn and Wien, 1892.)
$E_{(t-t')} = b(t-t')^{4/3}$ . . . (Paschen, 1893.)
$E_{(t-t')} = a(t-t') + b(t-t')^2$. (Steele, 1894.)
$E_{(T-T^\circ)} = mT^n - mT^{\circ n}$, $E_t = mt^n$ (Holman, 1896.)
$E_t = bt + c \log T/273$, $(c = Ts.)$. (Stansfield, 1898.)
$E_t = -a + bt + ct^2$ . . . (Holborn and Day, 1899.)
$E_t = at + ct^2 + s^\circ(T \log_e T - 273 \log_e 273)$.
(Where $s = s^\circ + 2cT$, and c is small. See sec. 15.)

For moderate ranges of temperature the binomial formula of Avenarius is generally sufficient, and has been employed by many observers. It is figured by Avenarius (*Pogg. Ann.*, 119, p. 406) as a semi-circle, but it is really a parabola with its axis parallel to the axis of E, and its vertex at the point $t = -b/2c$, which gives the neutral temperature. We have also the relations $dE/dt = b + 2ct$ and $d^2E/dt^2 = 2c$. The first relation gives the thermoelectric power p at any temperature, and is probably the most convenient method of stating results in all cases in which this formula is applicable. A discussion of some of the exponential formulæ is given by Holman (*Phil. Mag.*, 41, p. 465, June 1896).

§ 7. *Experimental Results.*—In the following comparative table of the results of different observers the values are referred to lead. Before the time of Tait's researches such data were of little interest or value, on account of insufficient care in securing the purity of the materials tested; but increased facilities in this respect, combined with great improvements in electrical measurements, have put the question on a different footing. The comparison of independent results shows in many cases a remarkable concordance, and the data are becoming of great value for the testing of various theories of the relations between heat and electricity.

TABLE I.—THERMOELECTRIC POWER, $p = dE/dt$, IN MICROVOLTS AT 50° C. OF PURE METALS WITH RESPECT TO LEAD. (The mean change, $2c = d^2E/dt^2$, of the thermoelectric power per degree C. over the range covered by the experiments, is added in each case.)

Metal.	Tait (0° to 300°).		Steele (0° to 100°).		Noll (0° to 200°).		Dewar and Fleming (+100° to −200°).	
	p.	2*c.*	*p.*	2*c.*	*p.*	2*c.*	*p.*	2*c.*
Aluminium	−0·56	+·0039	−0·42	+·0021	−0·41	+·00174	−0·394	+·00398
Antimony	...	...	+42·83	+·1450*	...	...	+3·210	+·02817
Bismuth	...	...	...	...	...	...	−76·870	−·08480
Cadmium	+4·75	+·0429	+4·79	+·0389	+4·71	+·0339	+4·792	+·02365
Carbon	...	...	...	...	...	...	+12·795	+·03251
Copper	+1·81*	+·0095	+3·37	+·0122	+3·22	+·0080	+3·156	+·00683
Cobalt	...	...	...	...	−19·252	−·0734	...	...
Gold	+3·30	+·0102	+3·19	+·0131	+3·10	+·0063	+1·161	+·00315
Iron	+14·74	−·0487	...	...	+11·835	−·0306	+14·522	−·01330
Steel (piano)	+9·75	−·0328	...	...	...	...	+9·600	−·01092
Steel (Mn 12 %)	...	...	...	...	...	...	−5·73	−·00445
Magnesium	+1·75*	−·0095	...	...	−0·113	+·0019	−0·126	+·00353
Mercury	...	...	...	...	−4·03	−·0086	...	...
Nickel	−24·23*	−·0512	...	...	−20·58	−·0302	−18·87	−·05639
Palladium	−8·04	−·0359	...	...	...	...	−9·100	−·04714
Platinum	−1·15*	−·0110	...	...	−4·09	−·0211	−4·347	−·03708
Silver	+2·86	+·0150	+3·07	+·0115	+2·68	+·0076	+3·317	+·00714
Thallium	...	...	+1·76	−·0077	...	...	...	...
Tin	−0·16	+·0055	−0·091	+·0004	−0·067	+·0019	+0·057	+·00021
Zinc	+3·51	+·0240	+1·77*	+·0195	+3·318	+·0172	+3·233	+·01040

Explanation of Table.—The figures marked with an asterisk represent discrepancies which are probably caused by impurities in the specimens. At the time of Tait's work in 1873 it was difficult, if not impossible, in many cases to secure pure materials. The work of the other three observers dates from 1894–95. The value of the thermoelectric power dE/dt at 50° C. is taken as the mean value between 0° and 100° C., over which range it can be most accurately determined. The values of d^2E/dt^2 agree as well as can be expected, considering the difference of the ranges of temperature and the great variety in the methods of observation adopted; they are calculated assuming the parabolic formula, which is certainly in many cases inadequate. Noll's values apply to the temperature of +100° C., Dewar and Fleming's to that of −100° C., approximately.

In using the above table to find the value of E or dE/dt at any temperature or between any limits, denoting by p the value of dE/dt at 50° C., and by $2c$ the constant value of the second coefficient, we have the following equations:—

$$dE/dt = p + 2c\,(t - 50), \text{ at any temperature } t, \text{ Cent.} \quad (3),$$

$$E_{(t-t')} = (t-t')\,(p + c\,(t + t' - 100)) \quad (4),$$

for the E.M.F. between any temperatures t and t'.

§ 8. *Methods of Observation.*—In Tait's observations the E.M.F. was measured by the deflection of a mirror galvanometer, and the temperature by means of a mercury thermometer or an auxiliary thermocouple. He states that the deviations from the formula were "quite within the limits of error introduced by the alteration of the resistance of the circuit with rise of temperature, the deviations of the mercury thermometers from the absolute scale, and the non-correction of the indications of the thermometer for the long column of mercury not immersed in the hot oil round the junctions." The latter correction may amount to about 10° C. at 350°. Later observers have generally employed a balance method (some modification of the Potentiometer or Poggendorf balance) for measuring the E.M.F. The range of Steele's observations was too small to show any certain deviation from the formula, but he notes capricious changes attributed to change of condition of the wires. Noll employed mercury thermometers, but as he worked over a small range with vapour baths, it is probable that he did not experience any trouble from immersion corrections. He does not record any systematic deviations from the formula. Dewar and Fleming, working at very low temperatures, were compelled to use the platinum thermometer, and expressed their results in terms of the platinum scale. Their observations were probably free from immersion errors, but they record some deviations from the formula which they consider to be beyond the possible limits of error of their work. The writer has reduced their results to the scale of the gas thermometer, assuming the boiling-point of oxygen to be − 182·5° C.

§ 9. *Peltier Effect.*—The discovery by Peltier (1834) that heat is absorbed at the junction of two metals by passing a current through it in the same direction as the current produced by heating it, was recognized by Joule as affording a clue to the source of the energy of the current by the application of the principles of thermodynamics. Unlike the frictional generation of heat due to the resistance of the conductor, which Joule (1841) proved to be proportional to the square of the current, the Peltier effect is reversible with the current, and being directly proportional to the first power of the current, changes sign when the current is reversed. The effect is most easily shown by connecting a voltaic cell to a thermopile for a short interval, then quickly (by means of a suitable key, such as a Pohl commutator with the cross connectors removed) disconnecting the pile from the cell and connecting it to a galvanometer, which will indicate a current in the reverse direction through the pile, and approximately proportional to the original current in intensity, provided that the other conditions of the experiment are constant. It was by an experiment of this kind that Icilius (1853) verified the proportionality of the heat absorbed or generated to the first power of the current. It had been observed by Peltier and Becquerel that the intensity of the effect depended on the thermoelectric power of the junction and was independent of its form or dimensions. The order of the metals in respect of the Peltier effect was found to be the same as the thermoelectric series. But on account of the difficulty of the measurements involved, the verification of the accurate relation between the Peltier effect and thermoelectric power was left to more recent times. If C is the intensity of the current through a simple thermocouple, the junctions of which are at temperatures t and t', a quantity of heat, $P \times C$, is absorbed by the passage of the current per second at the hot junction, t, and a quantity, $P' \times C$, is evolved at the cold junction, t'. The coefficients, P and P', are called coefficients of the Peltier effect, and may be stated in calories or joules per ampere-second. The Peltier coefficient may also be expressed in volts or microvolts, and may be regarded as the measure of an E.M.F. located at the junction, and transforming heat into electrical energy or *vice versâ*. If R is the whole resistance of the circuit, and E the E.M.F. of the couple, and if the flow of the current does not produce any other thermal effects in the circuit besides the Joule and Peltier effects, we should find by applying the principle of the conservation of energy, *i.e.*, by equating the balance of the heat absorbed by the Peltier effects to the heat generated in the circuit by the Joule effect,

$$(P-P')\,C=C^2R=EC, \text{ whence } E=P-P'. \quad (5)$$

If we might also regard the couple as a reversible thermodynamic engine for converting heat into work, and might neglect irreversible effects, such as conduction, which are independent of the current, we should expect to find the ratio of the heat absorbed at the hot junction to the heat evolved at the cold junction, namely P/P', to be the same as the ratio T/T' of the absolute temperatures of the junctions. This would lead to the conclusion given by Clausius (1853) that the Peltier effect varied directly as the absolute temperature, and that the E.M.F. of the couple should be directly proportional to the difference of temperature between the junctions.

§ 10. *Thomson Effect.*—Thomson (Lord Kelvin) had already pointed out (*Proc. R. S. Ed.*, 1851) that this conclusion was inconsistent with the known facts of thermoelectric inversion. (1) The E.M.F. was not a linear function of the temperature difference. (2) If the Peltier effect was proportional to the thermoelectric power and changed sign with it, as all experiments appeared to indicate, there would be no absorption of heat in the circuit due to the Peltier effect, and therefore no thermal source to account for the energy of the current, in the case in which the hot junction was at or above the neutral temperature. He therefore predicted that there must be a reversible absorption of heat in some other part of the circuit due to the flow of the current through the unequally - heated conductors. He succeeded a few years afterwards in verifying this remarkable prediction by the experimental demonstration that a current of positive electricity flowing from hot to cold in iron produced an absorption of heat, as though it possessed *negative* specific heat in the metal iron. He also succeeded in showing that a current from hot to cold evolved heat in copper, but the effect was smaller and more difficult to observe than in iron.

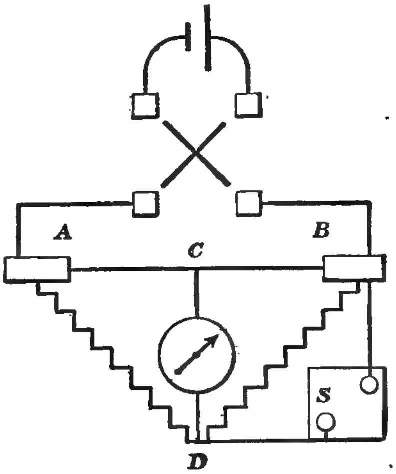

Fig. 1.—Diagram of Apparatus for Demonstrating the Thomson Effect.

The Thomson effect may be readily demonstrated as a lecture experiment by the following method (Fig. 1). A piece of wire (No. 28) about 4 cm. long is soldered at either end A, B to thick wires (No. 12), and is heated 100° to 150° C. by a steady current from a storage cell adjusted by a suitable rheostat. The experimental wire AB is connected in parallel with about 2 metres of thicker wire (No. 22), which is not appreciably heated. A low-resistance galvanometer is connected by a very fine wire (2 to 3 mils) to the centre C of the experimental wire AB, and also to the middle point D of the parallel wire so as to form a Wheatstone bridge. The balance is adjusted by shunting either AD or BD with a box containing 20 to 100 ohms. All the wires in the quadrilateral must be of the same metal as AB, to avoid accidental thermoelectric effects which would obscure the result. If the current flows from A to B there will be heat absorbed in AC and evolved in CB by the Thomson effect, if the specific heat of electricity in AB is positive as in copper. When the current is reversed, the temperature of AC will be raised and that of CB lowered by the reversal of the effect. This will disturb the resistance balance by an amount which can be measured by the deflection of the galvanometer, or by the change of the shunt-box, S, required to restore the balance. Owing to the small size of the experimental wire, the method is very quick and sensitive, and the apparatus can be set up in a few minutes when once the experimental quadrilaterals have been made. It works very well with platinum, iron, and copper. It was applied with elaborate modifications by the writer in 1886 to determine the value of the Thomson effect in platinum in absolute measure, and has recently been applied with further improvements by King to measure the effect in copper.

§ 11. *Thomson's Theory.*—Taking account of the Thomson effect, the thermodynamical theory of the couple was satisfactorily completed by Thomson (*Trans. R. S. Ed.*, 1854). If the quantity of heat absorbed and converted into electrical energy, when unit quantity of electricity (one ampere-second) flows from cold to hot through a difference of temperature, dt, be represented by sdt, the coefficient s is called the specific heat of electricity in the metal, or simply the coefficient of the Thomson effect. Like the Peltier coefficient, it may be measured in joules or calories per ampere-second per degree, or more conveniently and simply in microvolts per degree.

Consider an elementary couple of two metals A and B for which s has the values s' and s'' respectively, with junctions at the temperatures T and $T+dT$ (absolute), at which the coefficients of the Peltier effect are P and $P+dP$. Equating the quantity of heat absorbed to the quantity of electrical energy generated, we have by the first law of thermodynamics the relation

$$dE/dT=dP/dT+(s'-s'') \quad . \quad . \quad . \quad (6)$$

If we apply the second law, regarding the couple as a reversible engine, and considering only the reversible effects, we obtain

$$(s'-s'')/T=-d(p/T)/dT \quad . \quad . \quad . \quad (7)$$

Eliminating $(s'-s'')$ we find for the Peltier effect

$$P=TdE/dT=Tp \quad . \quad . \quad . \quad . \quad (8)$$

Whence we obtain for the difference of the specific heats

$$(s'-s'')=-Td^2E/dT^2=-Tdp/dT \quad . \quad . \quad (9)$$

From these relations we observe that the Peltier effect P, and the difference of the Thomson effects $(s'-s'')$, for any two metals are easily deduced from the tabulated values of dE/dt and d^2E/dt^2 respectively. The signs in the above equations are chosen on the assumption that positive electricity flows from cold to hot in the metal s'. The signs of the Peltier and Thomson effects will be the same as the signs of the coefficients given in Table I., if we suppose the metal s' to be lead, and assume that the value of s' may be taken as zero at all temperatures.

§ 12. *Experimental Verification of Thomson's Theory.*—In order to justify the assumption involved in the application of the second law of thermodynamics to the theory of the thermocouple in the manner above specified, it would be necessary and sufficient, as Thomson pointed out (*Phil. Mag.*, December 1852), to make experiments to verify quantitatively the relation $P/T=dE/dT$ between the Peltier effect and the thermoelectric power. A qualitative relation was known at that time to exist, but no absolute measurements of sufficient accuracy had been made. The most accurate measurements of the heat absorption due to the Peltier effect at present available are probably those of Jahn (*Wied. Ann.*, 34, p. 755, 1888). He enclosed various metallic junctions in a Bunsen ice calorimeter, and observed the evolution of heat per hour with a current of about 1·6 amperes in either direction. The Peltier effect was only a small fraction of the total effect, but could be separated from the Joule effect owing to the reversal of the current. The values of dE/dT for *the same specimens* of metal at 0° C. were determined by experiments between +20° C. and −20° C. The results of his observations are contained in the following table, heat absorbed being reckoned positive as in Table I.:—

TABLE II.

Thermo-couple.	dE/dT Microvolts per deg.	$P=Td\,E/dT$ Microvolts at 0° C.	Heat calc. Calories per hour.	Heat observ'd Calories per hour.
Cu-Ag	+2·12	+579	+0·495	+0·413
Cu-Fe	+11·28	+3079	+2·640	+3·163
Cu-Pt	−1·40	−382	−0·327	−0·320
Cu-Zn	+1·51	+412	+0·353	+0·585
Cu-Cd	+2·64	+721	+0·617	+0·616
Cu-Ni	−20·03	−5468	−4·680	−4·362

The agreement between the observed and calculated values in the last two columns is as good as can be expected considering the great difficulty of measuring such small quantities of heat. The analogous reversible heat effects which occur at the junction of a metal and an electrolyte were also investigated by Jahn, but he did not succeed in obtaining so complete an agreement with theory in this case.

§ 13. *Tait's Hypothesis.*—From general considerations concerning minimum dissipation of energy (*Proc. R. S. Ed.*, 1867–68), Tait was led to the conclusion that "the thermal and electric conductivities of metals varied inversely as the absolute temperature, and that the specific heat of electricity was directly proportional to the same." Subsequent experiments led him to doubt this conclusion as regards conductivity, but his thermoelectric experiments (*Proc. R. S. Ed.*, Dec. 1870) appeared to be in good agreement with it. If we adopt this hypothesis, and substitute $s=2cT$, where c is a constant, in the fundamental equation (9), we obtain at once $d^2E/dT^2=-2(c'-c'')$, which is immediately integrable, and gives

$$dE/dt=p=2(t_0-t)(c'-c'') \quad . \quad . \quad (10),$$

$$E_{t-t'}=(t-t')(c'-c'')\{2t_0-(t+t')\} \quad . \quad . \quad (11),$$

where t_0 is the temperature of the neutral point at which $dE/dt=0$. This is the equation to a parabola, and is equivalent to the empirical formula of Avenarius, with this difference, that in Tait's formula the constants have all a simple and direct interpretation in relation to the theory. Tait's theory and formula were subsequently assimilated by Avenarius (*Pogg. Ann.*, 149, p. 372, 1873), and are now generally attributed to Avenarius in foreign periodicals.

In accordance with this hypothesis, the curves representing the variations of thermoelectric power, dE/dt, with temperature are straight lines, the slope of which for any couple is equal to the difference of the constants $2(c'-c'')$. The diagram constructed by Tait on this principle is fully explained and illustrated in the article ELECTRICITY (*Ency. Brit.*, vol. viii. p. 97). It has since been generally adopted as embodying in a simple form the fundamental phenomena of thermoelectricity.

§ 14. *Experimental Verification.*—Tait's verification of this hypothesis consisted in showing that the experimental curves of E.M.F. were parabolas in most cases within the limits of error of his observations. He records, however, certain notable divergencies, particularly in the case of iron and nickel, and many others have since come to light from other observations. It should also be remarked that even if the curves were not parabolas, it would always be possible to draw parabolas to agree closely with the observations over a restricted range of temperature. When the question is tested more carefully, either by taking more accurate measurements of temperature, or by extending the observations over a wider range, it is found that there are systematic deviations from the parabola in the majority of cases, which cannot be explained by errors of experiment. A more accurate verification of these relations, both at high and low extremes of temperature, has become possible of late years owing to the development of the theory and application of the platinum resistance thermometer. (See THERMOMETRY.) The curves in Fig. 2 illustrate the differences from the parabolic formula, measured in degrees of temperature, as observed by Tory (*B. A. Report*, 1897). The deviations for the copper-iron couple, and for the copper cast-iron couple over the range 0° to 200° C., appear to be of the order of 1° C., and were carefully verified by repeated and independent series of observations. The deviations of the platinum and platinum-rhodium 10 per cent. couple over the range 0° to 1000° C. are shown on a

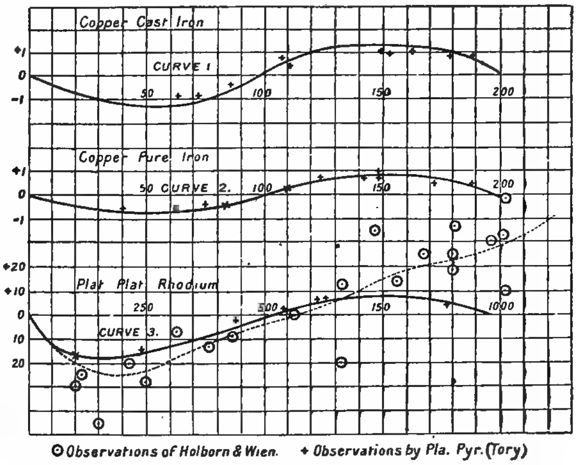

FIG. 2.—Temperature by Thermocouple. Difference from Tait's formula.

smaller scale, and are seen to be of a similar nature, but rather greater in proportion. It should be observed that these deviations are continuous, and differ in character from the abrupt changes observed by Tait in special cases. A number of similar deviations at temperatures below 0° C. were found by the writer in reducing the curves representing the observations of Dewar and Fleming (*Phil. Mag.*, July 1895) to the normal scale of temperature from the platinum scale in which they are recorded. In many cases the deviations do not appear to favour any simple hypothesis as to the mode of variation of s with temperature, but as a rule the indication is that s is nearly constant, or even diminishes with rise of temperature. It may be interesting therefore to consider the effect of one or two other simple hypotheses with regard to the mode of variation of s with T.

§ 15. *Other Assumptions.*—If we take the analogy of a perfect gas and assume $s=s^\circ=$constant, we have

$$dE^2/dT^2=-s^\circ/T,\ dE/dT=s^\circ \log_e T^\circ/T \quad . \qquad (12),$$

$$E_{(T-T')}=s^\circ T \log_e T^\circ/T-s^\circ T' \log_e T^\circ/T' \quad . \qquad (13),$$

where T and T' are the temperatures of the junctions, and T° is the neutral temperature. These formulæ are not so simple and convenient as Tait's, though apparently founded on a more simple assumption, but they frequently represent the observations more closely. If we suppose that s is not quite constant, but increases or diminishes slightly with change of temperature according to a linear formula $s=s^\circ+2cT$ (in which s° represents the constant part of s, and c may have either sign), we obtain a more general formula which is evidently the sum of the two previous solutions and may be made to cover a greater variety of cases (see above, p. 291). Another simple and possible assumption is that made by Stansfield (*Phil. Mag.*, July 1898), that the value of s varies inversely as the absolute temperature. Putting $s=c/T$, we obtain

$$E_{(T-T')}=c \log_e T/T'-c(T-T')/T^\circ \quad . \quad . \qquad (14),$$

which is equivalent to the form given by Stansfield, but with the neutral temperature T° explicitly included. According to this formula, the Peltier effect is a linear function of the temperature. It may appear at first sight astonishing that it should be possible to apply so many different assumptions to the solution of one and the same problem. In many cases a formula of the last type would be quite inapplicable, as Stansfield remarks, but the difference between the three is often much less than might be supposed. For instance, in the case of 10% Rh. Pt. - Pt. couple, if we calculate three formulæ of the above types to satisfy the same pair of observations at 0° - 445° and 0° - 1000° C., we shall find that the formula $s=$constant lies midway between that of Tait and that of Stansfield, but the difference between the formulæ is of the same order as that between different observers. In this particular case the parabolic formula appears to be undoubtedly inadequate. The writer's observations agree more nearly with the assumption $s=$ constant, those of Stansfield with $s=c/T$. Many other formulæ have been suggested. Holborn and Day (*Berl. Akad.*, 1899) have gone back to Tait's method at high temperatures, employing arcs of parabolas for limited ranges. But since the parabolic formula is certainly erroneous at low temperatures, it can hardly be trusted for extrapolation above 1000° C.

§ 16. *Absolute Measurement of Thomson Effect.*—Another method of verifying Tait's hypothesis, of greater difficulty but of considerable interest, is to measure the absolute value of the heat absorbed by the Thomson effect, and to observe whether or not it varies with the temperature. Le Roux (*Ann. Chim. Phys.*, x. p. 201, 1867) made a number of relative measurements of the effect in different metals, which agreed qualitatively with observations of the thermoelectric power, and showed that the effect was proportional to the current for a given temperature gradient. Batelli has applied the same method (*Accad. Sci. Turin*, 1886) to the absolute measurement. He observed with a thermocouple the difference of temperature (about ·01° C.) produced by the Thomson effect in twenty minutes between two mercury calorimeters, B_1 and B_2, surrounding the central portions of a pair of rods arranged as in Le Roux's method (see Fig. 3). The value of the Thomson effect was calculated by multiplying this difference of temperature by the thermal capacity of either calorimeter, and dividing by the current, by the number of seconds in twenty minutes, and by twice the difference of temperature (about 20°) between the ends a and b of either calorimeter. The method appears to be open to the objection that the difference of temperature reached in so long an interval would be more or less independent of the thermal capacities of the calorimeters, and would also be difficult to measure accurately with a thermocouple under the conditions described. The general results of the work appeared to support Tait's hypothesis that the effect was proportional to the absolute temperature, but direct thermoelectric tests do not appear to have been made on the specimens employed, which would have afforded a valuable confirmation by the comparison of the values of d^2E/dT^2, as in Jahn's experiments.

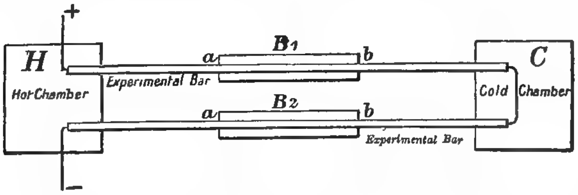

FIG. 3.—Thomson Effect. Batelli (Le Roux's method).

§ 17. *King's Experiments.*—The method employed by the writer, to which allusion has already been made, consisted in observing the change of distribution of temperature in terms of the resistance along a wire heated by an electric current, when the heating current was reversed. It has been fully described by King (*Proc. Amer. Acad.*, June 1898), who applied it most successfully to the case of copper. Although the effect in copper is so small, he succeeded in obtaining changes of temperature due to the Thomson effect of the order of 1° C., which could be measured with satisfactory accuracy. He also determined the effect of change of temperature distribution on the rate of generation of heat by the current, and on the external loss of heat by radiation, convection, and conduction. It is necessary to take all these conditions carefully into account in calculating the balance due to the Thomson effect. According to King's experiments, the value of the effect appears to diminish with rise of temperature to a slight extent in copper, but the diminution is so small that he does not regard it as established with certainty. The value found at a temperature of 150° C. was +2·5 microjoules per ampere-second per degree, or +2·5 microvolts per degree in the case of copper, which agrees very fairly with the value deduced from thermoelectric tests. The value found by Batelli for iron was - 5·0 microvolts per degree at 108° C., which appears too small in comparison. These measurements, though subject to some uncertainty on account of the great experimental difficulties, are a very valuable confirmation of the accuracy of Thomson's theory, because they show that the magnitude of the effect is of the required order, but they cannot be said to be strongly in support of Tait's hypothesis. A comparison of the results of different observers would also suggest that the law of variation may be different in different metals, although the differences in the values of d^2E/dT^2 may be due in part to differences of purity or errors of observation. It would appear, for instance, according to the observations of Dewar and Fleming, that the value of s for iron is positive below - 150° C., at which point it vanishes. At ordinary temperatures the value is negative, increasing rapidly in the negative direction as the temperature rises. This might be appropriately represented, as already suggested, by a linear formula $s=s^\circ-cT$.

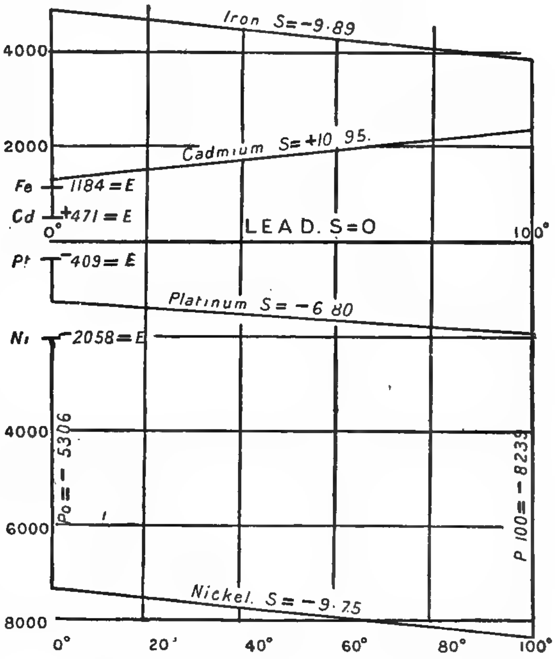

FIG. 4.—Potential Diagrams of Thermocouple on the Contact Theory.

§ 18. *Potential Diagrams on the Contact Theory.*—It is instructive to consider the distribution of potential in a thermoelectric circuit, and its relation to the resultant E.M.F. and to the seat of the E.M.F. In Fig. 4, which is given as an illustration, the cold junctions are supposed to be at 0° C. and the hot junctions at 100° C. Noll's values (Table I.) are taken for the E.M.F., and it is supposed that the coefficient of the Thomson effect is zero in lead, *i.e.* that there is no E.M.F. and that the potential is uniform throughout the length of the lead wire. Taking the lead-iron couple as an example, the value of dE/dt at the hot junction 100° C. is 10·305 microvolts per degree, and the value of the Peltier coefficient $P = TdE/dT$ is $+3844$ microvolts. In other words, we may suppose that there is an E.M.F. of that magnitude situated at the junction which causes positive electricity to flow from the lead to the iron. If the circuit is open, as represented in the diagram, the flow will cease as soon as it has raised the potential of the iron 3844 microvolts above that of the lead. In the substance of the iron itself there is an E.M.F. due to the Thomson effect of about 10 microvolts per degree tending to drive positive electricity from hot to cold, and raising the cold end of the iron 989 microvolts in potential above the hot end on open circuit. At the cold junction the iron is supposed to be connected to a piece of lead at 0° C., and there is a sudden drop of potential due to the Peltier effect of 3648 microvolts. If the circuit is cut at this point, there remains a difference of potential $E=1184$ microvolts, the resultant E.M.F. of the circuit, tending to drive positive electricity from the iron to the lead across the cold junction. If the circuit is closed, there will be a current $C=E/R$, where $R=R'+R''$, the sum of the resistances of the lead and iron. The flow of the current will produce a fall of potential ER'/R in the lead from cold to hot, and ER''/R in the iron from hot to cold, but the potential difference due to the Peltier effect at either junction will not be affected. For simplicity in the diagram the temperature gradient has been taken as uniform, and the specific heat $s=$constant, but the total P.D. would be the same whatever the gradient.

Similar diagrams are given in Fig. 4 for cadmium in which both the specific heat and the Peltier effect are positive, and also for platinum and nickel in which both coefficients are negative. The metals are supposed to be all joined together at the hot junction, and the circuit cut in the lead near the cold junction. The diagram will serve for any selected couple, such as iron-nickel, and is not restricted to combinations with lead. The following table shows the component parts of the E.M.F. in each case:—

TABLE III.

Thermocouple.	P_{100}		$-P_0$		$-100\times s_{50}$	=	E_{0-100}
Iron-lead . .	$+3844$	−	$+3648$	−	-988	=	$+1184$
Cadmium-lead .	$+2389$	−	$+823$	−	$+1095$	=	$+471$
Platinum-lead .	-1919	−	-828	−	-682	=	-409
Nickel-lead . .	-8239	−	-5206	−	-975	=	-2058

The components for any other combination of two are found by taking the algebraic difference of the values with respect to lead.

§ 19. *Relation to the Volta Effect.*—It is now generally conceded that the relatively large differences of potential observable with an electrometer between metals on open circuit, as discovered by Volta, are due to the *chemical* affinities of the metals, and have no direct relation to thermoelectric phenomena or to the Peltier effect. The order of the metals in respect of the two effects is quite different. The potential difference, due to the Volta effect in air, has been shown by Thomson (Lord Kelvin) and his pupils to be of the same order of magnitude, if not absolutely the same, as that produced in a dilute electrolyte in which two metallically-connected plates (*e.g.*, zinc and copper) are immersed. (On this hypothesis, it may be explained by regarding the air as an electrolyte of infinite specific resistance.) It is also profoundly modified by the state of the exposed surfaces, a coating of oxide on the copper greatly increasing the effect, as it would in a voltaic cell. The Peltier effect and the thermo-E.M.F., on the other hand, do not depend on the state of the surfaces, but only on the state of the substance. An attempt has been made to explain the Volta effect as due to the affinity of the metals *for each other*, but that would not account for the variation of the effect with the state of the surface, except as affecting the actual surface of contact. It is equally evident that chemical affinity between the metals cannot be the explanation of the Peltier E.M.F. This would necessitate chemical action at the junction when a current passed through it, as in an electrolytic cell, whereas the action appears to be purely thermal, and leads to a consistent theory on that hypothesis. The chemical action between metals in the solid state must be infinitesimal, and could only suffice to produce small charges analogous to those of frictional electricity; it could not maintain a permanent difference of potential at a metallic junction through which a current was passing. Although it is possible that differences of potential larger than the Peltier effect might exist between two metals in contact on open circuit, it is certain that the only effective E.M.F. in practice is the Peltier effect, and that the difference of potential in the substance of the metals when the circuit is complete cannot be greater than the coefficient P. The Peltier effect, it may be objected, measures that part only of the potential difference which depends upon temperature, and can therefore give no information about the absolute potential difference. But the reason for concluding that there is no other effective source of potential difference at the junction besides the Peltier effect, is simply that no other appreciable action takes place at the junction when a current passes except the Peltier generation or absorption of heat.

§ 20. *Convection Theory.*—The idea of convection of heat by an electric current and the phrase "specific heat of electricity" were introduced by Thomson as a convenient mode of expressing the phenomena of the Thomson effect. He did not intend to imply that electricity really possessed a positive or negative specific heat, but merely that a quantity of heat was absorbed in a metal when unit quantity of electricity flowed from cold to hot through a difference of temperature of 1°. The absorption of heat was considered as representing an equivalent conversion of heat energy into electrical energy in the element. The element might thus be regarded as the seat of an E.M.F., $dE=sdT$, where dT is the difference of temperature between its ends. The potential diagrams already given have been drawn on this assumption, that the Thomson effect is not really due to convection of heat by the current, but is the measure of an E.M.F. located in the substance of the conductor. This view with regard to the seat of the E.M.F. has been generally taken by the majority of writers on the subject. It is not, however, necessarily implied in the reasoning or in the equations given by Thomson, which are not founded on any assumptions with regard to the seat of the E.M.F., but only on the balance of heat absorbed and evolved in all the different parts of the circuit. In fact, the equations themselves are open to an entirely different interpretation in this respect from that which is generally given.

Returning again to the equations already given in § 11 for an elementary thermocouple, we have the following equivalent expressions for the E.M.F. dE, namely,

$$dE=dP+(s'-s'')dT=(P/T)dT=pdT=(p''-p')dT,$$

in which the coefficient, P, of the Peltier effect, and the thermoelectric power, p, of the couple, may be expressed in terms of the difference of the thermoelectric powers, p' and p'', of the separate metals with respect to a neutral standard. So far as these equations are concerned, we might evidently regard the seat of the E.M.F. as located entirely in the conductors themselves, and not at all at the junctions, if p or $(p''-p')$ is the difference of the E.M.F.s per degree in corresponding elements of the two metals. In this case, however, in order to account for the phenomenon of the Peltier effect at the junctions, it is necessary to suppose that there is a *real convection of heat* by an electric current, and that the coefficient P or pT is the difference of the quantities of heat carried by unit quantity of electricity in the two metals. On this hypothesis, if we confine our attention to one of the two metals, say p'', in which the current is supposed to flow from hot to cold, we observe that $p''dT$ expresses the quantity of heat converted into electrical energy per unit of electricity by an E.M.F. p'' per 1° located in the element dT. It happens that the absolute magnitude of p'' cannot be experimentally determined, but this is immaterial, as we are only concerned with differences. The quantity of heat liberated by convection as the current flows from hot to cold is represented in the equation by $dP = d(pT)$. Since $d(p''T) = p''dT + Tdp''$, it is clear that the balance of heat liberated in the element is only $Tdp'' = s''dT$, namely, the Thomson effect, and is *not* the equivalent of the E.M.F. $p''dT$, because on this theory the absorption of heat is masked by the convection. If p is constant there is no Thomson effect, but it does not follow that there is no E.M.F. located in the element. The Peltier effect, on the other hand, may be ascribed entirely to convection. The quantity of heat $p''T$ is brought up to one side of the junction per unit of electricity, and the quantity of heat $p'T$ taken away on the other. The balance $(p''-p')T$ is evolved at the junction. If, therefore, we are prepared to admit that an electric current can carry heat, the existence of the Peltier effect is no proof that a corresponding E.M.F. is located at the junction, or, in other words, that the conversion of heat into electrical energy occurs at this point of the circuit, or is due to the contact of dissimilar metals. On the contact theory, as generally adopted, the E.M.F. is due entirely to change of substance $(dP - Tdp)$; on the convection theory, it is due entirely to change of temperature (pdT). But the two expressions are equivalent, and give the same results.

§ 21. *Potential Diagrams on Convection Theory.*—The difference between the two theories is most readily appreciated by drawing the potential diagrams corresponding to the supposed locations of the E.M.F. in each case. The contact theory has been already illustrated in Fig. 4. Corresponding diagrams for the same metals on the convection theory are given in Fig. 5. In this diagram the metals are supposed to be all joined together and to be at the same time potential at the cold junction at 0° C. The ordinate of the curve at any temperature is the difference of potential between any point in the metal and a point in lead at the same temperature. Since there is no contact E.M.F. on this theory, the ordinates also represent the E.M.F. of a thermocouple metal-lead, in which one junction is at 0° C. and the other at $t°$ C. For this reason the potential diagrams on the convection theory are more simple and useful than those on the contact theory. The curves of E.M.F. are in fact the most natural and most convenient method of recording the numerical data, more particularly in cases where they do not admit of being adequately represented by a formula. The line of lead is taken to be horizontal in the diagram, because the thermoelectric power, p, may be reckoned from any convenient zero. It is not intended to imply that there is no E.M.F. in the metal-lead with change of temperature, but that the value of p in this metal is nearly constant, as the Thomson effect is very small. It is very probable that the absolute values of p in different metals are of the same sign and of the same order of magnitude, being large compared with the differences observed. It would be theoretically possible to measure the absolute value in some metal by observing with an electrometer the P.D. between parts of the same metal at different temperatures, but the difference would probably be of the order of only one-hundredth of a volt for a difference of 100° C. It would be sufficiently difficult to detect so small a difference under the best conditions. The difficulty would be greatly increased, if not rendered practically insuperable, by the large difference of temperature.

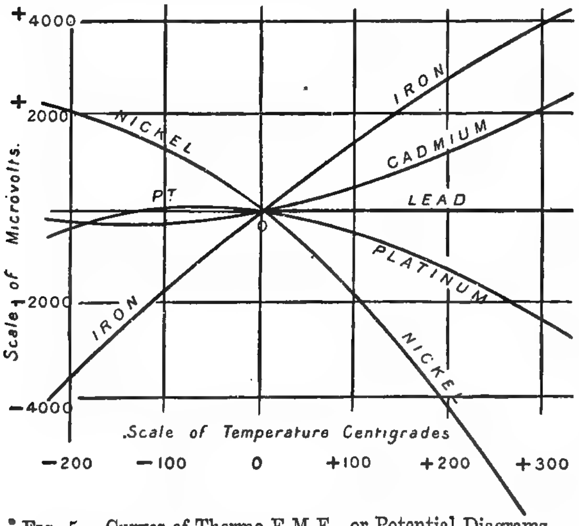

FIG. 5.—Curves of Thermo-E.M.F., or Potential Diagrams, on the Convection Theory.

§ 22. *Conduction Theory.*—In Thomson's theory it is expressly assumed that the reversible thermal effects may be considered separately without reference to conduction. In the conduction theory of Kohlrausch (*Pogg. Ann.*, 1875, vol. 156, p. 601), the fundamental postulate is that the thermo-E.M.F. is due to the conduction of heat in the metal, which is contrary to Thomson's theory. It is assumed that a flow of heat Q, due to conduction, tends to carry with it a proportional electric current $C = aQ$. This is interpreted to mean that there is an E.M.F. $dE = -akr\,dT = -\theta dT$, in each element, where k is the thermal conductivity and r the specific resistance. The "thermoelectric constant," θ, of Kohlrausch, is evidently the same as the thermoelectric power, p, in Thomson's theory. In order to explain the Peltier effect, Kohlrausch further assumes that an electric current, C, carries a heat-flow, $Q = A\theta C$, with it, where "A is a constant which can be made equal to unity by a proper choice of units." If A and θ are constant, the Peltier effects at the hot and cold junctions are equal and opposite, and may therefore be neglected. The combination of the two postulates leads to a complication. By the second postulate the flow of the current increases the heat-flow, and this by the first postulate increases the E.M.F., or the resistance, which therefore depends on the current. It is difficult to see how this complication can be avoided, unless the first postulate is abandoned, and the heat-flow due to conduction is assumed to be independent of the thermoelectric phenomena. By applying the first law of thermodynamics, Kohlrausch deduces that a quantity of heat, $C\theta dT$, is absorbed in the element dT per second by the current C. He wrongly identifies this with the Thomson effect, by omitting to allow for the heat carried. He does not make any application of the second law to the theory. If we apply Thomson's condition $P = TdE/dT = Tp$, we have $A = T$. If we also assume the ratio of the current to the heat-flow to be the same in both postulates, we have $a = 1/T\theta$, whence $\theta^2 = kr/T$. This condition has recently been applied by Liebenow (*Wied. Ann.*, 68, p. 316). It simplifies the theory, and gives a possible relation between the constants, but it does not appear to remove the complication above referred to, which seems to be inseparable from any conduction theory.

Boltzmann (*Sitz. Wien. Akad.*, 1887, vol. 96, p. 1258) gives a theoretical discussion of all possible forms of expression for thermoelectric phenomena. Neglecting conduction, all the expressions which he gives are equivalent to the equations of Thomson. Taking conduction into account in the application of the second law of thermodynamics, he proposes to substitute the inequality, $Td/dET - P \leqq 2\sqrt{T}(\sqrt{k'r'} + \sqrt{k''r''})$, instead of the equation given by Thomson, namely, $P = TdE/dT$. Since, however, Thomson's equation has been so closely verified by Jahn, it is probable that Boltzmann would now consider that the reversible effects might be treated independently of conduction.

§ 23. *Thermoelectric Relations.*—A number of suggestions have been made as to the possible relations between heat and electricity, and the mechanism by which an electric current might also be a carrier of heat. The simplest is probably that of Weber (*Wied. Ann.*, 1875), who regarded electricity as consisting of atoms much smaller than those of matter, and supposed that heat was the kinetic energy of these electric atoms. If we suppose that an electric current in a metal is a flow of negative electric atoms in one direction, the positive electricity associated with the far heavier material atoms remaining practically stationary, and if the atomic heat of electricity is of the same order as that of an equivalent quantity of hydrogen or any other element, the heat carried per ampere-second at 0° C., namely P, would be of the order of ·030 of a joule, which would be ample to account for all the observed effects on the convection theory. Others have considered conduction in a metal to be analogous to electrolytic conduction, and the observed effects to be due to "migration of the ions." The majority of these theories are too vague to be profitably discussed in an article like the present, but there can be little doubt that the study of thermoelectricity affords one of the most promising roads to the discovery of the true relations between heat and electricity.

Alphabetical Index of Symbols.

a, b, c = Numerical constants in formulæ.
C = Electric Current.
E = E.M.F. = Electromotive Force.
k = Thermal Conductivity.
P = Coefficient of Peltier Effect.
$p = dE/dt$ = Thermoelectric Power.
Q = Heat-flow due to Conduction.
R = Electrical Resistance; r, Specific Resistance.
s = Specific Heat, or Coefficient of Thomson Effect.
t = Temperature on the Centigrade Scale.
T = Temperature on the Absolute Scale.

(H. L. C.)

Thermometry; Pyrometry.—A Pyrometer is an instrument specially designed for measuring high temperatures, and differs from a thermometer in details of construction only, and not in principle, so that the two subjects may be most advantageously treated together. The theoretical principles underlying the science of thermometry have been ably expounded by Lord Kelvin in the article Heat (*Ency. Brit.*, vol. xi. p. 554). The most important varieties of thermometer in common use have also been described in the articles Thermometer (*Ency. Brit.*, vol. xxiii. p. 288) and Pyrometer (*Ency. Brit.*, vol. xx. p. 129). The object of the present article is to describe and explain the advances which have been made in the practice of scientific thermometry or "thermometry of precision," and in the practical application of electrical methods to the accurate measurement of temperature, during the last twenty years of the 19th century.

§ 1. *Temperature.*—The idea of temperature or degree of hotness is a primary conception derived directly from our sensations of heat and cold, and in part from those of light and colour. For ordinary temperatures the sense of touch serves as a rough thermometer, for high temperatures the sense of sight as a rough pyrometer. The idea of temperature therefore requires no explanation or definition. It is very often explained as "the condition of a body considered with reference to its power of communicating heat to other bodies." Similarly difference of temperature is often defined in terms of the flow of heat. Such definitions are somewhat unsatisfactory, because the "flow of heat" is really a secondary conception derived from observations of changes of state and temperature. In considering the measurement of temperature it is necessary, however, to define the scale or system on which it is to be measured.

§ 2. *Zero: Fundamental Interval.*—In all systems of measuring temperature it is necessary (1) to choose a zero or starting-point from which to reckon, (2) to determine the size of the degree by subdividing the interval between two selected fixed points of the scale (called the "fundamental interval") into a given number of equal parts. In all systems of measurement, the fundamental interval selected is that between the temperature of melting ice and the temperature of condensing steam, under standard atmospheric pressure. On the Centigrade system, which alone need be considered here, the fundamental interval is divided into 100 parts, and the melting-point of ice is taken as the zero of the scale. We shall denote temperature reckoned on this system by the letter t, or by affixing the letter C. It is often convenient to reckon temperature, not from the melting-point of ice, but from a theoretical or absolute zero representing the lowest conceivable temperature. We shall denote temperature reckoned in this manner by the letter T, or θ, or by affixing the letters *Abs.* In practice, since the absolute zero is unattainable, the absolute temperature is deduced from the Centigrade temperature by adding a constant quantity, T_0, representing the interval between the absolute zero and the melting-point of ice; thus $T = t + T_0$.

§ 3. *Arbitrary Scales.*—An arbitrary scale can be constructed by selecting any physical property of a substance which varies regularly with the temperature, such as the volume of a liquid, or the pressure or density of a gas, or the electrical resistance of a metal. Thus if V denote the volume of a given mass at the temperature t, and if V_0, V_1 represent the volumes of the same mass at the temperatures 0° and 100° C., the size of 1° C. on the scale of this arbitrary thermometer is one hundredth part of the fundamental interval, namely $(V_1 - V_0)/100$, and the temperature t at volume V is the number of these degrees contained in the expansion $V - V_0$ between 0° and t° C. We thus arrive at the formula

$$t = 100\,(V - V_0)/(V_1 - V_0) \quad . \quad . \quad . \quad (1),$$

which is the general expression for the temperature Centigrade on any such arbitrary scale, provided that we substitute for V the particular physical property selected as the basis of the scale. If we prefer to reckon temperature from an arbitrary zero defined by the vanishing of V, which may conveniently be called the *fundamental zero* of the scale considered, we have, putting $V = 0$ in equation (1), the numerical values of the fundamental zero T_0, and of the temperature T reckoned from this zero

$$T_0 = 100\,V_0/(V_1 - V_0), \text{ and } T = T_0 V/V_0 = t + T_0 \quad . \quad (2).$$

It is frequently convenient to measure temperature in this manner when dealing with gases, or electrical resistance thermometers.

§ 4. *Thermodynamical Scale.*—It is possible, by reference to the principles of thermodynamics, to construct scales of temperature which shall be "absolute" in the sense of being independent of the properties of any material substance. The thermodynamical scale generally selected is that defined by Lord Kelvin in such a manner as to coincide as closely as possible with the scale of the gas-thermometer. His definition (*Proc. R. S. Ed.*, 1854) is as follows (see also Thermodynamics, § 4): "The ratio of any two temperatures on the thermodynamical scale is the ratio of the quantity of heat taken in at the higher temperature to the quantity of heat rejected at the lower temperature by a perfectly reversible thermodynamical engine working with a source and refrigerator at the temperatures considered." If, when the engine is working between the temperatures θ_0 and θ_1 corresponding to 0° and 100° C. respectively on the thermodynamical scale, a quantity of heat H_1 is taken in at θ_1 for each quantity H_0 rejected at θ_0, and if the fundamental interval is divided into 100 degrees, we have for the numerical values of the temperature of the melting-point of ice θ_0 on the thermodynamic scale, and of the temperature θ reckoned from the absolute zero,

$$\theta_0 = 100 H_0/(H_1 - H_0), \text{ and } \theta = \theta_0 H/H_0 = t + \theta_0, \quad . \quad (3)$$

where H is the quantity of heat taken in at θ for each quantity H_0 rejected at θ_0. This scale can be most nearly realized in practice by observing the temperature T on the scale of a gas-thermometer, and making special experiments on the gas to determine how far its scale deviates from that of the thermodynamical engine. In the case of the gases hydrogen and helium, which can exist in the liquid state only at very low temperatures, the deviations from the thermodynamical scale at ordinary temperatures are so small that they cannot be certainly determined. Thermometers containing these gases are generally taken as the ultimate standards of reference in practical thermometry.

MERCURIAL THERMOMETRY.

§ 5. The most familiar type of thermometer depends on the apparent expansion of a liquid hermetically sealed in a glass bulb attached to a graduated stem of fine bore. Of all liquid-in-glass thermometers that containing mercury is almost invariably selected for scientific purposes, although at first sight mercury would appear to be the least suitable liquid, on account of its small coefficient of expansion. The smallness of the expansion necessitates an extremely fine bore for the stem, which introduces errors in consequence of the high surface tension of mercury. The considerable density of the liquid also tends to exaggerate the effects of change of position due to variation of the pressure exerted on the interior of the bulb by the liquid column. These errors are small and fairly regular, and can be corrected within certain limits. A much more serious source of trouble, especially at high temperatures, is the imperfect elasticity of the glass, which causes more or less irregular changes in the volume of the bulb. The effect of these changes on the readings of the thermometer is enhanced by the smallness of the expansion of mercury, and might be reduced by employing a more expansible liquid. It is more likely, however, that the defect will be remedied in the near future by the construction of thermometers of fused silica (SiO_2), which is the most perfectly elastic solid hitherto discovered. For work at low temperatures the range of a mercury thermometer is limited by its freezing-point (–39° C.). These are the serious disadvantages attending the use of mercury, but in other respects it possesses so many advantages over alcohol or other substitutes, that it will in all probability continue to be used almost exclusively in thermometers of this type for scientific work. Among its chief advantages may be reckoned its high boiling-point (357° C.), and the absence of evaporation from the top of the thread, which is so serious a source of error with the alcohol thermometer. With mercury the evaporation is almost inappreciable at 100° C., and can in all cases be avoided by exposing the upper parts of the emergent thread to the temperature of the air. Although an evacuated mercury thermometer cannot be safely used at temperatures over 300° C., owing to the breaking up of the thread of liquid in the stem, it has been found possible, by filling the upper part of the stem with nitrogen or carbonic acid gas under high pressure, to extend the range to 550° C. A more important advantage for accurate work is the fact that mercury does not wet glass, and avoids any possible errors due to adherent films of liquid on the walls of the tube. This greatly facilitates observations, and also renders it possible to "calibrate" the thermometer *after* construction, which cannot be satisfactorily accomplished with other liquids. The process of construction and calibration is further facilitated by the fact that mercury does not dissolve air to any appreciable extent. In consequence of the regularity of expansion of mercury at ordinary temperatures, the scale of the mercury thermometer agrees very closely with that of the gas thermometer. The liquid is very easily obtained in a high state of purity by distillation, and has practically no chemical action on glass. In this respect it is superior to the liquid alloy of potassium and sodium, which rapidly reduces silica at high temperatures. The high conductivity and low specific heat of mercury as compared with most other liquids tend to render the thermometer quick and sensitive in action. Its opacity considerably facilitates accurate reading, and even the smallness of its expansion has one great countervailing advantage, in that the correction for stem-exposure is proportionately reduced. This correction, which (even in the case of mercury) may amount to as much as 40° C. at 550° C., is far the most uncertain in its application, and is the most serious objection to the use of the liquid-in-glass thermometer at high temperatures.

§ 6. *Construction.*—The construction of the most accurate type of mercury thermometer has undergone some changes of detail in recent years. The range of the most accurate standards is generally restricted to the fundamental interval. The length of a degree on the stem can be increased to any extent by enlarging the bulb or diminishing the bore of the stem, but it is found in practice that there is no advantage in making the scale more open than one centimetre to the degree C. in standard instruments, or in increasing the number of divisions beyond ten or at most twenty to the degree. Enlarging the bulb makes the instrument sluggish, and exaggerates the errors due to imperfect elasticity. Diminishing the bore of the tube increases the errors due to capillary friction. Even one centimetre to the degree is an impracticable scale for thermometers graduated continuously from 0° to 100° C., owing to the excessive length of the stem. In order to secure so open a scale, it is necessary to limit the range to 35°, or at most 50°. The fixed points 0° and 100° may still be retained, for purposes of testing and reference, by the device, now commonly employed, of blowing auxiliary bulbs or "*ampoules*" on the stem, the volume of which is carefully adjusted to correspond with the number of degrees that it is desired to suppress. In the best instruments the bulb is not blown on the capillary tube itself, but is formed of a separate piece of tube fused on to the stem. It is possible in this manner to secure greater uniformity of strength and regularity of dimensions. The thickness of the glass is generally between half a millimetre and one millimetre. The advantage in point of quickness gained by making the glass thin is more than counterbalanced by increased fragility and liability to distortion. The best form of bulb is cylindrical, of the same external diameter as the stem. The bore of the stem should also be cylindrical, and not oval or flattened, in order to diminish errors due to capillarity, and to secure the greatest possible uniformity of section. The glass should be clear, and not backed with opal, both to admit of reading from either side, and to minimize risk of bending or distortion. In the commoner sorts of thermometers, which are intended for rough purposes and to be read without the application of minute corrections, it is not unusual to divide the tube into divisions of equal volume by a preliminary calibration. In the most accurate instruments it is preferable to divide the tube into divisions of equal length, as this can be more accurately effected. The corrections to be applied to the readings to allow for inequalities of bore can be most satisfactorily determined in the case of mercury thermometers by calibrating the tube after the instrument is completed (see CALIBRATION, vol. xxvi.). This correction is known as the "calibration correction." Instead of being separately determined, it may be included in the scale correction by comparison with a standard instrument, such as a platinum-resistance thermometer.

§ 7. *Corrections.*—The corrections to be applied to the readings of a mercury thermometer, in addition to the calibration correction, may be summarized under the following heads: (i.) Zero. (ii.) Fundamental Interval. (iii.) Internal and External Pressure. (iv.) Stem Exposure. (v.) Scale Correction, including Poggendorf's correction.

(I) The *changes of zero* are of two kinds. (*a*) *Secular rise* of zero due to gradual recovery from changes or strains acquired by the bulb during the process of manufacture. This process may be hastened and subsequent changes practically eliminated by annealing the bulb after manufacture, and before final adjustment, at a high temperature, such as that of boiling sulphur. A thermometer which has not been so treated may show a rise of zero amounting to as much as 20° or 30° when exposed for some time to a temperature of 350° C. (*b*) *Temporary depression* of zero after each exposure to a high temperature, followed by a slow recovery which may last for days or weeks. The best thermometers of hard glass show a depression of zero amounting to about one-tenth of 1° C. after exposure to 100° C. In softer glass the depression is usually greater and more persistent, and may amount to half a degree after 100° C. At higher temperatures the depression generally increases roughly as the square of the temperature above 0° C. It may amount to 2° or 3° at 300° C. The effect cannot be calculated or predicted in any series of observations, because it depends in so complicated a manner on the past history and on the time. It is a most serious difficulty in accurate mercurial thermometry, especially at high temperatures. The most satisfactory method of correction appears to be to observe the zero *immediately after each reading*, and to reckon the temperature from the variable zero thus observed. The rationale of this procedure is that the depression is produced at the high temperature much more rapidly than the subsequent recovery at the low temperature. The thermometer is taken from the bath and allowed to cool rapidly by free exposure to the air. As soon as it reaches 40° or 50° C., it is plunged in the melting ice, and the lowest point reached is taken as the temporary zero.

The following formulæ have been proposed by various observers to represent the depression of zero for different kinds of glass:—

$$\left.\begin{array}{l}\text{Pernet, French } \textit{cristal},\ dz=0{\cdot}0040(t/100)^2 \quad . \quad . \quad . \\ \text{Guillaume, } \textit{Verre dur},\ 0-100^\circ\text{ C.},\ dz=(8886t+10{\cdot}84t^2)\,10^{-7} \\ \quad ,, \qquad \textit{Cristal dur},\ 0-190^\circ\text{ C.},\ dz=(7970t+329t^2)10^{-7} \\ \text{Bottcher, Jena, 16, iii.},\ dz=((7100t-8t^2)\,10^{-7} \quad . \quad . \end{array}\right\}\ (4).$$

The symbol dz in these formulæ stands for the depression of zero produced by an exposure to a temperature t. The depression is about three times as large in French crystal as in English flint glass, and varies roughly as the square of t. *Verre dur* and Jena, 16, iii., are varieties of hard glass chosen as standards in France and Germany respectively, on account of the comparatively small depression of zero to which they are liable. At low temperatures, up to 50° C., the depression is very nearly proportional to t, but at temperatures above 100° C. it is necessary to adopt another formula in which the term depending upon t^2 is more important. These formulæ are useful as giving an idea of the probable size of the correction in any case, but they cannot be employed in practice except in the simplest cases and at low temperatures. On account of these temporary changes of zero, a mercury thermometer intended for the most accurate work at ordinary temperatures (as in calorimetry) should preferably never be heated above 40° or 50° C., and certainly never above 100° C. Above 100° C. the changes of zero become more irregular and more variable, depending on the rate of cooling and on the sequence of previous observations, so that even if the method of observing the zero after each reading is adopted, the order of precision attainable rapidly diminishes.

(II) *Fundamental Interval.*—The thermometer to be tested is exposed to steam condensing at atmospheric pressure in an apparatus which is often called a "hypsometer," constructed with double walls to protect the inner tube containing the thermometer from any cooling by radiation. The standard atmospheric pressure at which the temperature of the steam is by definition equal to 100° C. is equivalent to that produced by a column of mercury at 0° C. and 760 millimetres high, the force of gravitation being equal to that at sea-level in latitude 45°. The atmospheric pressure at the time of observation is reduced to these units by applying the usual corrections for temperature and gravitation. If the pressure is near 760 mm., the temperature of the steam may be deduced by assuming that it increases at the rate of 1° C. for 27·2 mm. of pressure. If the pressure is not near 760 mm., the application of the correction is less certain, but is generally taken from Regnault's tables, from which the following data are extracted. Thermometers cannot be satisfactorily tested at an elevated station where the height of the barometer H is less than 700 mm., as the steam point is too uncertain.

TABLE I.—*Temperature of Steam at pressures from* 790 *to* 710 *mm.*

Pressure (corrected) . .	790	780	770	760	750	740	730	720	710
Steam temp. = 100° C. + . .	+1·083	+·726	+·365	0	−·369	−·742	−1·120	−1·502	−1·888

$$\text{Approximate formula } dt_1=\cdot0367(H-760)-\cdot000020(H-760)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

If the barometer has a brass scale correct at 0° C., and H be the reading in millimetres, the correction for temperature is made approximately by subtracting 0·00163 H mm.

If L is the latitude and M the height of the station in metres above the sea-level, the correction for gravitation is approximately made by subtracting $(0{\cdot}0026 \cos 2L+0{\cdot}0000002M)\,H$ mm.

The zero of the thermometer is observed immediately after the steam point. If n be the interval in degrees of the scale between the two observations, and if t_1 be the temperature of the steam, the fundamental interval of the thermometer may be taken as $100\,n/t_1$, provided that t_1 is nearly 100° C. Since all the readings of a thermometer have to be corrected for the error of the fundamental interval, by dividing by the fundamental interval thus observed and multiplying by 100, it is a matter of some convenience in practice to have the instrument graduated so that the difference between the readings in ice and at 100° C. is very nearly 100° of the stem. The correction can then be applied as a small percentage independently of the other corrections. The method of determining the fundamental interval above described applies to all other kinds of thermometers, except that it is not generally necessary to observe the zero *after* the steam point. The temperature of the steam t_1 should be expressed in the scale of the thermometer tested, if the scale differs appreciably from that of Regnault.

(III) *Pressure Correction.*—The corrections for variations of internal and external pressure on the bulb are of some importance in accurate thermometry, but can be applied with considerable certainty at moderate temperatures. The correction for external pressure is assumed to be proportional to the change of pressure, and to be independent of the temperature. It is generally determined by enclosing the thermometer to be tested in a vessel of water, and observing the change of reading on exhausting or readmitting the air. The correction is generally between one and two thousandths of a degree per centimetre of mercury change of pressure, but must be determined for each thermometer, as it depends on the nature of the glass and on the form and thickness of the walls of the bulb. The coefficient of the correction for internal pressure is greater than that for external pressure by the difference between the compressibility of mercury and that of glass, and may be calculated from it by assuming this relation. If b_0, b_1, are the external and internal coefficients, expressed in degrees of temperature per centimetre of mercury, we have the relation

$$b_1=b_0+0{\cdot}00015,\ \text{degrees per cm. of mercury} \quad . \quad . \quad (6)$$

The coefficient of internal pressure can also be determined by taking readings in the horizontal and vertical positions when the thermometer is at some steady temperature such as that of ice or steam. The reading of the thermometer is generally reduced to an external pressure of one standard atmosphere, and to an internal pressure corresponding to the horizontal position. It is also possible to include the internal pressure correction in the scale correction, if the thermometer is always read in the vertical position. In addition to the variations of internal pressure due to the column of mercury in the stem, there are variations due to capillarity. The internal pressure is greater when the mercury is rising than when it is falling, and the reading is depressed to an extent depending on the fineness of the bore and the thinness of the walls of the bulb. The capillary pressure does not depend only on the bore of the tube, but also apparently to an even greater extent on the state of the walls of the tube. The least trace of dirt on the glass or on the mercury is capable of producing capillary pressures much greater than would be calculated from the diameter of the tube. Even in the best thermometers, when there are no inequalities of bore sufficient to account for the observed variations, it is seldom found that the mercury runs equally easily in all parts of the stem. These variations of capillary pressure are somewhat capricious, and set a limit to the order of accuracy attainable with the mercury thermometer. It appears that the difference of reading of a good thermometer between a rising and falling meniscus may amount to five or ten thousandths of a degree. The difference may be reduced by continuous tapping, but it is generally best to take readings always on a rising column, especially as the variations in the angle of contact, and therefore in the capillary pressure, appear to be much smaller for the rising meniscus. In ordinary work the zero reading and the steam reading would both generally correspond to a falling meniscus; the former necessarily, the latter on account of the phenomenon of the temporary depression of zero, which causes the thermometer to read higher during the first moments of its exposure to steam than it does when the expansion of the bulb has reached its limit. It is easy to secure a rising meniscus at the steam point by momentarily cooling the thermometer. At the zero point the meniscus generally commences to rise after five or ten minutes. The question, however, is not of much importance, as the error, if any, is regular, and the correction for capillarity is necessarily uncertain.

(IV) *Stem-Exposure Correction.*—When the bulb of a mercury thermometer is immersed in a bath at a temperature t, and a part of the column of mercury having a length of n degrees is exposed to a lower temperature t_2, the reading of the thermometer will be lower by $a \times n \times (t - t_2)$ degrees (nearly) than it would have been if the whole of the mercury and stem had been at the temperature t. The factor a in this expression is the apparent coefficient of expansion of mercury in glass, and varies from ·000150 to ·000165 for different kinds of glass. In order to apply this correction, it is usual to observe t_2 by means of an auxiliary "stem-thermometer" with its bulb placed near the middle of the emergent column n. Occasionally stem-thermometers with long thin bulbs are employed to give more nearly the average temperature of the whole emergent column. Owing to conduction along the stem of the thermometer, and to heated vapours near the bath, the mean temperature determined in this manner is generally too low. To allow for this empirically, an arbitrary reduction is often made in the value taken for n or a, but this cannot be regarded as satisfactory for work of precision. The only practical method of reducing the correction is to limit the number of degrees n exposed, or, in other words, to work with thermometers of "limited range." Each of these thermometers must then be corrected by comparison with a standard thermometer free from stem-exposure correction, such as a platinum-resistance thermometer. To secure results of any value the correction must be determined at each point under the actual conditions of observation under which the thermometer is to be used. In work of precision it is necessary to use ten or twenty thermometers to cover a range of 300°, as this is the only method of securing an open scale and reasonable accuracy as regards stem-exposure. To quote the opinion of M. Guillaume, one of the leading authorities on mercurial thermometry: "When this correction is large, it cannot generally be determined with sufficient approximation for measurements of precision. The mercury thermometer should then be replaced by other instruments, among which those based on the variation of the electrical resistance of metals hold the first rank."

(V) *Scale Correction.*—The correction required to reduce the readings of a mercurial thermometer to the normal scale may appropriately be called the "scale correction." One of the chief advantages of the mercurial thermometer for scientific purposes is that its scale agrees very closely with the thermodynamical scale between 0° and 200° C. The scale corrections of the standard French thermometers of *verre dur* have been very carefully determined over the range 0° to 80° C. by M. Chappuis using a constant-volume gas thermometer containing hydrogen (at an initial pressure of one metre of mercury at 0° C.) as the representative of the normal scale. His observations between 0° and 80° C. are represented by the quartic equation

$$t_h - t_m = t(t - 100)\ (-61{\cdot}859 + 0{\cdot}47351\,t - 0{\cdot}0011577\,t^2) \times 10^{-6}, \quad (7)$$

in which t_h and t_m represent temperature on the scales of the hydrogen and mercury thermometers respectively. The *verre dur* mercury thermometer reads 0·112° C. above the hydrogen thermometer at 40° C., where the difference of the scales is a maximum. The scale corrections of the Jena-glass thermometers, deduced by comparison with the French *verre dur*, appear to be practically of the same magnitude, but show differences of as much as 0·010° C. on either side of the mean. It may be questioned whether it is possible to construct mercury thermometers with scales agreeing more closely than this, owing to inevitable variations in the quality and treatment of the glass. According to Guillaume, the scale of a French *cristal* thermometer t_c differs from that of the standard *verre dur* t_m between 0° and 50° C., according to the cubic formula

$$t_c - t_m = t(100 - t)(14{\cdot}126 - 0{\cdot}0311t) \times 10^{-6} \quad . \quad . \quad (8)$$

According to some unpublished observations made by the writer in 1893–94, the scale of an English flint-glass thermometer, tested by comparison with a platinum thermometer, does not differ from that of the constant-pressure air thermometer by more than one or two hundredths of a degree between 0° and 100° C. But for the comparison of the scales to be of any value, it would be necessary to study a large number of such thermometers. It is possible to obtain much more consistent results if the thermometers are not heated above 50° C.

The comparisons of the *verre dur* thermometers with the normal scale at the International Bureau at Paris have not as yet extended beyond 100° C. The most important observations on the mercury thermometer above these limits appear to be those of Regnault already given in a previous article (HEAT, *Ency. Brit.*, vol. xi. p. 554). The more recent observations of Crafts were confined to French thermometers of *cristal dur* (*Comptes Rendus*, vol. 95, p. 863, 1882). He finds the following deviations from the hydrogen scale:—

t_h	150°	170°	200°	230°	250°	280°	300°	330°
$t_h - t_m$	+ ·25	+ ·35	+ ·27	− ·02	− ·26	− ·63	− 1·21	− 2·48

The correction changes sign at about 230° C., owing to the rapid increase in the expansion of mercury. Between 0° and 150° C. it would appear that the coefficient of expansion of glass increases more rapidly than that of mercury.

Poggendorf's Correction.—It should be observed that, since in the construction of a mercury thermometer the tube is divided or calibrated so as to read in divisions of equal volume when the whole of the tube is at one temperature, the degrees do not as a matter of fact correspond to equal increments of the apparent expansion of mercury. The scale does not therefore agree in practice with the theoretical formula (1) for the scale of the expansion of mercury, since the expansion is measured in a tube which itself is expanding. A similar argument applies to the method of the weight thermometer, in which the overflow is measured by weight. Even if the expansion of mercury and glass were both uniform, as measured on the thermodynamical scale, the scale of the mercury thermometer, as ordinarily calibrated, would not agree with the thermodynamical scale. The difference can be easily calculated if the actual expansion of mercury and glass is known. The correction is known as Poggendorf's, but is generally included in the scale correction, and is not applied separately. It has the effect of making the thermometer read higher at temperatures between 0° and 100° than it would if the divisions of the stem did not expand as the temperature rose. The amount of the correction for *verre dur* is given by Guillaume as

$$P.C. = t(100 - t)(23{\cdot}920 + 0{\cdot}0240t) \times 10^{-6} \quad . \quad . \quad (9)$$

The value of this correction is between ·060° and ·080° at 50° C. for different thermometers.

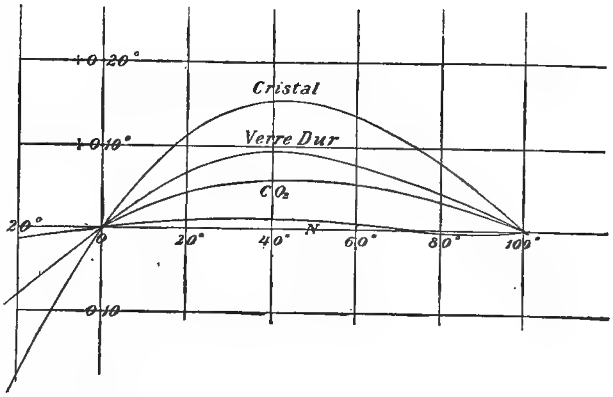

FIG. 1.—Differences between Scales of Mercury, and Gas Thermometers and Hydrogen Scale, according to Guillaume and Chappuis.

GAS THERMOMETRY.

§ 8. The absolute or thermodynamical scale cannot be directly realized on account of the impossibility of constructing a perfectly reversible thermodynamic engine, and of the great practical difficulties involved in the accurate measurement of quantities of heat. It is necessary, therefore, to have recourse to indirect methods. Among the most interesting of these methods are the vapour-pressure thermometers described by Lord Kelvin (HEAT, vol. xi. p. 554). These instruments have the great advantage that the pressure is a function of the temperature only, and that no measurements of the volume of the space in which the thermometric substance is enclosed are required. The temperature scale of such an instrument depends only on the substance, and not on the material of the enclosure. From a practical point of view, however, the range of each instrument is too limited, and the scales differ too widely from uniformity. Although it is theoretically possible to deduce the absolute temperature from a study of the properties of each vapour, it is practically impossible to carry out the required measurements, such as the determination of the specific volume of the saturated vapour, with sufficient accuracy to be of value for the realization of the absolute scale. On the other hand, the second method proposed by Lord Kelvin, and carried out experimentally with the assistance of Joule, for the reduction of the indications of the gas thermometer to the absolute scale, is in itself so delicate, and the deviations of the uncorrected gas thermometer from the absolute scale are so small, that this instrument is now universally regarded as the ultimate standard in thermometry. It had, in fact, already been adopted for this purpose by Regnault and others, on *à priori* considerations, before the absolute scale itself had been invented. Although the indications of a gas thermometer are not absolutely independent of the changes of volume of the envelope or bulb in which the gas is contained, the effect of any uncertainty in this respect is minimized by the relatively large expansibility of the gas. The capricious changes of volume of the bulb, which are so great a difficulty in mercurial thermometry, are twenty times less important in the case of the gas thermometer. As additional reasons for the choice we have the great simplicity of the laws of gases, and the approximate equality of expansion and close agreement of the thermometric scales of all gases, provided that they are above their critical temperatures. Subject to this condition, at moderate pressures and provided that they are not dissociated or decomposed, all gases satisfy approximately the laws of Boyle and Charles. These two laws are combined in the characteristic equation of the gaseous state, viz., $pv = RT$, in which p is the pressure and v the volume of unit mass of the gas in question, and R is a constant which varies inversely as the molecular weight of the gas, and is approximately equal to the difference of the specific heats. The equation in this form, without further restrictions, applies only to the ideal "perfect gas" which satisfies Boyle's law accurately, and in which the internal work of expansion is zero.

§ 9. *Practical Conditions.*—In practice it is not convenient to deal with unit mass, but with an arbitrary mass M occupying a space V, so that the specific volume $v = V/M$. It is also necessary to measure the pressure p in terms of mercury columns, and not in absolute units. The numerical value of the constant R is adjusted to suit these conditions, but is of no consequence in thermometry, as we are concerned with ratios and differences only. The equation may still be written in the form $T = pV/RM$, but in order to satisfy the essential condition that T shall be a definite function of the temperature in the case of a gas which does not satisfy Boyle's law exactly, it is necessary to limit the application of the equation to special cases which lead to definite, but not necessarily identical, thermometric scales. There are three special cases of practical importance, corresponding to three essentially distinct experimental methods.

(i.) *Volumetric Method* (constant-pressure).—In this method V is variable and p and M are constant. This method was employed by Gay-Lussac, and is typified in the ideal thermometer with reservoir of variable capacity designed by Lord Kelvin (*Ency. Brit.*, vol. xi. p. 575, Fig. 10). It corresponds to the method ordinarily employed in the common liquid-in-glass thermometer. It is not satisfactory in practice, owing to the difficulty of making a bulb of variable and measurable volume the whole of which can be exposed to the temperature to be measured.

(ii.) *Manometric Method* (constant-volume or density).—In this method p is variable and V and M are constant. Variations of temperature are observed and measured by observing the corresponding variations of pressure with a mercury manometer, keeping a constant mass, M, of gas enclosed in a volume, V, which is constant except for the unavoidable but small expansion of the material of which the bulb is made.

(iii.) *Gravimetric Method* (constant-pressure).—In this method M is variable and p and V are constant. This method is generally confounded with (i.) under the name of the constant-pressure method, but it really corresponds to the method of the weight thermometer, or the "overflow" method, and is quite distinct from an experimental standpoint, although it leads to the same thermometric scale. In applying this method, the weight M of the vapour itself may be measured, as in Regnault's mercury-vapour thermometer, or in Deville and Troost's iodine-vapour thermometer. The usual method of measuring the overflow is that of weighing mercury displaced by the gas. The mass of the overflow may also be estimated by observing its volume, or by water-displacement, but these methods are much less accurate.

In addition to the above, there are mixed methods in which both p and V or M are variable, such as those employed by Rudberg or Becquerel; but these are unsatisfactory for precision, as not leading to a sufficiently definite thermometric scale. There is also a variation of the constant-volume method (ii.), in which the pressure is measured by the volumetric compression of an equal mass of gas kept at a constant temperature, instead of by a manometer. This method is experimentally similar to (iii.), and gives the same equations, but a different thermometric scale to either (ii.) or (iii.). It will be considered with method (iii.), as the apparatus required is the same, and it is useful for testing the theory of the instrument. We shall consider in detail methods (ii.) and (iii.) only, as they are the most important for accurate work.

§ 10. *Construction of Apparatus.*—The manometric or constant-volume method was selected by Regnault as the standard, and has been most generally adopted since his time. His apparatus has not been materially modified except in points of detail. A description of his instrument will be found in most text-books on heat. The improvements introduced by M. Chappuis, of the International Bureau at Sèvres, in the construction of the constant-volume hydrogen thermometer selected by the committee for the determination of the normal scale, are also described in some recent text-books (*e.g.*, Watson's *Physics*). The most important is the combination of the manometer and the barometer into a single instrument with a single scale, thus materially reducing the number of readings required. The level of the mercury in the branch of the manometer communicating with the bulb of the gas thermometer is adjusted in the usual manner up to a fixed contact-point, so as to reduce the contained gas to a constant volume. Simultaneously the barometer branch of the manometer is adjusted so that the surface of the mercury makes contact with another point fixed in the upper end of the barometer tube. The distance between the two contact-points, giving the pressure of the gas in the thermometer, is deduced from the reading of a vernier fixed relatively to the upper contact-point. This method of reading the pressure is probably more accurate than the method of the cathetometer which is usually employed.

§ 11. *Pressure Correction.*—In the practical application of the manometric method there are certain corrections peculiar to the method, of which account must be taken in work of precision. The volume of the bulb is not accurately constant, but varies with change of pressure and temperature. The thermal expansion of the bulb is common to all methods, and will be considered in detail later. The pressure correction is small, and is determined in the same manner as for a mercury thermometer. The value so determined, however, does not apply strictly except at the temperature to which it refers. If the pressure-coefficient were constant at all temperatures and equal to e, the pressure correction, dt, at any point t of the scale would be obtainable from the simple formula

$$dt = ep_0t(t-100)/T_0, \quad . \quad . \quad . \quad (10)$$

where p_0 is the initial pressure at the temperature T_0. But as the coefficient probably varies in an unknown manner, the correction is somewhat uncertain, especially at high temperatures. Another very necessary but somewhat troublesome correction is the reduction of the manometer readings to allow for the varying temperatures of the mercury and scale. Since it is generally impracticable to immerse the manometer in a liquid bath to secure certainty and uniformity of temperature, the temperature must be estimated from the readings of mercury thermometers suspended in mercury tubes or in the air near the manometer. It is therefore necessary to work in a room specially designed to secure great constancy of temperature, and to screen the manometer with the utmost care from the source of heat in measurements of high temperature. Regnault considered that the limit of accuracy of correction was one-tenth of a millimetre of mercury, but it is probably possible to measure to one-hundredth as a mean of several readings under the best conditions, at ordinary temperatures.

§ 12. *Stem-Exposure.*—In all gas thermometers it is necessary in practice that the part of the gas in contact with the mercury or other liquid in the manometer should not be heated, but kept at a nearly constant temperature. The space above the mercury, together with the exposed portion of the capillary tube connecting the manometer with the thermometric bulb, may be called the "dead space." If the volume of the dead space is kept as nearly as possible constant by adjusting the mercury always up to a fixed mark, the quantity of air in this space varies nearly in direct proportion to the pressure, *i.e.*, in proportion to the temperature of the thermometric bulb at constant volume. This necessitates the application of a stem-exposure correction, the value of which is approximately given by the formula

$$dt = rt(t-100)/T_2, \quad . \quad . \quad . \quad . \quad . \quad (11)$$

where r is the ratio of the volume of the dead space to the volume of the thermometric bulb, and T_2 is the mean temperature of the dead space, which is supposed to be constant. The magnitude of the correction is proportional to the ratio r, and increases very rapidly at high temperatures. If the dead space is 1 per cent. of the bulb, the correction will amount to only one-tenth of a degree at 50° C., but reaches 5° at 445° C., and 30° at 1000° C. It is for this reason important in high-temperature work to keep the dead space as small as possible and to know its volume accurately. With a mercury manometer, the volume is liable to a slight uncertainty on account of changes of shape in the meniscus, as it is necessary to use a wide tube in order to secure accurate measurements of pressure.

§ 13. *Compensation Method with Oil-Gauge.*—It is possible to avoid this difficulty, and to make the dead space very small, by employing oil or sulphuric acid or other non-volatile liquid to confine the gas in place of mercury (*Phil. Trans.*, A. 1887, p. 171). The employment of a liquid which wets the tube makes it possible to use a much smaller bore, and also greatly facilitates the reading of small changes of pressure. At the same time the instrument may be arranged so that the dead space correction is automatically eliminated with much greater accuracy than it can be calculated. This is effected as shown diagrammatically in Fig. 2, by placing side by side with the tube AB, connecting the bulb B to the manometer A, an exact duplicate CD, closed at the end D, and containing liquid in the limb C, which is of the same size as the branch A of the manometer and in direct communication with it. The tube CD, which is called the compensating tube, contains a constant mass of gas under exactly similar conditions of volume and temperature to the tube AB. If therefore the level of the liquid is always adjusted to be the same in both tubes AB and CD, the mass of gas contained in the dead space AB will also be constant, and is automatically eliminated from the equations, as they contain differences only.

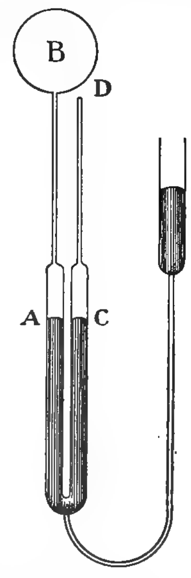

Fig. 2.—Method of Compensation.

§ 14. *Gravimetric Method.*—In the writer's opinion, the gravimetric or overflow method, although it has seldom been adopted, and is not generally regarded as the most accurate, is much to be preferred to the manometric method, especially for work at high temperatures. It is free from the uncertain corrections above enumerated as being peculiar to the manometric method. The apparatus is much simpler to manipulate and less costly to construct. If the pressure is kept constant and equal to the external atmospheric pressure, there is no strain of the bulb, which is particularly important at high temperatures. There is no dead space correction so long as the temperature of the dead space is kept constant. The troublesome operation of reading and adjusting the mercury columns of the manometer is replaced by the simpler and more accurate operation of weighing the mercury displaced, which can be performed at leisure. The uncertain correction for the temperature of the mercury in the manometer is entirely avoided. The reasons which led Regnault to prefer the constant-volume thermometer are frequently quoted, and are generally accepted as entirely conclusive, but it is very easy to construct the constant-pressure or gravimetric instrument in such a manner as to escape the objections which he urges against it. Briefly stated, his objections are as follows: (1) Any error in the observation of the temperature of the gas in the overflow space produces a considerable error in the temperature deduced, when the volume of the overflow is large. This source of error is very simply avoided by keeping the whole of the overflow in melting ice, an expedient which also considerably simplifies the equations. It happened that Regnault's form of thermometer could not be treated in this manner, because he had to observe the level of the mercury in order to measure the pressure. It is much better, however, to use a separate gauge, containing oil or sulphuric acid, for this purpose. The use of ice also eliminates the correction for the variation of density of the mercury by which the overflow is measured. (2) Regnault's second objection was that an error in the measurement of the pressure, or in reading the barometer, was more serious at high temperatures in the case of the constant-pressure thermometer than in the constant-volume method. Owing to the incessant variations in the pressure of the atmosphere, and in the temperature of the mercury columns, he did not feel able to rely on the pressure readings (depending on observations of four mercury surfaces with the cathetometer) to less than a tenth of a millimetre of mercury, which experience showed to be about the limit of accuracy of his observations. This would be equivalent to an error of 0·036° with the constant-volume thermometer at any point of the scale, but with the constant-pressure thermometer the error would be larger at higher temperatures, since the pressure does not increase in proportion to the temperature. This objection is really unsound, because *the proportionate error* dT/T, or the error considered as a fraction of the whole temperature, remains constant at constant pressure, for a given constant error in the pressure. This is the ideal condition to be aimed at. That the proportionate error diminishes with rise of temperature, in the case of the constant-volume thermometer, is really of no advantage, because we can never hope to be able to measure high temperatures with greater proportionate accuracy than ordinary temperatures. The great increase of pressure at high temperatures in the manometric method is really a serious disadvantage, because it becomes necessary to work with much lower initial pressures, which implies inferior accuracy at ordinary temperatures and in the determination of the initial pressure and the fundamental interval.

§ 15. *Compensated Differential Gas Thermometer.*—The chief advantage of the gravimetric method, which Regnault and others appear to have missed, is that it is possible to make the measurements altogether independent of the atmospheric pressure and of the observation of mercury columns. This is accomplished by using, as a standard of constant pressure, a bulb containing a constant mass of gas in melting ice, side by side with the bulb in which the volume of the overflow is measured. The pressure in the thermometric bulb is adjusted to equality with the standard by means of a delicate oil-gauge of small bore, in which the difference of pressure is observed by means of a cathetometer microscope. This kind of gauge permits the rapid observation of small changes of pressure, and is far more accurate and delicate than the mercury manometer. The fundamental measurement of the volume of the overflow in terms of the weight of mercury displaced at 0° C. involves a single weighing made at leisure, and requires no temperature correction. The accuracy obtainable at ordinary temperatures in this measurement is about ten times as great as that attainable under the best conditions with the mercury manometer. At higher temperatures the relative accuracy diminishes in proportion to the absolute temperature, or the error dt increases according to the formula

$$dt/t = -(T/T_o)\,dw/w, \quad . \quad . \quad . \quad (12)$$

where w is the weight of the overflow and dw the error. This diminution of the sensitiveness of the method at high temperatures is commonly urged as a serious objection to the method, but the objection is really without weight in practice, as the possible accuracy of measurement is limited by other conditions. So far as the weighing alone is concerned, the method is sensitive to one-hundredth of a degree at 1000° C., which is far beyond the order of accuracy attainable in the application of the other corrections.

§ 16. *Description of Practical Form of Instrument.*—A form of gas thermometer constructed on the principles above laid down, with the addition of a duplicate set of connecting tubes for the elimination of the stem-exposure correction by the method of automatic compensation already explained, is shown in Fig. 3. This type of instrument, designed for work of the highest precision, was described and exhibited at a meeting of the Royal Society in December 1891 (*Proc. R. S.*, vol. 50, p. 243), but has not hitherto been figured in any publication, except in a diagrammatic form (*e.g.*, Preston's *Heat*, p. 133). The connexions of the various parts of the instrument will be better understood by reference to the diagram (Fig. 4), in which the two sides of the instrument are separated. The connecting tubes to the thermometric bulb T are compensated by a similar pair of tubes C, which are shown in the diagram on the extreme right, but are really in close proximity to the thermometric bulb. The taps t_1 t_2 serve for cleaning and drying the apparatus, and for the introduction and removal of mercury when the bulb T is used as a weight thermometer for determining the expansion of the glass. The thermometric bulb T is connected to the "overflow" bulb M, in which the expansion is measured by the displacement of mercury. The system of tubes and taps connected to the overflow bulb serves for the introduction or removal of weighed quantities of mercury. The standard pressure-bulb S is an exactly similar bulb to the overflow bulb, and is provided with an exactly similar set of connexions. It is placed side by side with the overflow bulb in a large vessel of ice. Between the two bulbs is the oil-gauge G, in which the difference pressure is observed by a cathetometer microscope. An auxiliary mercury-gauge N is added to show when the difference of pressure is small enough to be within the range of the oil-gauge.

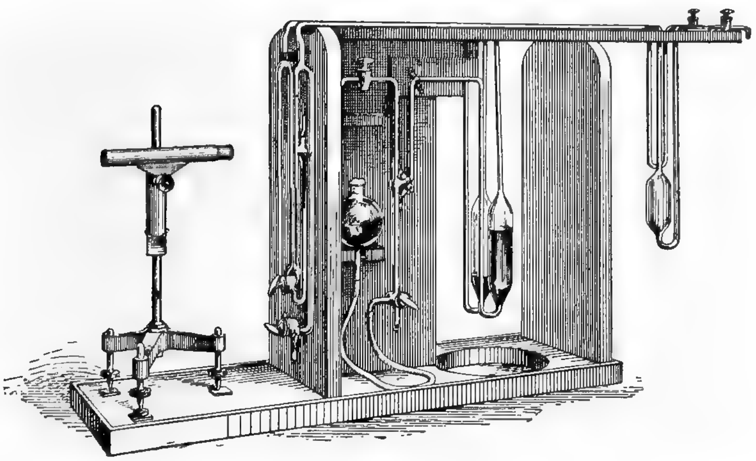

FIG. 3.—Compensated Differential Gas Thermometer.

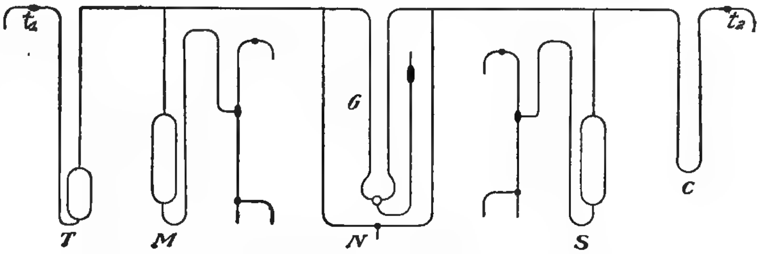

FIG. 4.—Diagram of Compensated Differential Gas Thermometer.

In setting up the instrument, after cleaning and drying and calibrating the bulbs and connecting tubes, the masses of gas on the two sides are adjusted as nearly as possible to equality, in order that any changes of temperature in the two sets of connecting tubes may compensate each other. This is effected with all the bulbs in melting ice, by adjusting the quantities of mercury in the bulbs M and S and equalizing the pressures. The bulb T is then heated in steam to determine the fundamental interval. A weight w_1 of mercury is removed from the overflow bulb M in order to equalize the pressures again. If W is the weight of the mercury at 0° C. which would be required to fill the bulb T at 0° C., and if $W+dW_1$ is the weight of mercury at 0° which would be required to fill a volume equal to that of the bulb in steam at t_1, we have the following equation for determining the coefficient of expansion a, or the fundamental zero T_0,

$$at_1 = t_1/T_0 = (w_1 + dW_1)/(W - w_1), \quad . \quad . \quad (13)$$

Similarly if w is the overflow when the bulb is at any other temperature t, and the expansion of the bulb is dW, we have a precisely similar equation for determining t in terms of T_0, but with t and w and dW substituted for t_1 and w_1 and dW_1. In practice, if the pressures are not adjusted to exact equality, or if the volumes of the connecting tubes do not exactly compensate, it is only necessary to include in w a small correction dw, equivalent to the observed difference, which need never exceed one part in ten thousand.

It is possible to employ the same apparatus at constant volume as well as at constant pressure, but the manipulation is not quite so simple, in consequence of the change of pressure. Instead of removing mercury from the overflow bulb M in connexion with the thermometric bulb, mercury is introduced from a higher level into the standard bulb S so as to raise its pressure to equality with that of T at constant volume. The equations of this method are precisely the same as those already given, except that w now signifies the "inflow" weight introduced into the bulb S, instead of the overflow weight from M. It is necessary, however, to take account of the pressure-coefficient of the bulb T, and it is much more important to have the masses of gas on the two sides of the apparatus equal than in the other case. The thermometric scale obtained in this method differs slightly from the scale of the manometric method, on account of the deviation of the gas compressed at 0° C. from Boyle's law, but it is easy to take account of this with certainty.

Another use to which the same apparatus may be put is the accurate comparison of the scales of two different gases at constant volume by a differential method. It is usual to effect this comparison indirectly, by comparing the gas thermometers separately with a mercury thermometer, or other secondary standard. But by using a pair of bulbs like M and S simultaneously in the same bath, and measuring the small difference of pressure with an oil-gauge, a higher order of accuracy may be attained in the measurement of the small differences than by the method of indirect comparison. For instance, in the curves representing the difference between the nitrogen and hydrogen scales (Fig. 1), as found by Chappuis by comparison of the nitrogen and hydrogen thermometers with the mercury thermometer, it is probable that the contrary flexure of the curve between 70° and 100° C. is due to a minute error of observation, which is quite as likely to be caused by the increasing aberrations of the mercury thermometer at these temperatures as by the difficulties of the manometric method. It may be taken as an axiom in all such cases that it is better to measure the small difference itself directly than to deduce it from the much more laborious observations of the separate magnitudes concerned.

§ 17. *Expansion Correction.*—In the use of the mercury thermometer we are content to overlook the modification of the scale due to the expansion of the envelope, which is known as Poggendorf's correction, or rather to include it in the scale correction. In the case of the gas thermometer it is necessary to determine the expansion correction separately, as our object is to arrive at the closest approximation possible to the absolute scale. It is a common mistake to imagine that if the rate of expansion of the bulb were uniform, the scale of the apparent expansion of the gas would be the same as the scale of the real expansion—in other words, that the correction for the expansion of the bulb would affect the value of the coefficient of expansion $1/T_0$ only, and would be without effect on the value of the temperature t deduced. A result of this kind would be produced by a constant error in the initial pressure on the manometric method, or by a constant error in the initial volume on the volumetric method, or by a constant error in the fundamental interval on any method, but *not* by a constant error in the coefficient of expansion of the bulb, which would produce a modification of the scale exactly analogous to Poggendorf's correction. The correction to be applied to the value of t in any case to allow for any systematic error or variation in the data is easily found by differentiating the formula for t with respect to the variable considered. Another method, which is in some respects more instructive, is the following:—

Let T be the function of the temperature which is taken as the basis of the scale considered, then we have the value of t given by the general formula (1), already quoted in § 3. Let dT be the correction to be added to the observed value of T to allow for any systematic change or error in the measurement of any of the data on which the value of T depends, and let dt be the corresponding correction produced in the value of t, then substituting in formula (1) we have,

$$t+dt=100(T-T_0+dT-dT_0)/(T_1-T_0+dT_1-dT_0),$$

from which, provided that the variations considered are small, we obtain the following general expression for the correction to t,

$$dt=(dT-dT_0)-(dT_1-dT_0)t/100 \quad . \quad . \quad (14)$$

It is frequently simpler to estimate the correction in this manner, rather than by differentiating the general formula.

In the special case of the gas thermometer the value of T is given by the formula

$$T=pV/RM=pV/R(M_0-M_2), \quad . \quad . \quad (15)$$

where p is the observed pressure at any temperature t, V the volume of the thermometric bulb, and M the mass of gas remaining in the bulb. The quantity M cannot be directly observed, but is deduced by subtracting from the whole mass of gas M_0 contained in the apparatus the mass M_2 which is contained in the dead space and overflow bulb. In applying these formulæ to deduce the effect of the expansion of the bulb, we observe that if dV is the expansion from 0° C., and V_0 the volume at 0° C., we may write

$$V=V_0+dV. \quad T=p(V_0+dV)/RM=(pV_0/RM)(1+dV/V_0),$$

whence we obtain approximately

$$dT=TdV/V_0 \quad . \quad . \quad . \quad . \quad (16)$$

If the coefficient of expansion of the bulb is constant and equal to the fundamental coefficient f (the mean coefficient between 0° and 100° C.), we have simply $dV/V_0=ft$; and if we substitute this value in the general expression (14) for it, we obtain

$$dt=(T-T_1)ft=ft(t-100) \quad . \quad . \quad (17)$$

Provided that the correction can be expressed as a rational integral function of t, it is evident that it must contain the factors t and $(t-100)$, since by hypothesis the scale must be correct at the fixed points 0° and 100° C., and the correction must vanish at these points. It is clear from the above that the scale of the gas thermometer is not independent of the expansion of the bulb even in the simple case where the coefficient is constant. The correction is by no means unimportant. In the case of an average glass or platinum reservoir, for which f may be taken as 0·000025 nearly, the correction amounts to −0·0625° at 50° C., to 3·83° at 445° C., and to 22·5° at 1000° C.

The value of the fundamental coefficient f can be determined with much greater accuracy than the coefficient over any other range of temperature. The most satisfactory method is to use the bulb itself as a mercury weight thermometer, and deduce the cubical expansion of the glass from the absolute expansion of mercury as determined by Regnault. Unfortunately the reductions of Regnault's observations by different calculators differ considerably even for the fundamental interval. The values of the fundamental coefficient range from ·00018153 Regnault, and ·00018210 Broch, to ·00018253 Wüllner. The extreme difference represents an uncertainty of about 4 per cent. (1 in 25) in the expansion of the glass. This uncertainty is about 100 times as great as the probable error of the weight thermometer observations. But the expansion is even less certain beyond the limits of the fundamental interval. Another method of determining the expansion of the bulb is to observe the linear expansion of a tube or rod of the same material, and deduce the cubical expansion on the assumption that the expansion is isotropic. It is probable that the uncertainty involved in this assumption is at least of the same order as the other in the case of glass or porcelain bulbs, on account of the difficulty of perfect annealing. In the case of metallic bulbs it is probable that this assumption is more nearly correct, provided that they have been perfectly annealed.

Except for small ranges of temperature, the assumption of a constant coefficient of expansion is not sufficiently exact. It is therefore usual to assume that the coefficient is a linear function of the temperature, so that the whole expansion from 0° C. may be expressed in the form $dV=t(a+bt)V_0$, in which case the fundamental coefficient $f=a+100b$. Making this substitution in the formula already given, we obtain the whole correction

$$dt=(f+bT)\,t\,(t-100) \quad . \quad . \quad . \quad (18)$$

It will be observed that the term involving b becomes of considerable importance at high temperatures. Unfortunately, it cannot be determined with the same accuracy as f, because the conditions of observation at the fixed points are much more perfect than at other temperatures. Provided that the range of the observations for the determination of the expansion is coextensive with the range of the temperature measurements for which the correction is required, the uncertainty of the correction will not greatly exceed that of the expansion observed at any point of the range. It is not unusual, however, to deduce the values of b and f from observations confined to the range 0° to 100° C., in which case an error of 1 per cent., in the observed expansion at 50° C., would mean an error of 60 per cent. at 445°, or of 360 per cent. at 1000° C. Moreover, it by no means follows that the average value of b between 0° and 100° C. should be the same as at higher or lower temperatures. The method of extrapolation would therefore probably lead to erroneous results in many cases, even if the value could be determined with absolute precision over the fundamental interval. It is probable that this expansion correction, which cannot be reduced or eliminated like many of the other corrections which have been mentioned, is the chief source of uncertainty in the realization of the absolute scale of temperature at the present time. The uncertainty is of the order of one part in five or ten thousand on the fundamental interval, but may reach 0·5° at 500° C., and 2° or 3° at 1000° C.

§ 18. *Thermodynamical Correction.*—Of greater theoretical interest, but of less practical importance on account of its smallness, is the reduction of the scale of the gas thermometer to the thermodynamical scale. The theory of the reduction was first given by Thomson, and the requisite experimental data for air, hydrogen, and carbonic acid were subsequently obtained by Joule and Thomson in their celebrated series of experiments on the "Thermal Effects of Fluids in Motion" (*Phil. Trans.*, 1854, 1862). These experiments have been discussed by Thomson (*Ency. Brit.*, vol. xi. p. 554), and more recently by a number of other writers, but little has been done in the direction of the practical application of the results to the construction of a table of corrections for the reduction of the scales of different gas thermometers. This is the more to be regretted as the original table of corrections for the air thermometer given by Joule and Thomson in their first paper (1854) was calculated from imperfect data and formulæ. Unfortunately, this table has been very widely quoted, even by later authors (cf. Guillaume, *Thermometry*, 1889), and has given rise to the impression that the corrections calculated by the method of Thomson and Joule are of no value as compared with those obtained by direct comparison of the scales of different gases. It may therefore be of interest to give a more complete table of corrections calculated from their later experiments, and to explain the method of calculation and discuss its limitations.

Lord Kelvin (*Ency. Brit.*, vol. xi. p. 554), assuming that the cooling effect in adiathermal expansion through a porous plug varies inversely as the square of the absolute temperature, and taking Regnault's values for the coefficients of expansion at constant pressure, finds the following results for the absolute zero :—

TABLE II.—*Absolute Zero from Regnault's Expansion-Coefficients.*

Gas employed . . .	Air.	Hydrogen.	Carbonic Acid.
Coefficient of expansion . a	·0036706	·0036613	·0037100
Fundamental zero of gas . T_0	272·44	273·13	269·50
Correction to abs. zero $\theta_0 - T_0$	+0·70	−0·13	+4·4
Absolute zero deduced . θ_0	273·14	273·00	273·90

He concludes that the absolute zero is probably within one-tenth of a degree of 273·0, at which point it may be taken (as a round number) until more accurate experiments are forthcoming. He does not consider the case of the pressure-coefficient at constant volume. The objection has been raised to his formula, that the simple inverse square law does not represent the observed increase in the heating effect with rise of temperature in the case of hydrogen, and that it does not satisfy the observations on carbonic acid very accurately. It appears that more consistent results might be obtained by taking account of the "covolume" b, which affords an explanation of the heating effect for hydrogen, and by employing the more general equation (see THERMODYNAMICS, equation (17), § 11),

$$v - b = R\theta/p - c, \quad . \quad . \quad . \quad . \quad (19)$$

in which b is a constant depending on the volume of the molecules themselves, and c is a term depending on the molecular co-aggregation, which may be assumed to vary inversely as the nth power of the absolute temperature. The index n is equal to 2 in the Joule-Thomson equation, but is probably different for different gases.

Calculation of Correction.—In order to calculate the value of the correction by this equation, it is preferable to write it in the form $\theta = pv/R + q$, where q is a small quantity of the same dimensions as a temperature. Comparing this with equation (19), we have generally

$$q = (c - b)p/R \quad . \quad . \quad . \quad . \quad (20)$$

In using a gas thermometer we assume an equation of the form $T = pv/R_1$, in which T is the temperature on the scale of the gas thermometer, and R_1 is a constant, differing slightly from R, and depending on the method of thermometry employed. The value of R_1 has to be determined by observations at the fixed points 0° and 100° C., which gives the relations

$$R_1 = (p_1v_1 - p_0v_0)/100, \quad R = R_1(1 + (q_1 - q_0)/100), \quad . \quad (21)$$

where p_0, v_0, q_0 are the values of p, v, q, at 0° C., and p_1, v_1, q_1 are the values at 100° C. Similarly for the value of the freezing-point of water on the absolute thermodynamical scale, we have

$$\theta_0 = p_0v_0/R + q_0 = T_0 + q_0 - (q_1 - q_0)\theta_0/100\,; \quad . \quad . \quad (22)$$

and for the correction dt to be added to the temperature Centigrade on the scale of the gas thermometer to reduce to temperature Centigrade on the thermodynamical scale, we have by formula (14),

$$dt = (q - q_0) - (q_1 - q_0)\, t/100 \quad . \quad . \quad . \quad (23)$$

The values of c and b for the gas may be deduced from the observations on the cooling effect Q for a difference of pressure P in terms of the specific heat S at constant pressure, as explained in the article THERMODYNAMICS, § 10, by means of the relation

$$SQ/P = (n + 1)c - b \quad . \quad . \quad . \quad . \quad (24)$$

If, for instance, we take from the observations of Joule and Thomson on the cooling effect in the case of carbonic acid for a change of pressure $P = 100$ inches of mercury, the values $Q = 4·64$° C. at 0° C., and 2·15° at 95·6°, assuming the index $n = 2$, we should find $c_0 = 4·62$ c.c. at 0° C., and $b = 2·18$ c.c. The specific heat S is taken as 0·85 joule, but this is a little uncertain. The value of q is easily found in terms of c and b by equation (20), but as it depends on p as well as θ, its value is different for different methods of thermometry. In the case of the constant-pressure thermometer we have $p = p_0$, the initial pressure, but for the constant-volume thermometer $p = p_0\theta/\theta_0$. Thus if $n = 2$, substituting in (22) and (23) we have the following very simple expressions for the correction for the constant-volume thermometer :—

$$\left.\begin{array}{ll}\text{Zero correction (const. vol.),} & \theta_0 - T_0 = 646\ C \\ \text{Scale correction \quad ,, \quad ,,} & dt = Ct(t - 100)/\theta\end{array}\right\} \quad . \quad (25)$$

where C is used as an abbreviation for the constant factor $c_0p_0/373R$, which has the following values if $n = 2$, $p_0 = 760$ mm.: air, $C =$ ·00085 ; hydrogen, $C =$ ·000132 ; carbonic acid, $C =$ ·00650.

For the constant-pressure thermometer, the constant C has the values already given for each gas, and the corrections are as follows :—

$$\left.\begin{array}{l}\text{Zero correction, } \theta_0 - T_0 = 846\ C - bp_0/R \\ \text{Scale correction, } dt = Ct(t - 100)(1·732 + 273/\theta)/\theta\end{array}\right\} \quad . \quad (26)$$

The covolume b occurs only in the zero-correction of the constant-pressure thermometer. All the corrections vary in direct proportion to the initial pressure p_0 at 0° C. By assuming a standard value such as 273·0 for the absolute zero θ_0, the formulæ for the zero-correction will give the value of T_0, the reciprocal of the fundamental expansion- or pressure-coefficient for any initial pressure p_0.

The values of the corrections given in Table IV. have been calculated by the above formulæ, assuming $n = 2$. If the corrections between 0° and 100° for the constant-volume thermometer are increased in the proportion of 4/3, to correspond with an initial pressure of 100 cms., they are found to agree very fairly in general character and also in magnitude with those found experimentally by Chappuis, and illustrated in Fig. 1. The theory may also be verified by comparison with the observed values of the pressure-coefficients.

TABLE III.—*Absolute Zero from Pressure-Coefficients.*

Observer . . .	Regnault, $p=76$ cms.			Chappuis, $p=100$ cms.		
Gas employed . .	Air.	H_2.	CO_2.	N_2.	H_2.	CO_2.
Coef. $\times 10^7$ . . .	36650	36678	36880	36748	36625	37250
Fund. zero T° . .	272·85	272·64	271·2	272·11	273 03	268·5
$\theta_0 - T_0$, $n=2$ . .	+0·56	+0·09	+4·2	+0·86	+0·11	+5·5
Abs. zero θ_0 . .	273·41	272·73	275·4	272·97	273·14	274·0
$\theta_0 - T_0$, $n=1$ . .	+0·83	+0·13	+6·4	+1·30	+0·17	+8·4
Abs. zero θ_0 . .	273·68	272·77	277·6	273·41	273·20	276·9

It is at once evident from this table that Regnault's values for the pressure-coefficients, which have been so long accepted, disagree among themselves, and cannot be reconciled with those of Chappuis. His values for the expansion-coefficients, on the contrary, are fairly concordant, and have been confirmed by subsequent work. This would indicate that, contrary to his own belief, the constant-pressure thermometer was more accurate in his hands than the constant-volume thermometer. Assuming that the Joule-Thomson effect for air may be applied to nitrogen, the values of θ_0 deduced from the observations of Chappuis on the pressure-coefficients of nitrogen and hydrogen at 100 cms. agree very fairly with those deduced by Lord Kelvin from the expansion-coefficients. For the sake of comparison, the values of the corrections have also been calculated on the assumption $n=1$, which corresponds to the formula of van der Waals. It will be seen that this introduces discrepancies so large as to be practically inadmissible. It would also make the scale correction for the constant-volume thermometer vanish, which cannot be reconciled with Chappuis's results (Fig. 1). So far as these particular observations alone are concerned, it would be possible to obtain better agreement empirically by the choice of some other values for the index n, but the real difficulty lies in reconciling the results by the Joule-Thomson method with the direct observations of specific volume by Amagat and others at higher temperatures. According to Amagat, CO_2 is still a notably imperfect gas (c greater than b) at 260° C. But according to the values of c and b calculated from the Joule-Thomson effect, it should become "pluperfect" (c less than b) at 125° C. On account of the difficulty of making experiments on the cooling effect at different temperatures, the work of Joule and Thomson has not yet been repeated, except in the case of steam, which offers special facilities. It is evident that further experiments are desirable, but in the meantime it appears preferable to retain the value $n=2$ for the index, as it simplifies the formulæ, and satisfies the observations within the probable limits of experimental error, over the range of the experiments 0° – 100° C.

TABLE IV.—*Thermodynamical Correction of Gas Thermometers.*

t Cent.	At Constant Volume, Initial Pressure 760 mm.			At Constant Pressure, $p_0=$ 760 mm.		
	Air.	H_2.	CO_2.	Air.	H_2.	CO_2.
−200°	(+·700)	+·109	(+5·36)	(+3·77)	+·586	(+28·8)
−150°	+·258	+·040	(+1·98)	+1·02	+·158	(+7·82)
−100°	+·099	+·015	(+·75)	+·328	+·050	(+2·48)
−50°	+·029	+·005	+·22	+·086	+·015	+·65
0°	0	0	0	0	0	0
+10°	−·0027	−·0004	−·0207	−·0073	−·0011	−·056
+20°	−·0046	−·0007	−·0356	−·0122	−·0019	−·095
+30°	−·0059	−·0009	−·0452	−·0155	−·0024	−·119
+40°	−·0065	−·0010	−·0500	−·0169	−·0026	−·130
+50°	−·0066	−·0010	−·0504	−·0170	−·0026	−·130
+60°	−·0061	−·0010	−·0470	−·0155	−·0025	−·120
+70°	−·0052	−·0008	−·0398	−·0132	−·0020	−·101
+80°	−·0039	−·0006	−·0295	−·0098	−·0015	−·074
+90°	−·0021	−·0003	−·0162	−·0052	−·0008	−·040
+100°	0	0	0	0	[illegible]	0
+150°	+·015	+·002	+·115	+·036	+·006	+·274
+200°	+·036	+ 006	+·275	+·083	+·013	+·635
+250°	+·061	+·009	+·466	+·137	+·021	+1·05
+300°	+·089	+·014	+·683	+·196	+·031	+1·51
+350°	+·119	+·019	+·913	+·258	+·040	+2·00
+400°	+·152	+·024	+1·16	+·325	+·050	+2·48
+450°	+·186	+·029	+1·42	+·392	+·061	+3·00
+500°	+·220	+·034	+1·68	+·460	+·071	+3·50
+600°	+·293	+·046	+2·24	+·60	+·093	+4·60
+700°	+·366	+·057	+2·81	+·73	+·114	+5·65
+800°	+·442	+·069	+3·40	+·88	+·137	+6·73
+900°	+·523	+·081	+4·00	+1·03	+·159	+7·83
+1000°	+·600	+·093	+4·60	+1·16	+·181	+8·93
+1500°	+1·01	+ 157	+7·72	+1·90	+·296	+14·5
+2000°	+1·42	+·221	+10·9	+2·62	+·407	+20·2
+3000°	+2·26	+·352	+17·3	+4·10	+·337	+31·4

§ 19. *Limitations.*—In the application of the gas thermometer to the measurement of high temperatures certain difficulties are encountered which materially limit the range of measurement and the degree of accuracy attainable. These may be roughly classified under the heads—(1) changes in the volume of the bulb; (2) leakage, occlusion, and porosity; (3) chemical change and dissociation. The difficulties arise partly from defects in the materials available for the bulb, and partly from the small mass of gas enclosed. The troubles due to irregular changes of volume of glass bulbs, which affect the mercury thermometer at ordinary temperatures, become so exaggerated at higher points of the scale as to be a serious source of trouble in gas thermometry in spite of the twentyfold larger expansion. For instance, the volume of a glass bulb will be diminished by from one-quarter to one-half of 1 per cent. the first time it is heated to the temperature of boiling sulphur (445° C.). This would not matter so much if the volume then remained constant. Unfortunately, the volume continues to change, especially in the case of hard glass, each time it is heated, by amounts which cannot be predicted, and which are too large to neglect. The most accurate method of taking account of these variations in a series of observations, without recalibrating and refilling and cleaning the bulb, is to assume the known constant value of the coefficient of expansion of the gas, and to calculate the volume of the bulb at any time by taking observations in ice and steam (*Phil. Trans.*, A. 1891, vol. 182, p. 124). Similar changes take place with porcelain at higher temperatures. Metallic bulbs are far more perfect than glass bulbs in this respect. It is probable that silica bulbs would be the most perfect. The writer suggested the use of this material (in the *Journal of the Iron and Steel Institute* for 1892), but failed to construct bulbs of sufficient size. Mr Shenstone, however, has recently succeeded, and there seems to be a good prospect that this difficulty will soon be minimized. The difficulties of leakage and porosity occur chiefly with porcelain bulbs, especially if they are not perfectly glazed inside. A similar difficulty occurs with metallic bulbs of platinum or platinum-iridium, in the case of hydrogen, which passes freely through the metal by occlusion at high temperatures. The difficulty can be avoided by substituting either nitrogen or preferably argon or helium as the thermometric material at high temperatures. With many kinds of glass and porcelain the chemical action of hydrogen begins to be appreciable at temperatures as low as 200° or 300° C. In any case, if metallic bulbs are used, it is absolutely necessary to protect them from furnace gases which may contain hydrogen. This can be effected either by enclosing the bulb in a tube of porcelain, or by using some method of electric heating which cannot give rise to the presence of hydrogen. At very high temperatures it is probable that the dissociation of diatomic gases like nitrogen might begin to be appreciable before the limit of resistance of the bulb itself was reached. It would probably be better, for this reason, to use the monatomic and extremely inert gases argon or helium.

§ 20. *Other Methods.*—Many attempts have been made to overcome the difficulties of gas pyrometry by adopting other methods of measurement. Among the most interesting may be mentioned—(i.) The variation in the wave-length of sound. The objection to this method is the difficulty of accurately observing the wave-length, and of correcting for the expansion of the material of the tubes in which it is measured. There is the further objection that the velocity varies as the square root of the absolute temperature. (ii.) A similar method, but more promising, is the variation of the refractivity of a gas, which can be measured with great accuracy by an interference method. Here again there is difficulty in determining the exact length of the heated column of gas, and in maintaining the temperature uniform throughout a long column at high temperatures. These difficulties have been ingeniously met by D. Berthelot (*Comptes Rendus*, 120, p. 831). But the method is not easy to apply, and the degree of accuracy attainable is probably inferior to the bulb methods. (iii.) Methods depending on the effusion and transpiration of gases through fine orifices and tubes have been put in practice by Barus and by the writer. The method of transpiration, when the resistance of the tube through which the current of gas is passed is measured on the Wheatstone bridge principle (*Nature*, 23rd March 1899), is extremely delicate, and the apparatus may be made very small and sensitive, but the method cannot be used for extrapolation at high temperatures until the law of increase of resistance has been determined with certainty. This may be successfully accomplished in the near future, but the law is apparently not so simple as is usually supposed.

On account of these and similar difficulties, the limit of gas thermometry at the present time must be placed at 1200° C., or even lower, and the accuracy with which temperatures near 1000° C. are known does not probably exceed 5° C. Although measurements can be effected with much greater consistency than this by means of electrical pyrometers, the absolute values corresponding to those temperatures must remain uncertain to this extent, inasmuch as they depend on observations made with the gas thermometer. Temperatures as high as 2000° C. have been determined, but only by extrapolation of empirical formulæ or other methods of estimation.

ELECTRICAL THERMOMETRY.

§ 21. The convenience of the mercurial thermometer lies in the fact that it is complete in itself, and can be read without subsidiary appliances beyond a magnifying glass. Its weakness lies in the very limited range of each single instrument, and in the troublesome and often uncertain corrections which must be applied to its readings in all work of precision. Electrical thermometers have the disadvantage of requiring auxiliary apparatus, such as galvanometers and resistances, the use of which involves some electrical training. But they far surpass the mercurial thermometer in point of range, delicacy, and adaptability, and can be applied to many investigations in which ordinary thermometers are quite useless.

There are two kinds of electrical thermometers, which depend on different effects of heat on the electrical properties of metals: (1) The *Thermocouple*, or *Thermopile*, which depends on the production of a thermoelectric force when the junctions of different metals in an electric circuit are at different temperatures; and (2) the *Electrical Resistance Thermometer*, the action of which depends on the fact that the resistance of a pure metal to the passage of an electric current increases very considerably when the temperature is raised. The theory of the thermocouple is discussed at some length in the article THERMOELECTRICITY, as it possesses many points of interest, and has been studied by many skilful experimentalists. The electrical resistance thermometer is of more recent origin; but although the theory has been less fully developed, the practice of the method bids fair to surpass all others in the variety and accuracy of its applications. In order to secure the widest possible range and the greatest constancy, in either variety of electrical thermometer, advantage is taken of the great stability and infusibility characteristic of the metals of the platinum group. Other metals are occasionally used in work at low temperatures with thermocouples for the sake of obtaining a larger electromotive force, but the substitution is attended with loss of constancy and uncertainty of reduction, unless the range is greatly restricted.

§ 22. *Applications of the Thermocouple.*—The principal uses of the thermocouple in thermometry are for measuring high temperatures, and for measuring small differences of temperature, more particularly when the temperature is required to be measured *at a point*, or in a very small space. The electromotive force of the couple depends only on the temperature at the plane of junction of the two metals, which can be very exactly located. A typical instance of a measurement to which the thermocouple is peculiarly suited, is the determination of the cyclical variations of temperature at accurately measured depths from one-tenth to one-hundredth of an inch in the metal of the cylinder of a heat engine, the interior surface of which is exposed to cyclical variations of temperature in the working of the engine.[1] The exact depth of the plane of junction can be measured without difficulty to the thousandth of an inch. The insertion of the wire makes the least possible disturbance of the continuity of the metal. There is no lag, as the thermometer itself is part of the metal. The instantaneous value of the temperature at any particular point of the stroke can be measured separately by setting a periodic contact to close the circuit of the galvanometer at the desired point. A further advantage is gained by measuring only the difference of temperature between two junctions of a thermocouple at different depths, instead of the whole interval from some fixed point. None of these advantages could be secured by the use of any ordinary thermometer; some depend on the fact that the method is electrical, but some are peculiar to the thermocouple, and could not be otherwise attained.

On the other hand, the thermocouple is not well suited for thermometry of precision, on account of the smallness of the electromotive force, which is of the order of ten microvolts only per degree for the most constant couples. By the use of very delicate galvanometers it is possible to read to the hundredth or even in special cases to the thousandth of a degree on this small difference, but unfortunately it is not possible to eliminate accidental thermal effects in other parts of the circuit due to small differences of temperature and material. These accidental effects seldom amount to less than one or two microvolts even in the best work, and limit the accuracy attainable in temperature measurement to about the tenth of a degree with a single platinum thermocouple. This limit can be surpassed by using couples of greater thermoelectric power and less permanence, or by using a pile or series of couples, but in either case it is doubtful whether the advantage gained in power is not balanced by loss of simplicity and constancy. A method of avoiding these effects, which the writer has found to be of great use in delicate thermoelectric researches, is to make the whole circuit, including all the terminals and even the slide-wire itself, of pure copper. Platinoid, german silver, constantan, and other alloys most commonly used for resistances and slide-wires, are particularly to be avoided, on account of their great thermoelectric power when connected to copper. Manganin and platinum-silver are the least objectionable, but the improvement effected by substituting copper is very marked. It is clear that this objection to the use of the couple does not apply with the same force to high temperatures, because the electromotive force of the couple itself is greater, and the accuracy attainable is limited by other considerations.

§ 23. *The Resistance Thermometer.*—In practice the resistance thermometer is almost invariably made of platinum, since there is very seldom any advantage to be gained by the substitution of baser metals. The instrument is for this reason often referred to simply as the "platinum thermometer." It is important that the platinum should be pure, both for the sake of uniformity and also because the change of electrical resistance with temperature is greater the purer the metal. The observation of the fundamental coefficient, which is ·00390 (or rather larger than the coefficient of expansion of a gas) for the purest metal hitherto obtained, is one of the most delicate tests of the purity of the metal. In addition to the constancy and infusibility of the metal, a special advantage which is secured by the use of platinum is the close agreement of the thermodynamical scale with the platinum scale of temperature, as defined by the formula

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[1] Hall, *Trans. Amer. Inst. Elect. Eng.*, 1891, vol. viii. p. 226; Callendar and Nicolson, *Proc. Inst. C. E.*, vol. cxxxi. p. 1.

$$pt=100(R-R_0)/(R_1-R_0), \quad . \quad . \quad . \quad (27)$$

in which the symbol *pt* stands for the temperature on the platinum scale Centigrade, and R, R_1, and R_0 are the observed resistances of the thermometer at the temperatures *pt*, 100°, and 0° C. respectively. A platinum thermometer is generally arranged to read directly in degrees of temperature on the platinum scale, just as a mercury thermometer is graduated in degrees of the mercury scale. The reduction to the scale of the gas thermometer is most conveniently effected by the difference formula

$$t-pt=dt(t-100)/10{,}000, \quad . \quad . \quad (28)$$

in which d is a constant, called the difference-coefficient, the value of which for pure platinum is about 1·50, but varies slightly for different specimens. This formula was first given by the writer as the result of a series of comparisons of different platinum wires with each other and with other metals, and also with an air thermometer over the range 0° to 625° C. The platinum wire in these comparisons was enclosed inside the bulb of the air thermometer itself, and disposed in such a manner as to be at the mean temperature of the bulb in case the temperature were not quite uniform throughout (*Phil. Trans.*, A. 1887, p. 161). The formula was subsequently verified by Griffiths (*Phil. Trans.*, A. 1891), by the comparison of platinum thermometers of different construction at temperatures up to the boiling-point of sulphur, 445° C., and by Heycock and Neville (*Jour. Chem. Soc.*, February, 1895), by the observation of a number of higher points up to the freezing-point of copper at 1082° C., which they showed to agree with the most probable mean of all the best determinations by various methods of gas thermometry. At still higher temperatures, beyond the present range of the gas thermometer, the writer has succeeded in obtaining presumptive evidence of the validity of the same formula by comparison with the scales of the expansion and the specific heat of platinum, which appear to follow similar laws (*Phil. Mag.*, December 1899). If we assume that the coefficient of expansion of platinum, the coefficient of increase of resistance, and the specific heat are all three linear functions of the temperature, we obtain results which are in agreement within the limits of error of observation up to the fusing point of platinum itself. Quite recently the same formula has been independently verified by the comparison of platinum thermometers with the constant-volume nitrogen thermometer by Harker and Chappuis (*Phil. Trans.*, A. 1900), working at the International Bureau at Sèvres, over the range 0° to 650° C. It has also been shown by the experiments of Fleming and others that the same formula satisfies very closely the observations on the variation of electrical resistance of other metals over wide ranges of temperature. Although the theoretical explanation of the formula has not yet been given, owing to our ignorance of the true nature of electrical conduction and of the molecular constitution of metals, it may be regarded from an empirical point of view as being one of the most accurately established of all thermometric formulæ. It will be observed that it also represents the simplest possible type of divergence from the thermodynamical scale. It has for this reason been proposed to adopt a scale of temperature based on this formula as a practical standard of reference pending more accurate determinations of the thermodynamical scale at high temperatures. The advantage of this practical standard would be that all measurements made at the present time could be referred to it directly with much greater accuracy than they can be referred to the gas thermometer. The latter instrument is extremely difficult to use, especially at high temperatures, and cannot be directly applied to the majority of investigations. The order of accuracy attainable with a platinum thermometer is at least ten times greater than with the gas thermometer, on account of the uncertainty of the expansion of the envelope, a source of error from which the platinum thermometer is free. By adopting the platinum thermometer as a practical standard of reference, a higher order of accuracy of comparison is attainable, in addition to much greater ease and convenience of manipulation.

§ 24. *Methods and Apparatus.*—The methods of electrical thermometry may be roughly classified under two heads as (1) deflection methods, in which the temperature is deduced from the observed deflection of a galvanometer; and (2) balance methods, in which the resistance or the electromotive force is balanced against a known adjustable resistance or potential difference. The former methods are most suitable for rough work and rapid reading, the latter for the accurate measurements. In the practice of the deflection method it is customary to use a movable-coil galvanometer, the sensitiveness of which can be varied by varying the resistance in circuit, or by varying the stiffness of the suspension. The accuracy attainable is of the order of one-half of 1 per cent. on the deflection, and is limited by variations of resistance of the galvanometer, and by the imperfect elasticity of the suspension. In any case the scale of the galvanometer should be "calibrated" or tested for uniformity. In this kind of work the thermocouple has the advantage over the resistance thermometer in that the latter requires an auxiliary battery to supply the current; but in many cases this is no disadvantage, because it permits a greater latitude of adjustment, and makes it possible to obtain greater power than with the thermocouple. For example, the electromotive force of a 10 per cent. Rh. Pt. – Pt. couple at 500° C. is only about 4 millivolts (·004 volt). To read so small a potential difference with any accuracy requires a suspended coil galvanometer with a mirror and scale. Even with the smallest resistance thermometer, with a coil containing only two inches of fine wire, it is easy to have a difference of potential of 40 or 50 millivolts at 500° C., which is well within the range of an ordinary portable pivoted millivoltmeter, such as is commonly used in every power station for measuring electric currents by the fall of potential method. With larger thermometers the power available would be much greater. This is most advantageous, not only for accurate work, but also for practical applications, in which automatic records are often a great convenience. With a resistance thermometer it is easy to obtain records in pen and ink on a scale of an inch to the degree by a balance method. With a thermocouple it is necessary to employ photography and very delicate apparatus to secure a similar scale.

In cases where it is desired to obtain greater accuracy without abandoning the quickness of reading which is the principal advantage of the deflection method, it is possible to combine the two methods by balancing part of the potential difference by means of a potentiometer (see ELECTRICITY: *Electric Current*) and using the galvanometer for the small changes only. In cases where the greatest accuracy is required, a very sensitive galvanometer should be used, and the whole of the potential difference should be balanced as nearly as possible, leaving very little to depend on the deflection of the galvanometer. The degree of sensitiveness and accuracy obtainable depends primarily on the delicacy of the galvanometer, on the power available, and on the steadiness of the conditions of experiment. For thermometry of precision the resistance thermometer possesses three very great advantages over the thermocouple: (1) The power available, owing to the use of a battery, is enormously greater; (2) it is possible completely to eliminate the errors due to accidental thermal effects by reversing the battery; (3) the Wheatstone bridge method can be employed in place of the potentiometer, so that the constancy of the battery is immaterial, and it is not necessary to use a standard cell. The conditions to be satisfied in the attainment of the greatest possible accuracy in the measurement of temperature by this method differ somewhat from those which obtain in ordinary measurements of resistance, so that a special type of apparatus has been evolved for the purpose, a brief description of which will be given.

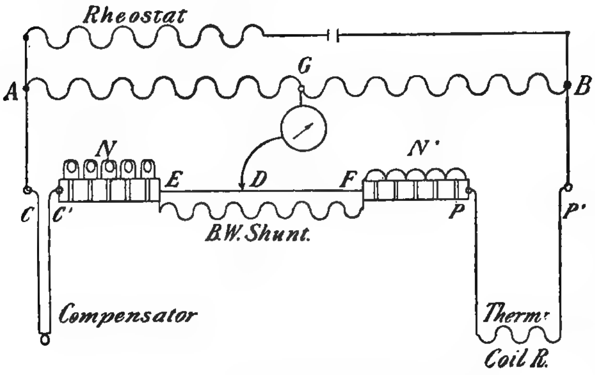

FIG. 5.—Diagram of Compensated Bridge Method.

§ 25. *Compensated Bridge Apparatus.*—It is necessary that the thermometer should be connected to the measuring apparatus by wires or "leads" of considerable length, generally at least two or three metres, in order to avoid exposing the galvanometer and resistance box, or other delicate parts of the apparatus, to changes of temperature. It is also essential that the leads should not be too thick or heavy, for convenience in handling, and to prevent conduction of heat along the stem of the thermometer. The resistance of that part of the leads which is exposed to variations of temperature necessarily changes, and would give rise to serious errors if it were not determined or compensated. The method now generally adopted in accurate work is to compensate the variations of resistance of the leads by an exactly similar pair of dummy leads called the "compensator" and connected as shown diagrammatically in Fig. 5. The battery, consisting of a single cell, with a rheostat and reversing key in circuit, is connected to the terminals AB of the two equal resistance coils AG, GB, which form the ratio arms of the balance. These coils must be carefully tested for equality of temperature-coefficient, and placed in close proximity to each other so as to be always at the same temperature. If they are interwound on the same reel, they must be most carefully insulated from each other. In parallel circuit with the ratio coils are connected the compensator CC′ and the balancing resistances C′E, on one side of the bridge-wire EF, and the compensating resistances FP and the pyrometer and leads PRP′ on the other side. The galvanometer is connected to the point G between the ratio coils, and to the sliding contact D on the bridge-wire. Since the ratio coils are always equal, equal changes of resistance on either side of D are eliminated, and do not affect the balance. Thus the changes of the pyrometer leads PP′ are balanced by the equal changes of the compensator leads CC′ on the other side. As a further refinement, which is of some importance in delicate work, the ends of the compensator leads are connected by a short piece of the same wire as the pyrometer coil. For instance, in observing the variations of temperature of the steam in the cylinder of a steam engine at different points of the stroke with a very delicate thermometer made of wire one-thousandth of an inch in diameter (*Proc. Inst. C. E.*, vol. cxxxi. Fig. 16, p. 23), the ends of the fine wire attached to the thick leads could not follow the rapid variations of temperature, and it was found necessary to adopt this device to eliminate the end-effect. It is also useful in other cases to eliminate the effect of conduction along the leads in cooling the ends of the fine wire coil. The balancing resistances C′E are made of some alloy such as manganin or platinum-silver, the resistance of which varies very little with change of temperature. Platinum-silver is probably the best material, as it can be perfectly annealed at a red heat without risk of burning, and is then extremely constant, whereas manganin resistances are liable to change, and require frequent recalibration. Unless the box can be kept at an absolutely constant and uniform temperature, which is not impossible but often inconvenient, it is necessary to allow for the change of resistance of the balancing coils C′E due to change in the temperature of the box. The temperature of the coils cannot be accurately determined with a mercury thermometer unless they are immersed in oil, but even in that case it is necessary to know the temperature coefficient of each individual coil. A more convenient and accurate method, which eliminates the correction automatically, is to compensate each individual coil of the balancing coils C′E by a corresponding compensating coil at FP on the other side of the bridge-wire. The compensating coils are made of platinum, also annealed at a red heat, and each is placed in the box in close proximity to the coil it is intended to compensate. Each balancing coil and its compensator are tested together at various temperatures between 10° and 30° C., and are adjusted until their difference remains constant for any small variation of temperature in the neighbourhood of 20° C. This method of compensation was applied by the writer in 1887, but has not been generally adopted on account of the labour involved in adjusting the coils. The absolute values of the resistances are immaterial, but it is necessary to know the relative values with the greatest possible accuracy. For this reason it is preferable to arrange the resistances in the binary scale, each resistance being equal to twice the next smaller resistance, or to the sum of all the smaller resistances, the two smallest resistances being made equal. This arrangement permits the greatest accuracy of comparison in the simplest manner with the fewest observations. The bridge-wire EF provides a continuous scale for reading small changes of resistance. Any change of resistance of the pyrometer coil necessitates the movement of the balance point D through an equivalent resistance along the bridge-wire. The equivalent resistance of the bridge-wire per unit length of the attached scale is preferably adjusted, by means of a shunt shown in parallel with it in Fig. 5, to be an exact submultiple of the smallest resistance coil. It is usual also to adjust the resistances of the thermometers so that their fundamental intervals are convenient multiples of this unit, generally either 100, 200, 500, or 1000, so that the bridge-wire may read directly in degrees of temperature on the platinum scale. It is easy to get a scale of 10 cms. or more to the degree, and it is not difficult with a suitable galvanometer to read to the ten-thousandth part of a degree. The length of the bridge-wire itself need not be more than 20 or 30 cms., as the balancing resistances enable the scale to be indefinitely extended. Thus the instrument possesses the great advantage over the mercury thermometer that the most open scale may be easily secured without unwieldy length, and without restricting the range of each thermometer.

§ 26. *Errors and Corrections.*—It is most instructive to consider the errors and corrections involved in platinum thermometry on the same lines as those on which the corresponding errors of the mercury thermometer have already been treated.

(I) The changes of zero of the mercury thermometer arise chiefly from the small expansibility of mercury combined with the imperfect elasticity of the containing tube. In platinum thermometry the containing tube has nothing to do with the reading, and the effect of any possible strain of the fine wire of the coil is minimized by its small dimensions and by the large temperature-coefficient of the increase of resistance, which is more than twenty times greater than the coefficient of apparent expansion of mercury in glass. It is not surprising, therefore, that the changes of zero of a platinum thermometer should be practically negligible, provided that the wire is not strained and contaminated with impurities. It is probable that with ordinary care the changes of zero due to exposure to any given limits of temperature are in all cases less than the limit of accuracy of observation, due to other causes at the extreme limit of the range considered.

(II) *The fundamental interval* of each thermometer must be determined as usual by observations in ice and steam, and a correction must be applied by the method already described in the case of the mercury thermometer. The difference of the temperature of the steam from 100° C. should be determined on the platinum scale by the approximate formula

$$dpt_1 = \cdot 985 dt_1 = \cdot 0362(H - 760) - \cdot 000020(H - 760)^2 \quad . \quad (29)$$

(III) *Pressure Correction.*—The effect of change of pressure on a platinum thermometer of the ordinary tube form is of course nothing, as the wire itself is not exposed to the pressure. Even if the wire is naked and directly exposed to large changes of pressure, the change of reading is almost inappreciable. Similarly there is no source of error analogous to the effects of capillarity, which are so troublesome with delicate mercury thermometers.

(IV) *Stem Exposure.*—The reading of a platinum thermometer with compensated leads depends only on the temperature of the coil of wire forming the bulb, and not on the temperature of the stem, provided that the immersion is sufficient to avoid errors due to conduction or convection along the stem. It is desirable that the top of the bulb should be immersed to a depth equal to from three to five times the diameter of the tube, according to the size and the accuracy required.

(V) *Scale Correction.*—The reduction to the thermodynamical scale may be effected, within the limits of probable error of the most accurate measurements at present available, by the very simple difference formula (28) already given, over the whole range from −100° C. to +1100° C. This is in striking contrast with the mercury thermometer, which requires a cubic formula to cover the range 0° to 200° C. with equal accuracy. The value of the constant d in the formula varies but little, provided that the wire be fairly pure and the thermometers properly constructed. In order to determine its value in any special case, it is best to take an observation at the boiling-point of sulphur (S.B.P.) for temperatures above 0° C., or at that of oxygen for temperatures below 0° C. down to −200° C. It appears probable that there is a point of inflection in the curve of resistance-variation of platinum and some other metals in the neighbourhood of −200° C., and that the formula does not apply accurately below this point. It has been the custom for several years to assume the boiling-point of sulphur (S.B.P.) under normal pressure to be 444·53° C., as determined by Callendar and Griffiths, using a constant-pressure air thermometer, and to take the rate of change of temperature with pressure as ·082° per mm. from Regnault's observations. According to experiments made at Kew Observatory with platinum thermometers (Chree, *Proc. R. S.*, 1900), the rate of change is somewhat larger than that given by Regnault's formula, namely, about ·090° per mm., and it appears desirable to determine this constant with greater accuracy. The difference between the above formulæ reaches a tenth of a degree if the barometer differs by 12 mm. from 760 mm. The uncertainty in the absolute boiling-point of sulphur, however, is probably somewhat greater than one-tenth of a degree, on account of the uncertainty of the expansion correction of the gas thermometer (*Phil. Mag.*, December 1899). The thermodynamical correction of the gas thermometer, which amounts to half a degree, according to Table IV. above, is also to some extent uncertain, on account of the extrapolation. Provided, however, that some exact value of the S.B.P. is chosen for reference, for the reduction of observations with platinum thermometers, the results so reduced will be strictly comparable, and can be corrected at any subsequent time when the value of the S.B.P. is more accurately determined. The boiling-point of oxygen may be taken as −182·5° C. with sufficient approximation for a similar purpose.

(VI) *Calibration Correction.*—The calibration of the resistance box and the bridge-wire corresponds to the calibration of the stem of the mercury thermometer, but the process is much simpler for several reasons. It is more easy to obtain a uniform wire than a uniform tube. The scale of the wire is much more open, it corresponds to a very small part of the whole scale, and the process of calibration is easier. One box when calibrated will serve for any number of thermometers of different ranges and scales, and covers the whole range of temperature (see CALIBRATION, *Ency. Brit.*, vol. xxvi.).

§ 27. *Electrical Precautions.*—The platinum thermometer is so far superior to the mercury thermometer in all the points above enumerated that, if there were no other difficulties, no one would ever use a mercury thermometer for work of precision. In using a platinum thermometer, however, some electrical training is essential to obtain the best results. The manipulation and adjustment of a delicate galvanometer present formidable difficulties to the non-electrical observer. Bad contacts, faulty connexions, and defective insulation are not likely to trouble the practised electrician, but present endless possibilities of error to the tyro. A useful discussion of these and similar details is given in the paper by Chree already referred to. Bad insulation of the pyrometer and connexions can easily be detected, in the compensated instrument already described, by disconnecting one of the C leads from the battery and one of the P leads from the bridge-wire. Under these conditions the galvanometer should not deflect if the insulation is perfect. Defective insulation is most likely to be due to damp in the thermometer at low temperatures. This source of error is best removed by drying and hermetically sealing the thermometers. Trouble from bad contacts generally arises from the use of plugs for the resistance coils. If plugs are used, they must be specially designed so as not to disturb each other, and must be well fitted and kept very clean. Mercury cups with large copper terminals, well amalgamated, as used with standard resistance coils, are probably the simplest and most satisfactory method of changing connexions. Accidental thermoelectric effects in the circuit are a possible source of error, as with the thermocouple, but they are always very small if the thermometer is properly constructed, and are relatively unimportant owing to the large E.M.F. available. In any case they may be completely eliminated by reversing the battery. The heating effect of the current through the thermometer is often negligible, but should be measured and allowed for in accurate work. With a current of ·01 ampere the rise of temperature should not exceed $\frac{1}{100}$ or $\frac{2}{100}$ of a degree. With a delicate galvanometer it is possible to read to the ten-thousandth of a degree with a current of only ·002 ampere, in which case the heating effect is generally less than $\frac{1}{1000}$ of a degree. It can be very easily measured in any case by changing from one cell to two, thus doubling the current in the thermometer, and quadrupling the heating effect. The correction is then applied by subtracting one-third of the difference between the readings with one and two cells from the reading with one cell. The correction is always very small, if a reasonably sensitive galvanometer is used, and is frequently negligible, especially in differential work, which is one of the most fruitful applications of the platinum thermometer.

§ 28. *Construction of Thermometers.*—One of the chief advantages of the platinum thermometer for research work is the endless variety of forms in which it may be made, to suit the particular exigencies of each individual experiment. It is peculiarly suited for observing the average temperature throughout a length or space, which is so often required in physical experiments. For this purpose the wire may be disposed in a straight length, or in a spiral, along the space in question. Again, in observing the temperature of a gas, the naked wire, on account of its small mass and extremely low radiative power, is far superior to any mercury thermometer. The commonest form of platinum thermometer, and the most suitable for general purposes, contains a coil from ½ inch to 2 inches long, wound on a cross of thin mica, and enclosed in a tube, about ¼ to ½ inch in diameter, of glass or porcelain according to the temperature for which it is required. The pyrometer leads and the compensator leads are insulated and kept in place by passing through mica discs fitting the tube, which serve also to prevent convection currents up and down the tube. For temperatures above 1000° C. biscuit porcelain presents certain advantages over mica in strength and infusibility. For the highest temperatures it is proposed to use silica tubes and silica frames, which have been successfully constructed and possess the advantage of being tougher than porcelain. The chief objections to porcelain tubes arise from the glaze, which melts at 1100° C., and is liable to stick to and injure the coils.

It would not be within the scope of the present article to attempt to describe the many ingenious varieties of electrical thermometers which have been devised for special purposes. It would also be impossible to discuss the many other methods of thermometry or pyrometry, depending on expansion, on fusion, on calorimetry, or on radiation. These methods have many useful applications, but are not in general suited for work of precision. It has been thought desirable to restrict the discussion to the most accurate types, because they are the most important for the advancement of science, and could not be adequately treated in a smaller compass. Moreover, descriptions of the commoner methods can be found in many familiar text-books, whereas thermometry of precision is a more recent development, of which no complete exposition is to be found in any English work at the present time. On mercurial and gas thermometry the best treatise is that of Guillaume (*Thermométrie de Précision*, Paris), already referred to. On pyrometry there is a valuable report by Barus, Physical Congress, Paris, 1900; also a recent work by Chatelier and Boudouard (*Mesure des Températures Élevées*, Paris), which is concerned chiefly with the thermocouple, but is well illustrated and up to date. The electrical resistance method as applied to work of precision is to be found only in a series of papers, the most important of which have been referred to.

Alphabetical Index of Symbols.

a, b = Numerical constants in expansion formulæ (18).
C = Coefficient of thermodynamical correction formulæ (25).
c = Co-aggregation volume in formula (19).
f = Fundamental coefficient of expansion of bulb.
M = Mass of gas in bulb of gas thermometer.
p = Pressure of gas in bulb of gas thermometer.
R = Constant of gas thermometer, or resistance of platinum thermometer.

r = Ratio of dead space to volume of bulb.
T = Temperature by gas thermometer.
t = Temperature on the Centigrade scale.
θ = Temperature on the thermodynamical scale.
v = Specific volume of gas.
V = Volume of bulb of gas thermometer.
W = Weight of mercury filling bulb at 0° C.
w = Weight of mercury in overflow. (H. L. C.)

Thibaw, called by the Shans, and officially, Hsipaw, and also frequently Ong Pawng (the name of an old capital), is one of the northern Shan States of Burma. It includes four states—Thibaw, the main state, and the sub-states of Möng Lông, Möng Tung, and Thonzè (or Hsumhsai). The whole state has an estimated area of 4524 square miles, and the population in 1897 was calculated to be 73,248. There were 96 circles, 1260 villages, and 19,436 households. The main state lies on the geological fault which runs east and west across the Shan States, from the Salween at Kun Lông and beyond to nearly the rim of the Shan tableland at Gôkteik. It is therefore broken up into a mass of not very well defined ridges and spurs, crossing and re-entering. The chief plain land is in the valley of the Nam Tu (Myit-ngè), near Thibaw town, and the valley or strath of the Pyawng Kawng, Nawng Ping neighbourhood. Elsewhere the valleys are insignificant. The hills on the Möng Tung border reach their highest elevations in the peaks Loi Pan (6848 feet) and Loi Htan (6270 feet). To the north-west of Thibaw town, on the Tawng Peng border, Loi Lam rises to 6486 feet. The valley of the Nam Tu marks the lowest point in the state at Thibaw town, about 1400 feet, and rises on the east in Möng Tung to a plain level of about 2500 feet, and on the west in Möng Lông to a confused mass of hills with an average height of 4500 feet, broken up by the Nam Yawn and Nam Kaw valleys, which are about 3000 feet above mean sea-level.

The chief river is the Nam Tu or Myit-ngè, also frequently called by its classical name the Dôktawadi. The main stream rises in the Salween–Irrawaddy watershed, and is enlarged by considerable tributaries. At Thibaw town it is 250 yards wide and about 8 feet deep, with a fairly strong current. The Nam Tu is navigable only in local stretches, and between Thonzè and Lawksawk (Yatsauk) it flows through a gorge between cliffs three to four thousand feet high. At the gorge of Hokü̈t (Ngôkteik) the Nam Htang and the Nam Pasè unite to form the Nam Küt, which passes into the ground at the natural bridge where the Mandalay–Kun Lông railway crosses the gorge, and reappears to join the Nam Tu. The bed of the Nam Küt is about 1500 feet below the general level of the country. Coal is found at various places in the state, but is not of very high quality. Salt-wells are worked by the inhabitants of Mawhkio (Bawgyo) about 7 miles from Thibaw town. The average maximum temperature at the beginning of April is about 96°, and the minimum about the same period 65°. The rainfall averages about 70 inches for the year. The chief crops are rice, cotton, sesamum, tea in the hills, and *thanat*, the leaf of a tree used for the wrapper of the Burma, or "green" cheroot. Cotton cloth was formerly much more generally manufactured than it now is, and a coarse country paper is also made. Other industries are merely of articles for local use. The Government cart road to Lashio passes through the centre of the state, and from this various unmetalled cart roads radiate to different parts of the state and the neighbouring states. The Mandalay–Kun Lông railway under construction will also pass through the capital. Teak forests exist along the banks of the Nam Tu and in the Möng Lông states, but both have been practically exhausted, and will have to be closed for many years. Previous to the annexation, and in a general way still, the state is administered by the *sawbwa*, or chief, aided by a council of six *amats* or ministers. Under them are a number of *nè-baings*, who are in charge of circles and townships. Each *nè-baing* has an *asiyin*, or clerk, and each village has a headman, or *kin-man*. The *amats* supervise the administration of a certain number of districts. The old system is now being assimilated to that followed in Burma. The revenue in 1897–98 amounted to Rs.262,906, and the expenditure in the same year to Rs.221,127.

Thomar, a town of the district of Santarem, Portugal, 12 miles north-east of Lisbon. It is chiefly famous for the magnificent convent of the Order of Christ, founded by the Templar Knight Gualdim Paes, and greatly favoured by King Manuel; the windows of the chapter-house are especially noteworthy. Other interesting edifices are the church of St John the Baptist and the ruins of the Templars' Castle. Paper and cottons are manufactured. Population (1890), 5816; (1900), 6933.

Thomas, Arthur Goring (1850–1892), English musical composer, was the youngest son of Freeman Thomas and Amelia, daughter of Colonel Thomas Frederick. He was born at Ratton Park, Sussex, 20th November 1850, and educated at Haileybury College. He was intended for the Civil Service, but delicate health interfered with his studies, and in 1873 he went to Paris to cultivate the musical talent he had displayed from an early age. Here he studied for two years with Émile Durand. In 1875 he returned to England, and in 1877 entered the Royal Academy of Music, where for three years he studied under Ebenezer Prout and Arthur Sullivan, winning twice the Lucas medal for composition. At a later period he received some instruction in orchestration from Max Bruch. His first published composition was a song, "Le Roi Henri," which appeared in 1871. An early comic opera, *Don Braggadocio* (libretto by his brother, C. I. Thomas), was apparently unfinished; some of the music in it was afterwards used for the *The Golden Web*. A selection from his second opera, *The Light of the Harem* (libretto by Clifford Harrison), was performed at the Royal Academy of Music, 7th November 1879, with such success that Carl Rosa commissioned him to write *Esmeralda* (libretto by T. Marzials and A. Randegger), which was produced at Drury Lane, 26th March 1883. Two years later it was given (in German) at Cologne and Hamburg, and in 1890 (in French) at Covent Garden. On 16th April 1885 Rosa produced at Drury Lane Thomas's fourth and best opera, *Nadeshda* (libretto by Julian Sturgis), a German version of which was given at Breslau in 1890. A fifth opera, *The Golden Web* (libretto by F. Corder and B. C. Stephenson), slighter than its predecessors, was produced (after the composer's death) at Liverpool, 15th February, and at the Lyric Theatre, London, 11th March 1893. Besides these dramatic works Thomas's chief compositions were a psalm, "Out of the Deep," for soprano solo and chorus (London, 1878); a choral ode, "The Sun Worshippers" (Norwich, 1881), and a suite de ballet for orchestra (Cambridge, 1887). A cantata, *The Swan and the Skylark*, was found in pianoforte score among his MSS. after his death: it was orchestrated by C. Villiers Stanford, and produced at the Birmingham Festival of 1894. His minor compositions include over 100 songs and duets. In 1891 Thomas became engaged to be married; shortly afterwards he showed signs of mental disease, and his career came to a tragic end on 20th March 1892. He was buried in Finchley cemetery. Thomas will always occupy a distinct place among English composers of the 19th century. His music shows traces of his early French training, but he possessed a great talent for dramatic composition and a real gift of refined and beautiful melody. He was most critical of his own work, never attempting anything for which he felt he was unfitted, and constantly revising and rewriting his compositions. Personally he was the most amiable of men: the esteem in which he was held was shown by the concert given at St James's Hall after his death with the object of founding a scholarship in his memory, at which there appeared all the chief musicians then in London, both British and foreign. (W. B. S*.)

Thomas, Charles Louis Ambroise (1811–1896), French musical composer, was born at Metz, 5th August 1811. He studied at the Paris Conservatoire, and won the Grand Prix de Rome in 1832. Five years later, in 1837, his first opera, *La Double Échelle*, was produced at the Opéra Comique. For the next five-and-twenty years Thomas's productivity was incessant, and most of his operatic works belonging to this period enjoyed an ephemeral popularity. A few of these have survived, and are still occasionally heard on the Continent, their names being *Le Caïd* (1849), *Le Songe d'une Nuit d'Été* (1850), *Psyché* (1857). The overture to *Raymond* (1851) has remained popular. So far the composer's operatic career had not been marked by any overwhelming success. He occupied a place among the recognized purveyors of operas in the French capital, but could scarcely claim to having achieved European renown. The production of *Mignon* at the Opéra Comique in 1866, however, at once raised Ambroise Thomas to the position of one of the foremost French composers. Goethe's touching tale had very happily inspired the musician; Madame Galli Marié, the original interpreter of the title-rôle, had modelled her conception of the part upon the well-known picture by Ary Scheffer, and *Mignon* at once took the fancy of the public, its success being repeated all over the Continent. It has since remained one of the most popular operas belonging to the second half of the 19th century. Thomas now attempted to turn Shakespeare's *Hamlet* to operatic account. His opera of that name was produced with success at the Paris Opéra in 1868, where it enjoyed a long vogue. If the music is scarcely adequate to the subject, it nevertheless contains some of the composer's best work. The scene of the esplanade is genuinely dramatic, the part of Ophelia is poetically conceived, and the ballet music is very brilliant. Ambroise Thomas's last opera, *Françoise de Rimini*, was given at the Opéra in 1882, but has not maintained itself in the *répertoire*. Seven years later *La Tempête*, a ballet founded on Shakespeare, was produced at the same theatre. Ambroise Thomas succeeded Auber as director of the Paris Conservatoire in 1871. If it can be said that the talent of Thomas was in its nature rather assimilative, and that it successively yielded to the various influences of the moment, yet it must be allowed that the composer of *Mignon* was not altogether devoid of personality. His music is often distinguished by refined touches which reveal a sensitive mind, and there is a distinct element of poetry in his *Mignon* and *Hamlet*, two operas that should suffice to keep the composer's memory green for some time to come. He died on the 12th of February 1896. (A. HE.)

Thomas, George Henry (1816–1870), American soldier, was born in Southampton county, Virginia, 31st July 1816. He graduated from West Point in 1840, and served continuously in the army until his death in 1870, occupying every rank from second lieutenant to major-general. As a young officer of artillery he served in the war against the Seminole Indians in Florida (1841), and in the Mexican war at the battles of Fort Brown, Resaca de la Palma, Monterey, and Buena Vista, receiving three brevets for distinguished gallantry in action. In 1855 he was appointed by Jefferson Davis, then Secretary of War, junior major of the 2nd Cavalry, of which Johnston (A. S.) was colonel, Lee was lieut.-colonel, and Hardee was senior major. At the outbreak of the Civil War these three officers resigned and joined the Confederate States. Thomas was in doubt as to what his duty required, but finally decided to adhere to the United States. He was promoted in rapid succession to be lieut.-colonel and colonel in the regular army, and brigadier-general of volunteers. In command of an independent force in eastern Kentucky, on 19th January 1862, he attacked the Confederate General Zollicoffer at Mill Springs and completely routed him, gaining the first Union victory in the west. In command of an army corps, under General Buel, he was engaged in the battles of Perryville and Stone River. Under Rosecrans, at the battle of Chickamauga, 19th September 1863, he achieved great distinction, his firmness on that disastrous field, where he gained the name of "The Rock of Chickamauga," being all that saved a terrible defeat from becoming a hopeless rout. He succeeded Rosecrans in command of the army of the Cumberland. At Chattanooga, 25th November 1863, in many respects the most brilliant battle of the war, Thomas played a most conspicuous part, his divisions under Sheridan, Wood, and Baird carrying Missionary Ridge in superb style. In Sherman's advance through Georgia in the spring of 1864, Thomas commanded the army of the Cumberland, consisting of three army corps, and numbering over 60,000 men present for duty. Thomas handled these with great skill in all the engagements and flanking movements from Chattanooga to Atlanta. When Hood broke away from Atlanta in the autumn of 1864, menaced Sherman's long line of communications and endeavoured to force Sherman to follow him, Sherman determined to abandon his communications and march to the sea, leaving to Thomas the difficult task of taking care of Hood. Thomas hastened back with a comparatively small force, racing with Hood to reach Nashville where he was to receive reinforcements. At the battle of Franklin, 30th November 1864, a large part of Thomas's force, under command of Schofield, checked Hood long enough to effect a concentration at Nashville. Here Thomas had to organize his force, which consisted largely of quartermaster's employés and improvised troops. He declined to attack until his army was ready and the ice which covered the ground had melted sufficiently to enable his men to move. Grant was impatient of the delay. He sent Logan with an order to supersede Thomas, and soon afterwards left the army of the Potomac to take command in person. Before either arrived Thomas made his attack, 15th and 16th December 1864, and inflicted on Hood a most crushing defeat, so absolute and complete that Hood's army never again appeared as a factor in the Civil War. For this brilliant victory Thomas was made a major-general in the regular army, and received the thanks of Congress. After the termination of the Civil War he served on reconstruction duty in command of military departments in Kentucky and Tennessee until 1869, when he was ordered to command the division of the Pacific with headquarters at San Francisco. He died there of apoplexy, while writing an answer to an article criticizing his military career, 28th March 1870.

Thomas was beloved by his soldiers, for whom he always had a fatherly solicitude. He was a man of solid rather than brilliant attainments: he remained in the army all his life, and never had any ambitions outside of it; his mind acted deliberately, and his temperament was somewhat sluggish; but his judgment was remarkably accurate, his knowledge of his profession was complete in every detail, and when he had finally grasped a problem, and the time arrived for action, he could strike with extraordinary vigour and rapidity. The only two battles in which he had no immediate superior—Mill Springs and Nashville, one at the beginning and the other at the end of the war—were signal victories, without defect and above criticism. His service during the intervening three years of almost incessant conflict and manœuvring was marked by loyal obedience to his superiors, skilful command of his subordinates, and successful accomplishment of every task entrusted to him. (F. V. G.)

Thomas, Theodore (1835-——), American musician, was born in Esens, Germany, 11th October 1835. His early musical training was received chiefly from his father. His career began early, for at the age of six he made his first public appearance as a violinist. Four years later he was taken to America by his parents, and when only fifteen years old (1850) was first violin in the orchestra that accompanied Jenny Lind in her American tour. From 1855 to 1869 he took part in a series of chamber music concerts in New York. In 1867 he organized the Thomas Orchestra, and it is in the capacity of orchestra conductor that he made his reputation. His orchestra made its first tour in 1869, and continued to give concerts in various American cities until it was disbanded in 1888. During most of the seasons from 1877 to 1891 he was conductor of the New York Philharmonic Society, and from 1862 to 1891, of the Brooklyn Philharmonic Society. He was director of the Cincinnati College of Music, 1878–81, conductor of the American Opera Company, 1885–87, and for a quarter of a century (1873–98) the conductor of the biennial May festivals at Cincinnati. In 1891 he removed to Chicago, and was subsequently the conductor of the Chicago Orchestra. In 1893 he was musical director of the Columbian Exposition in that city. His ability as a conductor has had an important influence in the elevation of public taste for music in America.

Thomasville, a city of Georgia, U.S.A., capital of Thomas county, in the southern part of the state, on a line of the Plant Railway system, and on the Tifton, Thomasville, and Gulf railway, at an altitude of 250 feet. It is known as a winter resort for Northern people. The surrounding country produces much cotton and early vegetables and fruit, the latter being raised mainly for Northern markets. Population (1880), 2555; (1890), 5514; (1900), 5322, of whom 69 were foreign-born and 3296 negroes.

Thompson, a town of Windham county, Connecticut, U.S.A., with an area of 50 square miles of hill country, traversed by French river, and by a line of the New York, New Haven, and Hartford railroad, in the north-eastern part of the state. It contains several villages, among which are Thompson, West Thompson, Mechanicsville, Grosvenordale, North Grosvenordale, and Quinebaug. Population (1880), 5051; (1890), 5580; (1900), 6442, of whom 2914 were foreign-born.

Thompson, Sir Henry, Bart. (1820-——), English surgeon, was born at Framlingham, Suffolk, on the 6th of August 1820. His father wished him to enter business, but circumstances ultimately enabled him to follow his own desire of becoming a physician, and in 1848 he entered the medical school of University College, London. There he had a brilliant career, and obtained his degree at London University in 1851 with the highest honours in anatomy and surgery. In 1853 he was appointed assistant surgeon at University College Hospital, becoming full surgeon in 1863, professor of clinical surgery in 1866, and consulting surgeon in 1874. In 1884 he became professor of surgery and pathology in the Royal College of Surgeons, which in 1852 had awarded him the Jacksonian prize for an essay on the *Pathology and Treatment of Stricture of the Urethra*, and again in 1860 for another on the *Health and Morbid Anatomy of the Prostate Gland*. These two memoirs indicate the department of medical practice to which he devoted his main attention. Specializing in the surgery of the genito-urinary tract, and in particular in that of the bladder, he went to Paris to study under Civiale, who in the first quarter of the 19th century proved that it is possible to crush a stone within the human bladder, and after his return he soon acquired a high reputation as a skilful operator in that class of disease. In 1863, when the King of the Belgians was suffering from stone, he was called to Brussels to consult in the case, and after some difficulties was allowed to perform the operation of lithotrity: this was quite successful, and in recognition of his skill Thompson was appointed surgeon-extraordinary to the king, an appointment which was continued by Leopold II. Nearly ten years later he carried out a similar operation on the Emperor Napoleon, who, however, died four days after the second crushing, not from the surgical interference, as was proved by the post-mortem examination, but from uræmic poisoning. Besides devising various operative improvements in the treatment of the disorders which were his speciality, Sir Henry Thompson wrote various books and papers dealing with them, including *Clinical Lectures on Diseases of the Urinary Organs*, *Practical Lithotomy and Lithotrity*, *Tumours of the Bladder*, *Suprapubic Lithotomy*, and *Preventive Treatment of Calculous Disease*. Among other books of a medical character that came from his pen were *Food and Feeding*, and *Diet in Relation to Age and Activity*, both of which passed through a number of editions. In 1874 he took a foremost part in founding the Cremation Society of England, of which he was the first president; and not only was he active in urging the advantages of cremation as a means of disposing of the body after death, but also did much towards the removal of the legal restrictions by which it was at first sought to prevent its practice in England. On various occasions he denounced the slackness and inefficiency of the methods of death-certification prevalent in Great Britain, and in 1892 his agitation was instrumental in procuring the appointment of a Select Committee to inquire into the matter; its report, published in the following year, in great measure confirmed his criticisms and approved the remedies he suggested. But medicine and hygiene by no means exhaust the list of Sir Henry Thompson's activities. In art he is an accomplished sketcher, and, moreover, an amateur of painting whose pictures have been hung at the Royal Academy and the Paris Salon. About 1870 he began to get together his famous collection of china, in particular of old blue and white Nanking; this in time became so large that he could no longer find room for it, and most of it was sold. A catalogue of it, illustrated by himself and Mr. James Whistler, was published in 1878. In his famous octaves he may be said to have elevated the giving of dinner parties into a fine art. The number of courses and of guests was alike eight, and both were selected with the utmost care and discrimination to promote the "feast of reason and the flow of soul." In literature, in addition to more serious works, he produced two novels—*Charley Kingston's Aunt* (1885) and *All But* (1886)—which met with considerable success. In science he became a devotee of astronomy, and for a time maintained a private observatory in his house at Molesey. He further did much to promote astronomical study in Great Britain by presenting Greenwich Observatory with some of the finest instruments now among its equipment, his gifts including a photoheliograph of 9-inch aperture, a 30-inch reflecting telescope, and a large refracting telescope having an object-glass of 26 inches diameter and a focal length of 22½ feet. The offer of the last instrument was made in 1894. Its manufacture was undertaken by Sir Howard Grubb of Dublin, and its erection was completed in 1897. It added greatly to the instrumental resources of Greenwich, especially for photographic work, and its importance may be gauged from the fact that both in aperture and focal length it is double the size of any instrument possessed by the observatory at the time it was put in place. That Sir Henry Thompson, who was knighted in 1867, received a baronetcy in 1899 was probably not unconnected with the presentation of this telescope to the national observatory.

Thomsen, Grímur (1820–1896), Icelandic poet and man of letters, was born in 1820. He came in 1837 to the University of Copenhagen, where he first studied law and philology, but later, philosophy and æsthetics. He became an enthusiastic follower of the Pan-Scandinavian movement, although this was not generally favoured by his countrymen. After some years of foreign travel, in 1848 he entered the Danish diplomatic service, and remained in it till 1851, when he returned to Copenhagen, where he became the chief of one of the departments of the Danish Foreign Office. He retired in 1866, and then went back to Iceland, where he passed the rest of his life, active in the politics and the literature of his native island. He died in 1896. He is the best ballad poet Iceland has produced. His poems are unaffected and mostly free from rhetoric, the besetting sin of Icelandic poets. His subjects are principally taken from Icelandic or Scandinavian history and mythology. He is very unlike most of his contemporaries, both in style and thought: he is Icelandic to the core, and on that account is perhaps the modern Icelandic poet most appreciated by foreigners. Besides his poems (two separate collections, Reykjavík, 1880, and Copenhagen, 1895), he is the author of numerous critical and historical essays in Icelandic and Danish, and some larger works in Danish, of which his dissertation on Lord Byron (Copenhagen, 1845) deserves to be mentioned. Grímur Thomsen was a warm admirer of Greek literature, and translated a great number of poems from that language into Icelandic. (S. BL.)

Thomson, James (1822–1892), British physicist and engineer, was born in Belfast on the 16th of February 1822, and, like his younger brother, Lord Kelvin, at an unusually early age began to attend the classes at Glasgow University, where his father had been appointed professor of mathematics in 1832. After his graduation he decided to study civil engineering, and for that purpose became a pupil in several engineering offices and works successively; but ill-health obliged him to leave them all, and he had finally to accept the fact that an occupation involving physical exertion was out of the question. Accordingly, from about 1843, he devoted himself to theoretical work and to mechanical invention. To this period belong his well-known researches in thermodynamics, which enabled him to predict by the application of Carnot's theorem that the temperature of the freezing-point of substances which expand on solidifying must be lowered by the application of pressure, the reverse being the case with substances which contract on solidification; and he was able to calculate the amount by which a given pressure lowers the freezing-point of water, a substance which expands on solidification. His results were experimentally verified in the physical laboratories of Glasgow University under Lord Kelvin's direction, and were afterwards applied to give the explanation of regelation which is now generally accepted. In 1861 he extended them in a paper on crystallization and liquefaction as influenced by stresses tending to change of form in crystals, and in other studies on the change of state he continued Andrews's work on the liquid and gaseous states of matter, constructing a thermodynamic model in three dimensions to show the relations of pressure, volume, and temperature in a substance like carbonic acid. With regard to his inventions, he devised a clever feathering mechanism for the paddles of steamboats when only a boy of sixteen, and later turned his attention to water engines. In 1850 he patented his "vortex water-wheel," and during the next three or four years carried on inquiries into the properties of "whirling fluids," which resulted in improved forms of blowing-fans and water-turbines and in the invention of a centrifugal pump. Settling in Belfast in 1851, he was selected to be the resident engineer to the Belfast Water Commissioners in 1853, and four years later became professor of civil engineering and surveying in Queen's College, Belfast. Thence he removed in 1873 to Glasgow as successor to Macquorn Rankine in the chair of engineering in the university, and retained this position until 1889, when the failure of his eyesight compelled him to resign. He died on the 8th of May 1892. Among other subjects which he worked at, in addition to those already mentioned, were the explanation of the parallel roads of Glen Roy and of the prismatic structure seen at the Giant's Causeway; the flow of water in rivers, in which, during 1876 and following years, he studied the origin of windings in alluvial plains and made many experiments with the aid of artificial rivers; and the currents of atmospheric circulation, which afforded him the material for the Bakerian lecture of 1892.

Thomson, Joseph (1858–1895), African explorer, was born on 14th February 1858 at Penpont, Dumfriesshire. In 1868 the family removed to Gatelawbridge, where young Thomson was soon attracted by the natural curiosities and historical associations of Nithsdale. In 1875 he went to Edinburgh University, where he paid particular attention to geology and botany, and after completing his course in 1878 he was appointed geologist and naturalist to the Royal Geographical Society's expedition to East Central Africa under Keith Johnston. The latter died at Behobeho, between the coast and the north end of Lake Nyasa, 28th June 1879, and Thomson then took command. Though very young, his coolness and tact were remarkable, and he successfully conducted the expedition across the desolate region of Uhehè and Ubena to Nyasa, and then by a hitherto unexplored track to Lake Tanganyika, where he settled the moot question of the Lukuga outlet. After enduring terrible hardships among the Warua, he returned through Bagamoyo, reaching London in August 1880. In the following year he published an account of his travels, under the title *To the Central African Lakes and Back.* About this time the Sultan of Zanzibar, being anxious to develop certain supposed coal-beds on the river Rovuma, was advised to obtain independent expert opinion as to their value. Application was made to Thomson, who undertook to survey them, and started from Mikindani, 17th July 1881. The coal, however, turned out to be merely bituminous shale, and Thomson, on his return to Zanzibar, had to endure much delay and vexation through the sultan's chagrin. For a considerable time the explorer had directed his attention to Masai-land, that wild region occupied by a powerful tribe of intractable savages, and Gordon had already pointed out that the true route to the head-waters of the Nile lay through that territory. In 1882 the Royal Geographical Society took up the question, and requested Thomson to report on the practicability of taking a caravan through the Masai country, which no European had yet been able to penetrate beyond Mount Kilimanjaro. By undaunted courage and great resourcefulness he succeeded in crossing the Njiri desert and exploring the great Rift Valley.

Thence he went with a picked company through Lykipia to Mount Kenia, emerged on Lake Baringo, and shortly afterwards traversed the unknown region lying between this lake and Victoria Nyanza. The account of this adventurous journey appeared in 1884, under the title of *Through Masai-land,* and it is a classic in modern travel. The hardships and anxieties attendant on such a career now began to tell upon Thomson's exceptionally hardy constitution, but he undertook an expedition to the Niger for the National African (afterwards the Royal Niger) Company, and succeeded by his energy in concluding valuable commercial treaties with the sultans of Sokoto and Gandu. In 1888, by way of recreation, he travelled through southern Morocco and explored a portion of the Atlas range, and published the results in the following year, under the title *Travels in the Atlas and Southern Morocco.* Twice again he visited Africa, proceeding in 1890–91 to the Zambezi for the British South Africa Company, on which occasion he met Mr Rhodes; and again in 1893 to South Africa, this time in search of health. His journey in 1890–91 had proved disastrous to a constitution already undermined, and after a short sojourn he returned to London, where he died on 2nd August 1895. The accounts of his minor travels were published in magazines or in the *Proceedings of the Royal Geographical Society.* "Thomson was endowed with a special genius for the observation of the natural features of a country. His methods of dealing with aborigines were so gentle and persuasive that his expeditions never had recourse to arms, and he covered so much unknown ground that he will probably remain the last great geographical pioneer of African exploration." (G. F. B.)

Thomson, William (1819–1890), English divine and logician, was born on 11th February 1819 at Whitehaven, in Cumberland. He was sent to Shrewsbury School, whence he proceeded to Queen's College, Oxford, of which he became a scholar. He took his B.A. degree in 1840, and was soon afterwards made fellow of his college. He was ordained in 1842, and worked as a curate at Cuddesdon, under the eye of the then bishop of Oxford. In 1847 he was made tutor of his college, and in 1853 he delivered the Bampton Lectures, his subject being "The Atoning Work of Christ viewed in Relation to some Ancient Theories." These lectures established his reputation, being thoughtful and learned, and they did much to clear the ground for the subsequent discussions on the doctrine of the Atonement, with which theologians are familiar. But Dr Thomson's activity was not confined to theology. He was made fellow of the Royal and the Royal Geographical Societies. He was examiner in logic and mental science for the Society of Arts. He wrote a treatise on *Pure and Applied Logic,* which immediately became popular, and soon reached a second edition. He sided with the party at Oxford which favoured University reform, but this did not prevent him from being appointed president of his college when the post became vacant in 1855. In 1858 he was made preacher at Lincoln's Inn, and there preached some striking sermons, a volume of which he published in 1861. In the same year he edited *Aids to Faith,* a volume written by eminent divines in opposition to the famous *Essays and Reviews,* which, with its advanced liberal sentiments, had stirred up a great storm in the Church of England. In December of that year, in recognition of the services he had rendered to the cause of orthodoxy in the Church, he was appointed to the see of Gloucester and Bristol, which had become vacant, and within a twelvemonth he was elevated to the archiepiscopal see of York. In this position Dr Thomson, whose orthodoxy was of what may be called the Moderate type, excited the fierce indignation of the High Church party by the support he gave to the passing of the Public Worship Regulation Act, and, as president of the Northern Convocation, he came frequently into sharp collision with the Lower House of that body. But if he incurred the hostility of the High Church party among the clergy, he was admired by the laity for his strong sense, his clear and forcible reasoning, and his wide knowledge, and he remained to the last a power in the north of England. In his later years he published an address read before the members of the Edinburgh Philosophical Institution (1868), one on *Design in Nature,* for the Christian Evidence Society, which reached a fifth edition, various charges and pastoral addresses, and he was one of the projectors of *The Speaker's Commentary.* He died on 25th December 1890. (J. J. L*.)

Thôngwa, a district in the Irrawaddy division of Lower Burma. It was formerly in the Pegu division, and contained 5413 square miles. Increase of population and of cultivation, however, led to its reduction in size, and a portion was taken from it in 1896 to form the district of Myaungmya. In 1898–99 the district had an area of 3470 square miles, and a population (1891) of 333,443; (1901), 482,680. The revenue paid in 1898–1899 by 971 villages was Rs.30,64,920. The population was made up in 1891 of 316,841 Buddhists and Jains, 3508 Hindus, 2769 Mahommedans, 1073 aborigines (mostly Karens), and 9252 Christians, of whom 8954 were natives (mostly Karens). Of a total acreage of 2,220,800, there were 788,065 acres cultivated in 1898–99; 651,918 acres were not available for cultivation; 34,560 acres were under forest; 685,577 acres were cultivable; and there were 60,680 acres of current fallow. The rainfall in 1898–99, taken at Maubin, was 96·67 inches. Yandoon (20,235 inhabitants) and Maubin (5327) were the chief towns. Maubin is the headquarters of the district, and has been a municipal town since 1888, with fifteen of a committee, eleven of whom are elective. The steamers of the Irrawaddy Flotilla Company call at Maubin and Yandoon.

Thorbecke, Jan Rudolf (1798–1872), Dutch statesman, was born at Zwolle, in the province of Overijssel, 14th January 1798. Thorbecke was of German extraction, his grandfather, Heinrich Thorbecke, having settled in Overijssel towards the end of the 17th century. Little is known of his youth, beyond the fact that he was sent in the year of Waterloo to Amsterdam for his education. For two years he stayed with a Lutheran clergyman of the name of Sartorius, whilst attending the lectures of the Athenæum Illustre. In 1817 he commenced his studies at Leyden University, proving a brilliant scholar, and twice obtaining a gold medal for his prize essays. In 1820 he obtained the degrees of Lit.D. and LL.D. In the following years Thorbecke undertook a journey of research and study in Germany, staying at most of her famous universities, and making the acquaintance of his best-known contemporaries in the Fatherland. At Giessen he lectured as an extraordinary professor, and at Göttingen, in 1824, published his treatise, *Ueber das Wesen der Geschichte.* After his return to Amsterdam in 1824 Thorbecke wrote his first political work of any importance, *Bedenkingen aangaande het Recht en den Staat* ("Objections anent Law and the State"), which by its close reasoning and its legal acumen at once drew attention to the young barrister, and procured him in 1825 a chair as professor in Ghent University. Here he wrote two pamphlets of an educational character before 1830. The Belgian revolt of that year forced

Thorbecke to resign his position at Ghent, and he subsequently went to Leyden. He did not approve of the Belgian movement, nor of the part that Europe played in it, and published his views in three pamphlets, which appeared in the years 1830 and 1831. In 1831 he was appointed professor of jurisprudence and political science at Leyden University. In that capacity, and, before his appointment at Leyden, as a lecturer on political science, history, and economics at Amsterdam, he gained great reputation as a political reformer, particularly after the publication of his standard work, *Aanteekeningen op de Grondwet* ("Annotations on the Constitution" 1839; second edition, Amsterdam, 1841–43), which became the text-book and the groundwork for the new Reform Party in Holland, as whose leader Thorbecke was definitively recognized. Thorbecke's political career until his death, which occurred at The Hague, 4th June 1872, has been sketched under HOLLAND: *History*. Thorbecke's speeches in the Dutch Legislature were published at Deventer in six volumes (1867–1870), to which should be added a collection of his unpublished speeches, printed at Groningen in 1900. The first edition of his *Historische Schetsen* ("Historical Essays") was issued in 1860, the second in 1872. At Amsterdam there appeared in 1873 a highly interesting *Correspondence* with his academy friend and lifelong political adversary Groen Van Prinsterer (*q.v.*), which, although dating back to the early 'thirties, throws much light on their subsequent relations and the political events that followed 1848. Of Dutch statesmen during the Napoleonic period, Thorbecke admired Falck and Van Hogendorp most, whose principles he strove to emulate. Of Van Hogendorp's *Essays* and *Speeches*, indeed, he published a standard edition, which is still highly valued. Thorbecke's speeches form a remarkable continuation of Van Hogendorp's orations, not only in their style, but also in their train of thought. Thorbecke's funeral furnished the occasion for an imposing national demonstration, which showed how deeply he was revered by all classes of his countrymen. In 1876 a statue of Thorbecke was unveiled in one of the squares of Amsterdam.

Thorbecke's gifts and public services as a statesman have been as fully recognized as his political genius has been. As an orator and writer his style was clear and forcible. His very dogmatism brought him many enemies, but at times, especially when he went in advance of his time, he was a much misunderstood man. These misunderstandings, frequently wilful, extended often beyond the domain of pure politics. Thus, by his enemies Thorbecke was often held up to scorn as a pure materialist, and no friend of the fine arts, because at a sitting of the States General in 1862 he had said that it is not the duty of the State, nor in the true interest of art itself, for the Government to "protect" art, since all State-aided art must be artificial, like any forced plant. This was popularly condensed into the aphorism, yet current in Holland, that "Art is not the business of the Government," and Thorbecke was condemned as the author of it. Again, his adversaries used to call him a dangerous demagogue. As a matter of fact, there was no more ardent royalist than Thorbecke. He believed in constitutional monarchy, as offering the best guarantees both for sovereign and people, and he was bitterly opposed to all forms of State Socialism. Long before his death he realized that he had outlived his own principles, and many of his former admirers had commenced to dub him a "rank Conservative," whose political aims and reforms were no longer adequate. But Thorbecke's life-work will endure, and the Dutch Constitution of 1887 practically embodied his principles, as laid down in the Constitution of 1848. The former is the outcome of the latter, and could not have been made without it.

The best biographical sketch of Thorbecke we owe to the late Professor Buys, his principal scholar and devoted friend, whose biography appeared in 1876 at Tiel. Another biography which deserves mention was issued in the same year at The Hague, from the pen of Dr J. A. Levy, an Amsterdam lawyer. (H. TI.)

Thorn, a fortified town of Prussia, province of West Prussia, on the right bank of the Vistula, 87 miles by rail north-east of Posen. The new garrison church (1897), the church of St James's (1309), a good specimen (in Gothic brick) of the architecture of the Teutonic Knights; the Junkerhof, restored in 1883; the Copernicus monument (1853), the municipal museum in the town hall, and the synagogue are the chief architectural features. Population (1885), 23,906; (1895), 30,314; (1900), 29,626.

Thornaby-on-Tees, a municipal borough and railway station in the Cleveland parliamentary division of the North Riding of Yorkshire, England, opposite Stockton-on-Tees (with which it is connected by a bridge), on the river Tees. The town was formerly known as South Stockton, and is still included in the parliamentary borough of Stockton, but was incorporated as a separate municipal borough in 1892. In the same year the town hall was completed. There are blast furnaces, iron foundries, engineering works, iron shipbuilding yards, extensive saw-mills, flour-mills, and a manufacture of "blue and white" pottery. Population (1881), 10,852; (1891), 15,637; (1901), 16,053.

Thóroddsen, Jón Þór ðarson (1819–1868), Icelandic poet and novelist, was born in 1819, at Reykhólar in western Iceland. He studied law at the University of Copenhagen, entered the Danish army as volunteer in 1848 in the war against the insurgents of Schleswig and Holstein, who were aided by Prussia and other German states. He went back to Iceland in 1850, became sheriff (*sýslumaður*) of Barðastrandarsýsla, and later in Borgarfjarðarsýsla, where he died in 1868. He is the first novel-writer of Iceland. Jónas Hallgrímsson had led the way by his short stories, but the earliest veritable Icelandic novel was Jón Thóroddsen's *Piltur og Stúlka* ("Lad and Lass"), a charming picture of Icelandic country life. Still better is *Maður og Kona* ("Man and Wife"), published after his death by the Icelandic Literary Society. He had a great fund of delicate humour, and his novels are so essentially Icelandic in their character, and so true in their descriptions, that he is justly considered by most of his countrymen not only as the father of the Icelandic novel, but as the best novelist Iceland has produced. His poems, mostly satirical, are deservedly popular: he follows Jónas Hallgrímsson closely in his style, although he cannot reach him in lyrical genius. (S. BL.)

Three Rivers, a city and port of entry of Quebec, Canada, at the confluence of the rivers St Maurice and St Lawrence. The principal development of trade has been the result of utilizing the immense water-power of the St Maurice at Shawanegan, Grand Mere, and other falls for the manufacture of wood-pulp. Population (1891), 8334; (1901), 9981.

Thring, Edward (1821–1887), one of the most distinguished schoolmasters of the 19th century, was the son of John Gale Dalton Thring, rector of Alford, Somerset, and was born 19th November 1821. His elder brother was HENRY THRING (born 1818), the distinguished Parliamentary counsel (1868–1886), who was made a peer as Baron Thring in 1886. Edward was educated first at Ilminster grammar school and afterwards at Eton, where he became head of the school, and Captain of Montem in 1841, the last occasion on which that ancient festival was celebrated. He then entered King's College, Cambridge, won the Porson prize for Greek, and was elected fellow. At that time King's College scholars retained the privilege of proceeding to a degree without examination, but Thring thought the maintenance of this usage inexpedient in the interests of learning and wholly indefensible in principle, and his vigorous protest against it aroused lively academic controversy, and became effective in 1851, when it was abolished. On leaving the university in 1846 he was ordained, and served for a short time as curate in Gloucester. Here he took remarkable interest in the elementary school of the parish, and ever afterwards attributed much of his professional success and his insight into educational principles and methods to the experience he had acquired in imparting the humble rudiments of learning to the children of the poor. After an interval of two or three years, spent partly in private tuition and partly as curate at Cookham Dean, he married in 1853 a daughter of Carl Koch, commissioner of customs at Bonn, and was elected to the mastership of Uppingham School, a post which he retained until his death in 1887. That school had been founded in 1584, was slenderly endowed, poorly housed, and little known. Thring found only twenty-five boys in it, but he succeeded in raising it both in numbers and repute to a position in the first rank among English public schools. He had a strong conviction that there should be a limit to the number of pupils entrusted to the care of one head-master, and he fixed that limit at 300, although, owing to the increasing popularity of the school, he was under strong temptation to exceed it. Little by little he surrounded himself with a loyal staff of masters, raised money for the building and equipment of a noble school-room and chapel, besides class-rooms and eleven boarding-houses. Among the distinctive features of his plans and achievements were: (1) his strong sense of the need for a closer study of the characteristics of individual boys than is generally found possible in large public schools; (2) his resolute adherence to the discipline of the ancient languages, in connexion with English, as the staple of a liberal education; (3) his careful provision of a great variety of additional employments and interests, in studies and in games, to suit the aptitudes of different pupils; (4) the value he attached to the æsthetic side of school training, as evinced in the encouragement he gave to music and to drawing, and to the artistic decoration of the school-rooms; and above all (5) his rebellion against mere routine, and his constant insistence on the moral purpose of a school as a training-ground for character, rather than as a place solely concerning itself with the acquisition of knowledge. The vigour and intrepidity of his character were conspicuously shown in 1875, when an outbreak of fever made Uppingham for a time untenable, and when, at a few days' notice, he took a disused hotel and some boarding-houses at Borth, on the Cardiganshire coast, and transported the whole 300 boys, with 30 masters and their households, to it as to a city of refuge. Here the school was carried on with undiminished and even fresh zest and efficiency for fourteen months, during which needful sanitary measures were taken in the town.

Unlike Arnold, with whose moral earnestness and lofty educational aims he was in strong sympathy, he took little or no part in outside controversies, political or ecclesiastical. All the activity of his life centred round the school. His was the first public school to establish a gymnasium, and the first to found a town mission in a district of South London, with a view to interest the boys in an effort to improve the social condition of the poor. He took the first step in 1869 in the formation of the Head Masters' Conference, an institution which has ever since done much to suggest improvements in method and to cultivate a sense of corporate life and mutual helpfulness among the teachers in the great schools. And in 1887 he took the bold and unprecedented step of inviting the Association of Head Mistresses to Uppingham, and giving to them a sympathetic address. He also formed an association in Uppingham, with lectures, cookery classes, concerts, and other aids to the intellectual and social improvement of the residents of the little town. He gave valuable evidence before the Schools Inquiry Commission of Lord Taunton in 1866, but it was very characteristic of him that he dreaded the intrusion of public authority, whether that of royal commissioners or of the legislature, into the domain of the school, wherein he thought it indispensable that the liberty and personal inventiveness and enthusiasm of teachers should have full scope and be hindered by no official regulations.

His contributions to literature were not numerous, but were all closely connected with his work as a schoolmaster. They were: *Thoughts on Life Science*, 1869, written under the assumed name of Benjamin Place; *Education and School*, 1864; *The Theory and Practice of Teaching*, 1883; *Uppingham School Sermons*, 1858; *The Child's Grammar*, 1852; *The Principles of Grammar*, 1868; *Exercises in Grammatical Analysis*, 1868; *School Songs*, 1858; *Borth Lyrics*, poems and translations, 1887; and a volume of *Miscellaneous Addresses*, published after his death in 1887.

The fullest account of his life is that written by Professor G. R. Parkin of Canada, 1898, containing copious extracts from his diary and letters, *A Memory of Edward Thring;* and *Uppingham by the Sea*, written by J. H. Skrine, the warden of Glenalmond, who was first a pupil and afterwards an assistant master at the school, presents a vivid and attractive picture of Thring's active life, and an affectionate and yet discriminating estimate of his character. Other particulars may be found in the chapter devoted to his biography in Sir Joshua Fitch's *Educational Aims and Methods*, and in *Edward Thring, Teacher and Poet*, by Canon H. D. Rawnsley. (J. G. F.)

Thun-Hohenstein.—The family of Thun-Hohenstein, one of the wealthiest of the Austrian nobility, which has for more than 200 years settled at Tetschen, in Bohemia, has given several distinguished members to the Austrian public service. Of the three sons of Count Franz, the eldest, FRIEDRICH (1810–1881), entered the diplomatic service; after holding other posts he was in 1850 appointed president of the restored German Diet at Frankfurt, where he represented the anti-Prussian policy of Schwarzenberg, and often came into conflict with Bismarck, who was Prussian envoy. He was afterwards ambassador at Berlin and St Petersburg. After his retirement from the public service in 1863 he supported in the Bohemian Landtag and the Austrian Reichsrath the federal policy of his brother Leo. In 1879 he was made hereditary member of the House of Lords. In this position he was on his death succeeded by his eldest son FRANZ ANTON, who was born in 1847. Like the rest of his family, he belonged to the Federalist party, and his appointment in 1889 as governor of Bohemia was the cause of grave dissatisfaction to the German Austrians. He took a leading part in the negotiation of 1890 for the Bohemian settlement, but the elections of 1891, in which the young Czechs who were opposed to the feudal party gained a decisive victory, made his position a very difficult one. Contrary to expectation, he showed great energy in suppressing disorder; but after the proclamation of a state of siege his position became untenable, and in

1895 he had to resign. On the resignation of Badeni in 1898, he was made minister president, an office which he held for little more than a year, for, though he succeeded in bringing to a conclusion the negotiations with Hungary, the support he gave to the Czechs and Slovenians increased the opposition of the Germans to such a degree that parliamentary government became impossible, and at the end of 1899 he was dismissed.

The third son of Count Franz, Leopold or Leo (1811–1888), was one of the leading Austrian statesmen. After studying at the University of Prague, he travelled through Europe, and among other countries he visited England, where he became acquainted with James Hope (afterwards Hope-Scott) and other leaders of the Tractarian party. He was much affected by the romantic movement and the Ultramontane revival, and after his return home interested himself greatly in the revival of Czech language and literature and the growth of the Bohemian national feeling. He formed a personal friendship with Palacky and others of the Czech leaders; he helped in the foundation of schools in which Czech should be taught, and set himself to acquire some knowledge of the language. He was also interested in prison reform, on which he wrote, and other philanthropic work. After serving under Stadion in Galicia, he was in 1848, after the outbreak of the revolution, appointed president of the administration and acting Stadthalter in Bohemia. He had scarcely entered on his duties when the rebellion of June broke out in Prague. In order to avoid bloodshed, he went down to the insurgents on the barricade, but was seized by them, imprisoned, and for some time his life was in danger. On his release he vigorously supported Windischgrätz, who was in command of the troops, in the restoration of order, but thereby lost his popularity and was superseded. He still defended the Bohemian national movement, and in one of his writings laid down the principle that nationality was one of the interests outside the control of the State. Notwithstanding this, in 1849 he accepted the office of religion and education, which he held in 1860 under the autocratic and centralizing administration of Schwarzenberg and Bach. At first he threw himself with great energy into the task of building up an adequate system of schools. He summoned experienced teachers, Protestant as well as Catholic, from Germany, established middle and higher schools in all parts of the empire, superseded the antiquated text-books and methods of instruction, and encouraged the formation of learned societies and the growth of a professional spirit and independence among the teachers. It is noticeable that at this time he insisted on the use of German in all schools of higher education. As minister of religion he was to a certain extent responsible for the concordat which again subjected the schools to the control of the Church: to a certain extent he thereby undid some of his work for the extension of education, and it was of him that Grillparzer said, "I have to announce a suicide. The minister of religion has murdered the minister of education." But during his administration the influence of the Church over the schools was really much less than, by the theory of the concordat, it would have appeared to be. The crisis of 1860, by which the office he held was abolished, was the end of his official career; for the rest of his life he was very prominent as the leader of the Federalist party in Bohemia. His high social position, his influence at Court, his character as well as his undoubted abilities, and learning not often in Austria found in a man of his rank, gave him great influence. He supported the claims of Bohemia to a full autonomy; he strongly attacked both the February constitution and the *ausgleich* with Hungary; what he desired was a common parliament for the whole empire based on a settlement with each one of the territories. With the old Czechs, he refused to recognize the constitution of 1867; he helped to draft the declaration of 1868 and the fundamental articles of 1871, and took a leading part in the negotiations during the ministry of Potocki and Hohenwart. In order to found a strong conservative party, he established a paper, the *Vaterland*, which was the organ of the Clerical and Federalist party. It is needless to say that he protested against the ecclesiastical legislation of 1867 and 1873. He married in 1847 the Countess Clàm-Martinitz, but there was no issue of the marriage.

See the very full article by Frankfurter in the *Allgemeine Deutsche Biographie*, which supersedes his earlier biography.

(J. W. He.)

Thuret, Gustave-Adolphe (1817–1875), French botanist, was born in Paris on 23rd May 1817. He came of an old Huguenot family, which had sought refuge for a time in Holland after the revocation of the Edict of Nantes. A trace of Dutch influence still persists in the pronunciation of the family name, in which the final *t* is sounded. Thuret's mother was brought up in England; English was the first language that he learnt, and he appears to have retained strong sympathies with Great Britain throughout life. As a young man he studied for the law; in his leisure time he was an ardent musician, and it was from a musical friend, de Villers, that he received, in 1837, his first initiation into botany. Beginning simply as a collector, he soon came under the influence of Decaisne, whose pupil he became. It was Decaisne who first encouraged him to undertake those algological studies which were to become the chief work of his life. Thuret twice visited Constantinople in company with the French ambassador, M. de Pontois, and was for a time attaché to the French embassy there. His diplomatic career, though of short duration, gave him a valuable opportunity of studying the Oriental flora. After travelling in Syria and Egypt in the autumn of 1841, he returned to France. Giving up his intention of entering the civil service, he retired to his father's country house at Rentilly, and thenceforth devoted himself to scientific research. He had already, in 1840, published his first scientific paper, "Notes sur l'anthére de *Chara* et les animalcules qu'elle renferme," in which he first accurately described the organs of motion of the "animalcules" or spermatozoids of these plants. He continued his studies of the zoospores and male cells of Algæ and other Cryptogams, and our exact knowledge of these remarkable motile stages in vegetable life is largely due to his labours. He spent a great part of his time, up to 1857, on the Atlantic coast of France, assiduously observing the marine Algæ in their natural habitat and at all seasons. In conjunction with his friend Édouard Bornet, he became the recognized authority on this important group of plants, of which the two colleagues acquired an unrivalled knowledge. Their work, while remarkable for taxonomic accuracy, was more especially concentrated on the natural history, development, and modes of reproduction of the plants investigated. The discovery of sexual reproduction in seaweeds is almost wholly the work of these two men. The researches on the fecundation of the Fucaceæ were published by Thuret in 1853 and 1855; the complicated and difficult question of the sexual reproduction in Florideæ was solved by the joint work of Thuret and Bornet (1867). These great discoveries—of far-reaching biological significance—stand out as the chief, but every group of marine Algæ was elucidated by the researches of Thuret and his colleague. There are few scientific authors whose work has so completely stood the test of subsequent investigation and criticism. Thuret's style in expounding his results was singularly clear and concise; he was a man of wide education, and possessed the power of expressing his ideas with literary skill. Unfortunately, much of his best work remained unpublished during his life. A portion of the material accumulated by himself and his colleague was embodied in two magnificent works published after his death—the *Notes Algologiques* (1876–80), and the still finer *Études Phycologiques* (1878). These volumes, as well as earlier memoirs, are illustrated by drawings of unequalled accuracy and beauty from the hand of the artist Riocreux, whom Thuret employed. In 1857 Thuret removed to Antibes on the Mediterranean coast, where, on a once barren promontory, he established a botanic garden which became famous throughout the scientific world. Since his death the Antibes establishment has been placed at the disposal of botanical workers as an institute for research. Thuret died suddenly, while on a visit to Nice, on 10th May 1875, when he had scarcely completed his fifty-eighth year. He was a man of considerable wealth, who devoted his money as freely as his time and labour to the advancement of science, but his high reputation rests on the brilliancy of his personal investigations.

The best and fullest account of Thuret's career is that by his friend and fellow-worker Bornet, published in the *Annales des Sciences Naturelles* for 1876. An English notice of his life, by Professor W. G. Farlow, will be found in the *Journal of Botany* for the same year. (D. H. S.)

Thurgau, one of the Swiss cantons. Its area is 387·8 square miles. Of this 327 square miles are reckoned as "productive," 70 square miles being covered with forests, and 7 square miles with vineyards, the remaining 250 being arable or meadow land. Of the 60·8 square miles classed as "unproductive," 59·7 square miles are occupied by the Lake of Constance. The population was 104,678 in 1888, while in 1900 it was 113,221, or 346 inhabitants to the square mile. The population is almost exclusively German-speaking, as in 1888 there were but 271 Italian-speaking, 195 French-speaking, and 61 Romonsch-speaking inhabitants. The existing cantonal constitution is that of 1869. The canton is divided into 8 administrative districts. The capital is Frauenfeld. In 1897 the state revenue of Thurgau was 1,874,140 francs (a rise of 43 per cent. since 1885), and the state expenditure 1,852,891 francs (a rise of 37¼ per cent. since 1885), but in 1898 there was a deficit of 107,260 francs. The public debt in 1897 was 2,710,000 francs.

Thurles, an inland town and urban sanitary district in the county of Tipperary, Ireland, on the river Suir, 87 miles south-west of Dublin by rail. There is an important monthly horse fair, largely attended by English and Continental buyers. Population (1891), 4511; (1901), 4411.

Thurman, Allen Granbery (1813–1895), American jurist and statesman, was born at Lynchburg, Va., on the 13th of November 1813. He early attained distinction at the Ohio bar, and was elected to the supreme bench of the state (1851). Save his one term in this position, and a term in Congress (1845–47), he avoided public office, though prominent in the Democratic party, till 1869, when he was sent to the United States Senate, serving there till 1881. He was recognized as a Democratic leader in the Senate, and served as chairman of the judiciary committee, and as a member of the Electoral Commission of 1877. A law through which the Government secured important advantage in its relations with the bond-aided Pacific railways was due largely to him, and was commonly known as the Thurman Act. In the Democratic conventions from 1876 onwards he was a candidate for the Presidential nomination. In 1888 he was named for Vice-President on the ticket with Cleveland, but was defeated in the election. He died at Columbus, Ohio, 12th December 1895.

Thyrostraca.—As shown by Burmeister in his historical review (1834), these animals, comprised by Linnæus in the genus *Lepas*, first received a more comprehensive title from Cuvier, who called them Cirrhopoda, a word strictly meaning tawny-footed. Lamarck in 1809 altered this into the hybrid form Cirrhipoda, meaning curl-footed, which was subsequently improved into Cirripedia or Cirrhipedia. So long as the group was held to be a subordinate member of the Entomostraca, this term, though not the earliest, was generally accepted. The name Thyrostraca, meaning door-shells or valve-shells, is now to be preferred, as agreeing in termination with the titles of the other two divisions, the Malacostraca and Entomostraca, from which, in the article Crustacea, the present group has been already distinguished. It may conveniently be arranged in two principal sections—the Genuina with cirrhiform feet, and the Anomala without them.

Thyrostraca genuina.—It is with these that Darwin's classical and still essential treatises (*Ray Soc.* and *Palæont. Soc.*, 1851–1854) are almost exclusively concerned. Therein an order Thoracica comprehends the pedunculate Lepadidæ, together with the operculate and sessile Balanidæ and Verrucidæ; a single species without cirrhi constitutes the order Apoda, and a single species with only three pairs of cirrhi the order Abdominalia. Within the last *Kochlorine* (Noll, 1872) with two species, and *Lithoglyptes* (Aurivillius, 1892) with three species, have since been included. But H. J. Hansen (*Die Cirripedien der Plankton-Expedition*, 1899) states that *Cryptophialus minutus*, for which the order Abdominalia was founded, has, like *Alcippe* and other Genuina, its cirrhi on the thorax, not, as Darwin wrongly supposed, on the abdomen. In place, therefore, of the Abdominalia, it will be right to accept the family Cryptophialidæ, v. Martens, side by side with the Lithoglyptidæ of Aurivillius and the Alcippidæ of Gerstaecker. These, with Darwin's three families above mentioned, will complete the section of genuine cirripedes now existent. Gruvel has recently submitted to the Linnæan Society a rearrangement of the Lepadidæ, unfortunately using for the first of his new families the preoccupied name Anaspidæ. It is confusing, but not uninstructive, to find that within the Balanid group such generic titles as *Stephanolepas* and *Platylepas* have been coined. The vernacular name barnacle, traceable to the fable of pedunculate cirripedes hatching out into bernicle geese, has also been transferred to the sessile cirripedes, which are popularly known as acorn barnacles. The scientific student may be congratulated on the fact that a complete and luminous list of all the recent species of Thyrostraca in both sections, down to the year 1897, has been published by Weltner (*Arch. Naturg.*, Jahr. § 63, part i., pp. 227–280, 1898). For fossil species, Woodward's *Catalogue of Brit. Foss. Crust.*, pp. 137–144, 1877, should be consulted. Hoek (*Challenger Reports*, vol. viii., "Cirripedia," pp. 8–11, 1883) gives a brief geological summary down to 1882. In that year J. M. Clarke (*Amer. Journ. Sci. and Arts*, ser. iii., vol. xxiv. p. 55) added a new species to *Plumulites* (Barrande, 1872), remarking that the species in question, *P. devonicus*, "is interesting in being the first representative of fossil barnacles from the Devonian, Barrande's species of *Plumulites* and *Anatifopsis*, as well as the *Turrilepis* of Woodward, being from the Upper and Lower Silurian, and *Plumulites Jamesi* (Hall and Whitf., *Pal. Ohio*, vol. ii.) from the Hudson River group." Since *Plumulites* appears to be a synonym of *Turrilepas* (not *Turrilepis*), the species *Turrilepas Wrightii*, Woodward, 1865, from the Upper Silurian of Dudley, did not long enjoy its isolated eminence as the oldest known cirripede. As pointed out by Dr Bather (*Geol. Mag.*, decade 4, vol. viii. p. 521, 1901), palæontologists themselves have in this branch not very closely followed the progress of their own science, since Dr Ruedemann, in regard to his new *Pollicipes siluricus*, 1901, speaks of "the enormous gap existing between the appearance of this Lower Siluric type and the next Upper Triassic (Rhætic) representatives of the genera *Pollicipes* and *Scalpellum*." Many species of *Scalpellum* from the Wenlock shale of Gotland were described in 1892 by C. W. S. Aurivillius, who at the same time founded the species *Pollicipes signatus* on an almost perfect specimen from the Lower Ludlow of Wisby in Sweden. "Aurivillius considered that *Pollicipes signatus* showed a closer approach to the Balanidæ than any other of the Lepadidæ, but he, too, in ignorance of the Devonian *Protobalanus* (Whitf.), discoursed needlessly about the gap in the distribution." Dr Bather justifiably anticipates further discoveries, but if, already in Silurian as in modern times, the members of these families had to pass through nauplius and cypris stages to maturity, there is one "enormous gap" between them and the common ancestor of the crustacean class that will not be very easily filled. To later phylogenetic links an addition is offered by Dr Woodward (*Geol. Mag.*, p. 145, 1901), who transfers his *Pyrgoma cretaceum*, 1865, to a new genus *Brachylepas* (Fig. 1), and a new family (*Brachylepadidæ*, intermediate between the Rhætic *Pollicipes* and the modern *Balanus*. Among other fossil genera of recent institution, *Archæolepas*, *Lepidocoleus*, *Squama*, *Stramentum*, can only be mentioned as incentives to research. Among living forms, added since Weltner's catalogue, may be noticed *Koleolepas Willeyi*, from the Loyalty Islands (Stebbing, in Willey's *Zool. Results*, part v., p. 677, 1900). This was found in a Turbo shell, occupied also by a Pagurid, and coated with Actinians. The cirripede, which has an elastic peduncle, a crested capitulum, but no valves, and the first cirrhi longer than the rest, should stand near *Eremolepas*, the name given by Weltner in place of the preoccupied *Gymnolepas* (Aurivillius). In the genus *Scalpellum*, *S. giganteum*, Gruvel (*Trans. Linn. Soc.*, 1901) disputes with *S. Stearnsii* (Fig. 2), Pilsbry, 1890, which shall be accounted the greatest. The latter is threatened with a new generic name (Chun, *Aus den Tiefen des Weltmeeres*, p. 502, 1900).

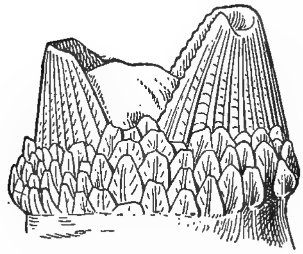
FIG. 1.—*Brachylepas cretacea* (Woodward), from Margate chalk.

The horizontal distribution of barnacles over all seas is fully explained by Darwin. The bathymetric range of sessile as well as pedunculate forms down to such depths as twelve or eighteen thousand feet—*Verruca quadrangularis*, Hoek, 1900 fathoms; *Scalpellum regium*, Wyville Thomson, 2850 fathoms—is a more recent discovery. Gruvel (*Contribution à l'étude des Cirrhipèdes*, 1894) found that species frequenting the sea surface or shallow water, notwithstanding their feeble powers of vision, cannot live long when entirely debarred from light. It must therefore be supposed that abyssal forms have gradually acquired such tolerance of darkness as makes their health independent of the sun. Among other singularities of habitats, not the least curious is the freedom with which some small species, especially in the genus *Dichelaspis*, occupy the very jaws of large crustaceans. It is generally stated that cirripedes are confined to salt water, and, generally speaking, that is true. But *Platylepas bissex-lobata* (De Blainville), from the west coast of Africa, is sometimes found entirely buried, except its operculum, in the skin of the manatee. Now, since it seems this *Manatus senegalensis* "freely ascends the rivers, frequents the lagoons, and has even been captured in Lake Tchad," we may infer that its parasite travels with it. Whether the journey is in any way detrimental to the cirripede, those should determine whom opportunity favours. Studer (*Crustacea of the Gazelle*, 1882) records *Balanus amphitrite*, Darwin?, from roots and stems of mangroves in the Congo, where, he says, "it follows the mangroves as far as their vegetation extends along the stream, to six sea-miles from the mouth." Darwin notes *B. improvisus* as quite tolerant of water not saline. Why the Thyrostraca, so hardy, so widely dispersed and multitudinous, and with a history so prolonged, should not have made more extended and more independent incursions into fresh water remains a problem. Though the *Ornitholepas australis*, Targioni Tozzetti, 1872, found on the tail feathers of a bird, represents only the cypris-larva of a cirripede, it still shows one of the many facilities for dispersion which these creatures enjoy. A striking instance of their abundance is cited by Aurivillius (1894) from a report by Captain G. C. Eckman, who late in the summer observed great masses of *Lepas fascicularis* forming broad belts in the North Sea. Aurivillius himself examined a humpback whale which had as many as fifty specimens of *Coronula diadema* on each side of its head. He believes that the cetacean approaches not only rocks but ships in the hope of freeing itself from its lodgers. Yet the fact that the long, soft *Conchoderma auritum* stands exposed on the *Coronula*, sometimes ten on one, indicates that the whale can have little chance of evicting its tenants, even at the expense of rubbing off the eighteen flattened horns of its own skin embedded in cavities round the domed base of the Coronula shell. The fecundity in the genus *Lepas* has struck many observers. Hoek (*Chall. Rep.*, vol. x., "Cirripedia," 1884) notes that, while in *Scalpellum* the number of eggs may be less than a hundred, "in *Lepas anatifera* it amounts, on the contrary, to many thousands and tens of thousands." In the same treatise Dr Hoek has useful chapters on the anatomy, development, and sexes of the group, with references to the important researches since Darwin by Krohn, Claus, Kossmann, and others. Francis Darwin, in the life of his father (vol. iii., p. 2, 1888), says, "Krohn stated that the structures described by my father as ovaries were in reality salivary glands, also that the oviduct runs down to the orifice described in the *Monograph of the Cirripedia* as the auditory *meatus*." Hoek, however, observes that the interpretation of the glands as salivary is not given by Krohn as his own opinion, but only quoted from Cuvier. Hoek himself proposes to call them pancreatic glands.

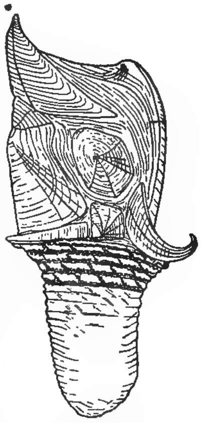
FIG. 2.—*Scalpellum Stearnsii.*

Two-thirds nat. size.

On the absorbing question of development, T. T. Groom (*Phil. Trans.*, vol. clxxxv., 1894) supplies a full bibliography, beginning with the pioneers Slabber, 1778 (properly 1769), and J. Vaughan Thompson, 1830. Groom's monograph was almost immediately supplemented by Chun's chapters on the same subject (*Bibliotheca Zoologica*, Heft 19, Lieferung 2, 1895), to which an important discussion is contributed by H. J. Hansen (*Cirripedien der Plankton Exp.*, 1899). He insists on the value of the upper lip or labrum for generic distinction, and as an aid in affiliating larval forms of different stages to their several species. He cites Groom's evidence that larvæ obtained from the egg readily go through one moult in the aquarium, and the known fact that the last larval stage is marked by a longitudinal series of six pairs of immovable spines or processes. He considers, then, that by a judicious comparison of larval forms with these two easily determinable stages the poverty of existing information on the subject may be gradually, if laboriously, diminished. The large and peculiar *Archizoea gigas* of Dohrn must, he thinks, belong to the Lepadidæ as a larva in the last stage, but not, as v. Willemoes Suhm supposed, to *Lepas australis*, or even to the genus *Lepas* at all.

Thyrostraca anomala.—This section comprises Darwin's Apoda, the footless, Lilljeborg's Suctoria, called by Fritz Müller the Rhizocephala, or rootlet-headed, and the group to which Lacaze-Duthiers gave the alternative names Ascothoracida, sac-bodied, or Rhizothoracida, rootlet-bodied. For the present these names may be dispensed with in favour of their equivalents, the three families Proteolepadidæ, Sacculinidæ, and Lauridæ. The first is still limited to the single genus and species *Proteolepas bivincta*, Darwin, parasitic within the sac of another cirripede. Nothing is certainly known of its development, except that the ova are extremely small, but H. J. Hansen (*Die Cirripedien der Plankton-Exp.*, p. 53, 1899) argues that various nauplii of a type not previously described may probably be referred to this group or family, to which man's ignorance rather than nature's insufficiency has hitherto given so trifling an extension. The second family, discussed by Delage, Giard, Kossmann, and others, has no dearth of genera and species, though about several of them the information is scanty enough. Almost all of them are parasitic on other crustaceans. *Sphærothylacus polycarpus*, Sluiter, 1884, has an ascidian for its host. *Sarcotaces* (Olsson, 1872) has two species parasitic in fishes. But these exceptional and dubious forms do not obtain nutriment by sending rootlets in a rhizocephalous manner into their patrons. The family Peltogastridæ is sometimes separated from the Sacculinidæ, and sometimes made to do duty for both, the latter course being improper, since *Sacculina* (J. Vaughan Thompson, 1836), is not, as has been supposed, preoccupied, and must therefore take precedence of *Peltogaster* (Rathke, 1843). In the same family stands the genus *Sylon*, noted by Kröyer without a name in 1842, named by him without a description in 1855, described by Michael Sars in 1869, and published by G. O. Sars in 1870. Hoek (*Challenger*, *Rep.*, vol. xxiv. App. A, 1888) will orientate the English reader on this genus. For the complicated parasitism of isopods and Sacculinidæ on the same hosts Giard and Bonnier (*Bopyriens*, p. 197, 1887) should be consulted.

The remaining family may till further knowledge be allowed to cover four remarkable species, three of them resident on Anthozoa, one on an echinoderm. Only the first, the celebrated *Laura gerardiæ*, Lacaze-Duthiers, 1865, sends such rootlets into its host as would justify the term Rhizothoracida. The small sinuous segmented body is enclosed, except for one small opening, in an enormous sac-like carapace, between the lamellæ of which are protruded from the body the ovary and "liver," both large, bifurcate, and ramified. It is this sac-like and not valvular carapace, therefore, that justifies the term Ascothoracida. But *Synagoga mira*, Norman, 1888 (*Brit. Assoc. Report* for 1887, has the body covered by two nearly circular valves instead of a sac. *Petrarca bathyactidis*, G. H. Fowler (*Quart. Journ. Micros. Sci.*, vol. xxx. part ii. p. 115, 1889), has a bilobed carapace, ventrally open. *Dendrogaster astericola*, Knipovitch (*Biologisches Centralblatt*, vol. x. p. 707, 1891), is a multilobular sac, with apparently indistinct segmentation of the body proper on the dorsal side. For this highly problematic group the original authorities should by all means be consulted. The student may then be asked to compare the account of *Synagoga mira* both with the figure of the cypris-stage of *Dendrogaster astericola* and with the figure of the "indeterminate animal found on Gerardia," about which Lacaze-Duthiers asks, "Is it the cypris-stage of Laura?" (*Mém. Acad. Sci.*, vol. xlii. p. 160, pl. 1, fig. 102, 1883). *S. mira* was found, like *Laura gerardiæ* (Fig. 3) in the Mediterranean, and found like it attached to an antipatharian. Its six pairs of limbs are not like the bare and simple feet of the *Laura*, but two-branched and setose as in the ordinary cypris-stage of the cirripede. The conclusion, therefore, from these facts and from the suggested comparisons, seems at least extremely probable that the question asked by Lacaze-Duthiers should be answered in the affirmative, and that *S. mira* is either the cypris-stage of *Laura gerardiæ* or of some congeneric species. In Lacaze-Duthiers's highly-elaborated memoir it should be noticed that he uses the term "cirrhes" rather misleadingly, not for cirrhiform feet, but as the equivalent of setæ. Also he gives two different reckonings of the segmentation, counting first eleven body segments without the caudal furca (p. 40), and then the caudal furca as itself the eleventh segment (p. 41). Of *Petrarca* the development is not yet known. The points of agreement and difference between it and *Laura* are carefully drawn out in the essay by Dr Fowler, who inclines to favour a close relationship between the Thyrostraca and Ostracoda. To the extreme development of the carapace in *Laura* as compared with the segmented body it would be difficult to find among crustaceans any analogy more striking than that of the great ovarial expansions in *Nicothoe astaci*, the little copepod parasite of the common lobster. The compactness of the class Crustacea is generally admitted; of the precise affinities of its subdivisions there is still much to learn. (T. R. R. S.)

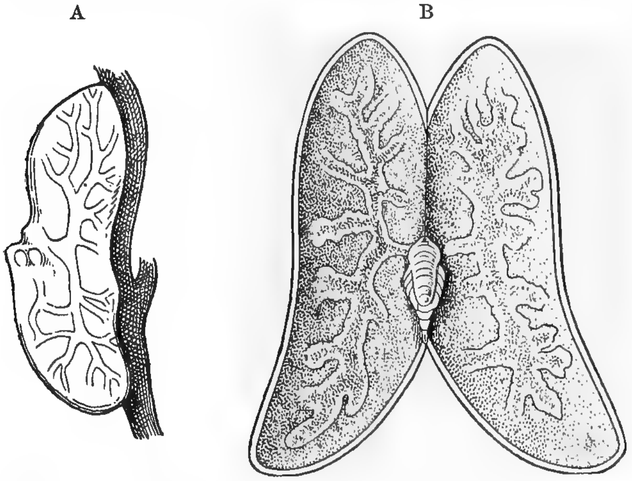

Fig. 3.—A, *Laura Gerardiæ;* B, carapace slit open to show the body proper.

Tiber (Italian, *Tevere*), a river of Italy. It traverses the Tuscan Apennines—in which it rises at a point some 5 miles north of Pieve San Stefano—in a series of picturesque ravines, skirts the west foot of the Sabine Mountains in a broad, shallow valley, then crosses the Roman Campagna, cutting its way through Rome, and finally enters the Tyrrhenian (Mediterranean) Sea by two arms at Ostia and Fiumicino. Its principal tributaries are the Paglia, the Nera, and the Anio or Teverone, and it is generally navigable by boats up to the confluence of the Nera, a distance of 104 miles. The total length of the river is 240 miles, of which 21 miles lie between Rome and the sea. This latter portion of the river's course, although the depth varies from only 7 to 20 feet, and in places at low water does not exceed 4 feet, is nevertheless navigated by vessels up to 180 tons burden. The area of the river basin is 6845 square miles. The stream is heavily charged with sedimentary matter, and from that circumstance got its ancient epithet of *flavus* (tawny). It does not, however, form a delta proportionate to the volume of its water. This is owing to the existence of a strong sea current flowing northwards close to the shore, to the sudden sinking of the sea to a great depth immediately off the mouth of the river, and possibly also to the permanent subsidence of the Italian coast from the Tiber mouth southwards to Terracina. Still it has in the course of centuries formed a small delta between its two arms, the district known to the ancients as the Isola Sacra (Sacred Island), about 3 miles across. From Rome to the sea the fall is only 6·5 : 1000. Fiumicino is connected with the river by a canal, dug by Trajan, 2½ miles long, 80 to 130 feet wide, and with a minimum depth of 5 feet. The lower course of the Tiber has from the earliest ages been subject to frequent and severe inundations, those of 1598, 1870, and 1900 having been especially destructive; but since the year 1876 the municipality of Rome, assisted by the Italian Government, has taken steps to check, and possibly to prevent the occurrence of these calamities, by constructing embankments of stone, resting on caissons, for a total distance (counting in both sides of the river) of 6 miles, at a cost amounting in 1900 to a total of £5,000,000. The portion of the river thus embanked, and otherwise improved by straightening and clearing the channel near the Tiber island, is that which stretches from the new Ponte Margherita (near the Piazza del Popolo), at which point the river is 80 yards wide, to the Ponte Palatino, below the Tiber island, where its width increases to 113 yards and its depth is 16 to 43 feet. In December 1900 fully a quarter of a mile of the solid masonry of this new embankment (made in 1885–86), on the right bank, between the Garibaldi and the Cestio bridges in Rome, collapsed and was swept away by the stream, while weakness and partial subsidence manifested themselves at other points of the embankment within the city. (J. T. Be.)

Tiberias, now *Tabarieh*, on the western shore of the Sea of Galilee. It is the seat of a mission of the United Free Church of Scotland with hospital and school, of a Franciscan hospice, church, and school, and of a Greek monastery and school. On a spur to the south of the town are the ruins of a fortress probably built by Herod. The population of 4000 includes about 2600 Jews.

Tibet.—The main outlines of Tibetan physiography have been so well illustrated already in the article on Tibet in vol. xxiii. (ninth edition) of this Encyclopædia, as to leave little more to be said, in spite of the continuous activity in geographical research which has been maintained in these regions during later years. The Indian approaches to Tibet have been systematically closed against travellers by the jealous interference of Tibetan and Chinese officials, so that nearly all the fresh geographical information which has been added since 1885, or thereabouts, to our previous knowledge of the country, has been obtained by travellers who crossed the border either from Kashmir on the west or from Turkestan and China on the north and east. Although Lhasa is within 200 miles of the frontiers of Sikkim, no European has lately succeeded in reaching that mysterious city, and our knowledge of it is still chiefly derived from native explorers. On the northern borders of the great Changtang—the central lake region which is flanked to the south and west by the Himalaya and their northern offshoots, and to the east by a vast mountain wilderness which contains the sources of the great rivers of Burma and China—the Kuen-lun and the secondary mountain chains diverging therefrom have been scientifically explored by a series of travellers following on the footsteps of Prjevalsky; and it is here that we have to note certain amendments which have become necessary to our previous conceptions of Tibetan mountain configuration. The surveys of the Pamir Boundary Commission in 1895, followed by those of Captain Deasy, subsequently show that it is no longer correct to describe the Tibetan plateau as merging into the Pamirs on the west. No part of the Pamir region directly borders Tibet, nor can there be traced that connexion between the Kuen-lun and the mountains bordering Lake Victoria which was claimed by Stoliczka. The Kuen-lun, indeed, in its extreme north-western offshoots, abuts on what is known as the Mariom Pamir, in the basin of the Zarafshan river, but the Kuen-lun has ceased to represent the northern boundary of Tibet politically (if not geographically) long before it touches the Zarafshan, and the Mariom Pamir (if it can be recognized as a true Pamir) is separated by the whole border of the double range of the Sarikol from the "Great" Pamir of Lake Victoria. A northern offshoot of the giant Muztagh chain, forming an irregular transverse watershed, which connects the eastern and final buttresses of the Muztagh with the Kuen-lun in about 80° E., represents the western boundary of Tibet as recognized politically in the present day, although the Changtang (or tableland) to the west of it differs in no essential physical aspect from the Aksai chain to the east. The long, straight axis of the Kuen-lun, extending through 20 degrees of longitude, along the parallel of 36° N., and defining the northern edge of the great central Tibetan upheaval as clearly as does the main snowy chain of the Himalaya on the south, is now known to be traversed by at least one important river (the Kiria), which passes from the plateau to the plains of Turkestan across the axis in about 82° E., and is finally lost on the sands of the Takhla Makan.

In the eastern section of the Kuen-lun, where the barren wind-swept solitudes of the Tsaidam stretch northwards to the Altyn Tagh and Nan Shan ranges, our geographical knowledge has been greatly extended by Russian explorations and by the researches of Sven Hedin. The absolute elevation of the Tsaidam uplands is about 9000 feet above sea, and its vast spread of desert and swamp is shown to be allied to the Tibetan tableland in configuration and physical aspect, and to be entirely distinct from the Turkestan depression which centres about Lob Nor to the north of it. We may therefore fairly include Tsaidam as an integral part of Tibetan geography. Such was the view taken by General Walker in the article in the ninth edition of this work, in contradistinction to later authorities, notably Mr W. Rockhill, who is disposed to regard Tsaidam politically as a sort of no man's land, because of the ethnographical and administrative distinctions existing between its nomadic and marauding Mongolian and Tibetan inhabitants and the tribes and people of the south.

In eastern Tibet much advance has been made in unravelling the secrets of Asiatic hydrography by the identification of the sources of the Yangtse, the Hoang Ho (Yellow river), the Mekong, and the Salween, all of which originate in the mountain borderland of eastern Tibet, and can now be placed with some approach to accuracy in their relative geographical positions on the map of Asia. The climate and conformation of the surface of the central tableland have also been the subject of scientific observation by the many distinguished travellers who have crossed it, and much new light has been thrown on the ethnographical conditions of its nomad inhabitants.

For these and many other recent additions to our scientific knowledge of Tibet we are indebted to a number of travellers, Russian, English, French, American, Swedish, and Indian, a brief summary of whose work is necessary in order to illustrate the gradual progress of scientific investigation.

Russian explorers.

The great Russian explorer Prjevalsky, although he was not, strictly speaking, an explorer of Tibet, did very much incidentally towards determining the conformation of its north-eastern and eastern mountain systems. His third journey into Central Asian wilds, which lasted from March 1879 to October 1880, included the sources of the Hoang Ho, or Yellow river, till then unmapped and unknown. His fourth journey, between November 1883 and October 1885, covered much of northern Tibet, and established the true character of Tsaidam. It was when setting out in 1888 to make an attempt to reach Lhasa that he died.

After Prjevalsky's death, Roborovski, with several companions, explored the western ranges of the Kuen-lun, and crossed southwards into Tibet, tracing the course of the Kiria river to the north-western plains of the central plateau. The distinguishing feature of these explorations, led by Russian officers, is their high scientific value, and the contributions they have offered to the botany, natural history, geology, and meteorology of the regions under investigation in addition to the actual geographical data attained. The Kuen-lun is known in their writings as the Russian Range.

Indian native explorers.

Following the example of previous distinguished native explorers of the Indian Survey, Lama Ugyen gyatso, who worked in direct connexion with Sarat Chandra Das of the Bengal Educational Department from 1878 to 1883, made Lhasa his chief objective. He was originally a teacher of Tibetan in a Darjiling school, and being deputed to take tribute from his monastery to Tashilunpo and Shaia, he secured permission from the Tibetan authorities for Chandra Das to visit the Tashilunpo monastery, where his name was entered as a student. This was the opportunity for a series of most valuable exploratory journeys through the Tibetan provinces adjoining the Indian and Nepalese frontiers, which have added greatly to our stock of information about Lhasa and the districts surrounding that city. In their first journey the travellers set out from Jongu in Sikkim, and traversing the north-east corner of Nepal, crossed into Tibet by the Chatang la, and travelled northwards to Shigatsé and Tashilunpo. They returned by much the same way to near Khamba djong, and re-entered Sikkim by the Donkhya la. The journey was fruitful of information and valuable for mapping.

After a second journey into southern Tibet, the lama undertook another journey in 1883 to complete and extend his former surveys. Travelling by way of Khamba djong directly to Gyantsé and Shigatsé, he turned eastwards at the latter town, finished the survey of the Yamdok tso, and crossed the Himalaya into the valley of the Lobratsangpo or upper Manas river. At Shakhang djong he was arrested, and his true character discovered. He managed, nevertheless, to extricate himself, and turning north-eastwards he passed through Chetang, and reached Lhasa by way of Samyé monastery. From this city he started for Darjiling, which he reached on 15th December 1883.

Sarat Chandra Das's reports of his two journeys were published by the Indian Government, but for political reasons were until about 1889 kept strictly confidential. In 1899 they were edited, but not yet published, by the Royal Geographical Society. They contain a great amount of valuable information on the geography, ethnology, and religion of Tibet. Chandra Das also brought back from his journeys a large number of interesting books in Tibetan and Sanskrit, the most valuable of which have been edited and published by him, some with the assistance of Ugyen gyatso. As a reward for these geographical and other services Chandra Das was made C.I.E. and granted a *jaghir*.

W. W. Rockhill, 1888–89, 1891–92.

In 1882 Mr Rockhill, an American, leaving the lamasery of Kumbum in north-western Kansu with three Chinese servants and a small caravan, proceeded round the north shore of Koko Nor, crossed eastern Tsaidam, and explored some of the rivers and lakes directly south of that region. Leaving Barong Tsaidam, he travelled south by way of the sources of the Yellow river, till he reached the Dré chu (upper Yangtse-kiang), which he crossed to the north of the important trading centre of Gyékundo. From this point he followed the valley of the Dré chu till about lat. 30° 30′, when he passed into the basin of the Yalung river, traversed the Horba states, and finally reached Tachienlu by the Gi la and the valley of the Darchu.

In 1891 Mr Rockhill, starting again from Kumbum with three Chinese, passed south of Koko Nor through the country of the pastoral Panaka Tibetans, and by a very difficult pass (Wahon la) entered again the basin of the Tsaidam. He then turned west, followed the base of the south Tsaidam range as far as the Naichi Gol, where he entered the southern mountainous region forming the northern borderland of Tibet. From this point the traveller followed a general south-westerly direction around the heads of all the feeders of the upper Dré chu, and thence into the lake region of northern central Tibet, crossing Bonvalot's route south of the Chib-chang tso and that of Bower a few days farther south. Near the Namru tso his farther progress south was arrested, and he was compelled to take an easterly course. After making a long détour north, often crossing the roads previously travelled by Bonvalot and Bower, and passing by Riwoche, he came to Chamdo and Tachienlu. The results of Mr Rockhill's two journeys were most valuable.

Gabriel Bonvalot 1889-90.

Bonvalot, accompanied by Father Dedeken of the Belgian Catholic Mission and Prince Henri d'Orléans, left Charkalik, south-west of the Lob Nor in November 1889, and taking a very nearly due southerly course, reached on the 13th of February 1890 the eastern end of the Tengri Nor. Then pushing on southwards, he crossed the Nyinchen tang la and entered the Dam district near the Lhasa-Hsining highroad. Here the party was stopped by Tibetan authorities and forced to take the tea route through Chinese Tibet (Gyade) by way of Batasumdo, Chebotenchin, Riwoche, Chamdo to Chiangka, near the upper Yangtse-kiang, whence they proceeded to Tachienlu by Batang and Litang. Bonvalot noted some extinct volcanoes in the northern Tibet desert.

Captain H. Bower, 1891-92.

Accompanied by Dr W. G. Thorold, of the India Medical Service, and a native sub-surveyor, Captain Hamilton Bower, I.S.C., set out from Leh on 1st June 1891, and crossed the Lanak la and the Ladak frontier on 3rd July. From this point the party took a general easterly direction past the Mangtza tso, Horpa tso, Charol tso, and around the northern end of the Aru tso, all important lakes, at an average altitude of about 16,500 feet. From the Aru tso the travellers took a south-easterly direction across the great northern plateau or Changtang till they reached the south-east side of the Garing tso, in about 31° 30′ N. and 89° 10′ E. At this point Bower was stopped by some of the headmen of the Tibetan pastoral tribes (here under the rule of Lhasa), and obliged to make a long circuit to the north well out of Lhasa territory, and then eastward—till he struck the road to Chamdo through Gyade or Chinese Tibet. Crossing the Hsining-Lhasa road a little south of the Dang la range, and about two days' journey north of Nagchuka, Captain Bower crossed the Su chu, and following a course parallel to the Gyama-nu chu, he made his way to Riwoche and thence to Chamdo, from which town he followed the Lhasa-Tachienlu highroad to the latter town, which he reached on 10th February 1892. The results of Captain Bower's journey were all of first-class importance.

Miss A. R. Taylor, 1892.

Miss Annie R. Taylor, an Englishwoman of the China Inland Mission, started from Tao-chou (Kansu) in September 1892, accompanied only by five Asiatics. Passing by the famous lamasery of Labrang, south of the Yellow river, she crossed that river and traversed the southern part of the country inhabited by the predatory Tibetan tribes called Golok. Thence, after crossing the upper Za (or Tsa) chu, which flows by the town of Kanzé, she pursued her journey to the upper course of the Yangtse-kiang (Dré chu), crossing that river somewhere near where A. K. had crossed it in 1881 and Rockhill in 1899, and then came to the town of Gyékundo. From this point she seems to have followed the Chamdo road to near that town, when she turned westwards and continued in that direction till she came on the highroad from Lhasa to Hsining Fu somewhere north of Nagchuka. Here, like all other European travellers who have tried to reach Lhasa from the north, she was stopped by the Lhasan authorities. She appears to have followed about the same route on her way back to China, for she again went to Gyékundo and thence by the highroad, followed previously by A. K. and Rockhill, to Tachienlu in Szechuen, where she arrived 12th April 1893.

Dutreuil de Rhins and F. Grenard, 1893-94.

In 1893 Mr J. L. Dutreuil de Rhins and F. Grenard, both Frenchmen, left Cherchen, with Lhasa as their objective. After crossing the Kara muren davan in the Arka Tagh, they entered the lake region of north Tibet and followed a general southerly direction across low ranges of hills and by numerous small lakes till they arrived in 32° 30′ N., where they changed direction to east-south-east, passing to the north of the Chargut and Gyaring lakes. The travellers were able to push on as far as the north-eastern bank of the great Tengri Nor, which they reached 30th November 1893. Here they were finally stopped by the Tibetans, and after a delay of six weeks passed in vain attempts to obtain permission to go to Lhasa, they were only allowed to proceed to Nagchuka on the Hsining-Lhasa road, and to continue by the Gyade route to Gyékundo, near the upper Dré chu, and thence to Hsining in Kansu. From Nagchuka the travellers followed a heretofore unexplored road through the Gyade country, crossing Rockhill's route in the Peré-Sangyi districts near Trashiling (their Tachi gomba). The road followed by them to Gyékundo is called by Tibetans the upper road (*gong lam*), and had apparently been followed previously by Miss Taylor. Reaching Gyékundo (or Giergundo) on 21st May 1894, the travellers started for the Koko Nor and Hsining on 1st June; but the party was attacked near Tungbumdo (Tumbumdo of previous travellers), and Dutreuil de Rhins was killed on 5th June. Mr Grenard after a few days resumed his march, passed east of the Noring tso, the eastern extremity of Tosu Nor, and thence by the south-east corner of Koko Nor to the town of Hsining Fu in Kansu. The results of this exploration have been a large number of maps and a report of great scientific importance.

St George R. Littledale, 1895.

Mr Littledale, an Englishman, accompanied by his wife, left Khotan in the early part of 1895, and travelling thence to Cherchen, he turned southwards, and following up the course of the Cherchen daria to a point near its source, he continued in that direction between 87° and 89° E. across the northern plateau of Tibet till he reached the Zillang (or Garing) tso. Pursuing, amidst great difficulties, his southerly course, he finally reached the western bank of Tengri Nor. Pushing rapidly on in the direction of Lhasa, when not over 50 miles away from the city (camp, 30° 12′ 12″ N.), he was finally stopped by the Lhasan authorities and obliged, in great part on account of the severe illness of Mrs Littledale, to give up the attempt to reach Sikkim, and to take a direct trail to Ladak. In the latter part of this remarkable journey Littledale's route lay parallel but to the south of the routes followed previously by Nain Sing, and more recently by Bower. Passing by Rudok, the party re-entered Ladak at the village of Shushal on 27th October 1895, and Leh on 2nd November. Mr Littledale surveyed about 1700 miles of country between Cherchen and Shushal, and brought back a valuable collection of plants, which, added to those collected by other travellers in this part of Tibet, has enabled botanists considerably to extend their very scanty knowledge of this region.

Captain M. S. Wellby, 1896.

Accompanied by Lieutenant Malcolm of the 93rd Highlanders, Captain Wellby, of the British army, left Leh on 4th May 1896. The travellers were compelled to enter Tibet by way of the Lingten tso in 35° N. From this point they turned due east, and continued, with the usual incidents experienced by all travellers in these regions—cold, storms, lack of food and of grass, loss of ponies and pack animals, &c.—until they reached the northern branch of the Dré chu, the Chumar. Passing into the valley of the Nomoron Gol, south of the Tsaidam, they made their way by Barong Tsaidam to Tankar and Hsining Fu by the highroad along the northern shore of the Koko Nor.

Captain H. H. P. Deasy, 1896.

Captain Deasy, of the British army, left Leh on 27th May 1896, and crossing the Lanak la, passed by the Mangtza tso, north of the Horpa tso, to Yeshil kul. Thence he endeavoured to proceed due east, but was obliged by the nature of the country to turn south, crossing Bower's route on the west side of the Aru tso. He finally completed a valuable survey of an important part of western Tibet.

Sven Hedin, 1896.

In 1896 Sven Hedin, a Scandinavian, left Kopa, a point about 100 miles south of Cherchen, and after crossing the Arka Tagh took an easterly course between that range and the western continuation of the Kokoshili range till he entered the valley of the most northerly feeders of the Dré chu, when he passed into the valley of the Naichi Gol and entered the Tsaidam. His careful observations concerning the meteorology of this region are of great value, and his surveys between Kopa and the Naichi Gol were in a country not previously explored. The country traversed, however, can hardly be considered as forming a part of Tibet, though its configuration is the same as that farther south in the great Tibetan plateau crossed by other travellers.

Sven Hedin, 1901.

During his second journey in Central Asia, Sven Hedin left Charkalik in May 1901, intending to cross Tibet in a diagonal direction to the sources of the Indus. Arriving within fourteen days of Lhasa, he left the bulk of his caravan and pushed rapidly on towards that city, but was stopped when about five days from it. Rejoining his caravan he turned westwards, and passing through the country previously traversed by Bower and Littledale, he reached Leh on 20th December 1901.

Captain P. K. Kozloff, 1900-1901.

In May 1900 Kozloff, in command of the Russian Geographical Society's expedition to Central Asia and Tibet, left Barong Tsaidam, and travelling southwards, came to the Dré chu (his Ndu chu or Blue river), at about the same point as Rockhill in 1889. Assisted by the old chief of Nyamtso, he crossed the river and reached Gyékundo (his Jarku Lomba). One stage beyond this place he left the route followed by former travellers and pushed northwards to near the town of Chamdo, where after a sharp fight with the natives he turned eastwards. The winter was passed in the valley of the Ra chu, a tributary of the Chamdo chu (his Dza chu), and excursions were made as far as Dergé droncher. In the spring of 1901 the expedition resumed its march eastwards around the Dré chu and the Ja chu (Yalung river), followed up the left bank of the latter, and got back to Russian Lelu (Oring tso) on 30th May 1901. The scientific results of this expedition, so far as can be judged from the very meagre accounts published, appear to be important.

Geography.

Physically Tibet may be divided into two parts, the *lake region* in the west and north-west, and the *river region*, which spreads out on three sides of the former on the east, south, and west. The lake region extends from the Pangong tso in Ladak, near the source of the Indus, to the sources of the Salween, the Mekong, and the Yangtse. This region is called the Changtang (Byang Tang) or "Northern Plateau" by the people of Tibet. It is some 700 miles broad, and covers an area about equal to that of France. From its great distance from the ocean it is extremely arid, and possesses no river outlet. The mountain ranges are spread out, rounded, disconnected, separated by flat valleys relatively of little depth. The country is dotted over with small lakes, many salt or alkaline, and intersected by streams, and the soil is boggy and covered with tussocks of grass, thus resembling the Siberian tundra and the Pamirs. Its average altitude is over 16,000 feet, the northern portion of it being the highest. The southern portion, from Lake Pangong to Tengri Nor, is inhabited by pastoral tribes of Tibetans, and possesses a few hamlets, such as Ombo, Rudok, and Sendja djong. The river region comprises the upper courses of the Brahmaputra (Yara tsangpo), the Salween (? Gyama nyul chu), the Yangtse (Dré chu), the Mekong (Nya-lung chu), and the Yellow river (Ma chu). Amidst the mountains there are many narrow valleys, partially cultivated from an altitude of 12,000 feet downwards, with here and there fine forests covering the mountain sides. Villages of high stone-built houses are to be found wherever the valley bottoms open out enough to afford a little space for agriculture. Barley and turnips are about the only products of the higher valleys; as one reaches lower levels, wheat, buckwheat, cabbages, potatoes, apricots, apples, and peaches are found, and in the so-called "hot country" (*tsa-rong*), in the southern part of Tibet, rice, oranges, pomegranates, and jujubes are raised successfully.

People.

The Tibetan race, which probably belongs to the Turko-Mongol stock, is divided between the tent-dwelling Tibetans of the lake region and the transition zone between it and the river region, and the sedentary population of the valleys. The tent-dwelling Tibetans are called by the Tibetans Dupa or Drupa (*hbrog-pa*), or "Steppe dwellers." They probably present the purest type of the race. An exception may be made in the case of the Tibetans of the Koko Nor region, also called Panaka, who show a Mongolized type. The males measure about 5 feet 5 inches; the females not appreciably less. The head is brachycephalic; the hair, when worn, is nearly invariably wavy; the eyes are usually of a clear brown, in some cases even hazel; the cheek-bones are high, but not so high as with the Mongols; the nose is thick, sometimes depressed at the root, in other cases prominent, even aquiline, but usually narrow, though the nostrils are broad. The teeth are strong but irregular; the ears, with tolerably large lobes, stand out from the head, but to a less degree than with the Mongols. The mouth is broad, the lips not very full and, among the people living in the lower altitudes, decidedly thin. The beard is very sparse, and with the exception of the moustache, which is sometimes worn, especially in central Tibet, it is carefully plucked out with tweezers. The shoulders are broad, the arms round; the legs are not well developed, the calf is especially small. The foot is large, the hand coarse. The women are usually stouter than the men, their faces much fuller. The colour of the skin of the Tibetans is a light brown, frequently nearly white, except where exposed to the weather, when it becomes a dark brown, nearly the colour of the American Indian's. Their voices are full, deep, and powerful. They can endure exposure without any apparent inconvenience. Hunger they can also endure; though the nature of the food they use is such that they cannot stand absolute privation for any considerable length of time, they can easily exist for long periods on starvation rations.

The sedentary population of Tibet has to a greater or less degree the same physical traits as the Drupa, but as one approaches China, India, or the border lands generally, one observes that the admixture of foreign blood during many centuries has considerably modified the primitive type. Among the customs of the Tibetans, that which is perhaps the most peculiar is the existence among them of polyandry, the brothers in a family having one wife in common. Polygamy is not unknown in Tibet, especially in the eastern parts of the country. Among the pastoral tribes monogamy seems to be the rule.

The population of Tibet has been estimated by various writers at from 3,000,000 to 8,000,000; the lower estimate seems the more acceptable; and in it should be counted the Tibetans of Ladak, Sikkim, and adjacent districts under British sovereignty. The latest estimate of the population of Tibet is that made by order of the emperor of China in 1737. According to it the grand total of the population for the whole of Tibet in the middle of the 18th century, was about a million and a half. No means exist of checking these figures, but when we take into account the existence of polyandry and promiscuity, the configuration of the soil, the ever-increasing number of the lamas, slavery, the frequent terrible ravages caused by smallpox, &c., it seems highly probable that the present population of the country, except in some highly-favoured districts, does not greatly exceed that given for 1737, at which figure it was estimated by Csoma de Koros, writing somewhere about 1830. If we add the Tibetans of north-western Kansu, the Koko Nor, and adjacent districts not included by Csoma de Koros, who do not, it is believed, number over 250,000, it would certainly appear that the total Tibetan population would hardly reach 3,000,000 as a maximum.

Political Divisions.

Tibetans divide their country into five provinces. (1) *Amdo*, which comprises that part of the Chinese province of Kansu which is inhabited by Tibetans, and Koko Nor region, extending southwards to the Yellow river and westwards as far as the Tsaidam. Amdo is inhabited in its eastern part by Tibetans, called Rongwa or "agriculturists," and in the western by pastoral tribes, collectively called Panaka or Panakasum. (2) *Khams* or *Khamdo*, which includes all eastern Tibet between the Chinese provinces of Szechuen and Yunnan, and the district of Lhorong djong, which forms the eastern border of the Lhasa-governed territory. This province is divided into the five Horba tribes, the eighteen Nyarong states in the valley of the upper Nyalung, and the districts of Litang, Batang, Dergé, Gartok, Chamdo, and Draya. In Khamdo, but subject to the direct rule of Lhasa, are several small districts; the principal are Nyarong, Tsarong, and Mär Khams or "Lower Khamdo." Most of these districts are governed by *déba* or chiefs, while a few have kings or *gyalpo*, the most powerful of the latter being the king of Dergé and of Chagla, or, as it is better known, Tachienlu. Khamdo is under the direct rule of the Chinese provincial authorities of Szechuen. Some of its rulers send also tribute missions to Peking. For convenience of classification, we may include in Khamdo a long strip of country extending along the northern border of the Lhasa territory of Lhorong djong and Larego as far as Tengri Nor, and bounded to the north by the Dang-la mountains, which is designated by Tibetans as *Gyade* or "the Chinese province." This strip of country has its own native chiefs, but is under the control of a high Manchu officer stationed at Lhasa, known colloquially as the "Superintendent of Savage Tribes." The third political division of Tibet is *Wu* (written Dbus), meaning "Central." It includes Lhasa, and a large number of outlying districts in south-eastern Tibet, such as Po yul, Pemakoichen, Za yul. The pastoral or Drupa tribes, north and north-east of Tengri Nor, are also under its rule. Lhasa is colloquially designated as Téba gzung, "the very centre." The fourth and fifth divisions of Tibet, called *Tsang* and *Nari* (Mngah-ris), include, the first, all south-west Tibet as far as Lake Manasarowar; the second, the whole country around the sources and along the upper course of the Indus and the Sutlej, and also all north-western Tibet generally. Tsang and Nari are under the rule of Lhasa, all the high civil and military authorities in these provinces holding their offices from it.[1]

The chief towns of Tibet.

Tibet hardly possesses a town of first-class importance besides Lhasa. The monastic towns of Tashilunpo (Shigatsé) and Gyantsé on the Nyang chu, a southern tributary of the Tsanpo, which joins that river about 150 miles above Lhasa, are perhaps the best-known towns of the southern districts of Tibet. Both of them are commercial centres of some significance.

Shigatsé, which is at the confluence of the Nyang chu with the Tsanpo, also called Digarcha, is a city of about 9000 inhabitants (exclusive of priests), about ¾ of a mile long by ½ a mile broad. About a mile from the north-east corner of the city is situated a monastery called Konkaling, whilst to the south-west is the far-famed Tashilunpo monastery, the residence of one of the great high priests of Tibet, coequal with the Dalai-Lama of Lhasa. Between the Tashilunpo monastery and the city is the Thom or open market, where all the business of the place is daily transacted. A wall about a mile in circumference surrounds the Tashilunpo monastery, within which are numerous temples and houses, four of the larger temples being decorated with gilded spires. A great wealth of jewels and precious metal is said to enrich the numerous idols of Tashilunpo. The monastery maintains 3300 priests. The city is protected by a fort which stands on a low hill to the north-west, and a garrison of 100 Chinese and 400 Tibetan soldiers is quartered here. The municipal government is in the hands of two däpon assisted by resident Djongpons. The soil around Shigatsé is rich and productive, the elevation being between 11,000 and 12,000 feet.

Gyantsé, the mart for Bhutan, to the south-east of Shigatsé, is described by "the Pundit" as being very similar in size to Shigatsé, but the government is in the hands of one däpon only, and the fort is near the centre of the city, maintaining a force of 50 Chinese and 200 Tibetans only. At Gyantsé wheat, barley oil, radishes, peas, and ghee are said to be cheap, and the town is famous for its manufacture of various kinds of cloth and of small bells, such as are attached to caravan horses.

Janglache, on the Tsanpo (where the trade-route from Ladak crosses from the left to the right bank of the river), is about 80 miles above Shigatsé. Here again we meet with the usual monastery and fort. Janglache is between 13,000 and 14,000 feet above sea-level.

On the Kashmir (or Ladak) frontier the little town of *Rudok* is important. Through Rudok all the trade of Tibet passes to Leh, and at Rudok is maintained the Chinese outpost which has so persistently interfered with all efforts at European exploration of the country. Nevertheless the political resident at Leh has already visited that town, and it may well happen that its bazaar will soon be as much traversed by Europeans as is Leh itself. Rudok is described as a small town picturesquely situated on the side of a hill standing isolated in the plain near the eastern end of Lake Pangong, across which the official boundary between Tibet and Kashmir now runs. The houses are built in tiers, whitewashed, and walled in. At the top of the hill is a large palace and several monasteries painted red. About a mile away from the foot of the hill is another monastery. Rudok is about 13,300 feet above sea-level, the height of Lhasa being 11,600 feet, and the greatest altitude on the route connecting the two, at the Mariom la (the pass which defines the water-parting between the sources of the Brahmaputra and those of the Sutlej), is 15,500 feet. It is a noteworthy fact in respect of the winter climate of Rudok and of all the towns of the Tsanpo basin that, owing to the intense dryness of the air and the light fall of snow, it seems to be bracing and exhilarating rather than severe. The thermometer apparently never sinks very low, and never approaches the minimum record of Puetra (in the same latitude and at half the absolute elevation), according to the observations of native surveyors.

Tachienlu (Darchendo) is on the extreme eastern boundary of Tibet, bordering the province of Szechuen in China. It is the great tea mart for Tibet, and from Tachienlu the two great trade-routes, the Gya lam and the Chang lam, diverge, the former to Ladak and the latter to Kashgar.

In eastern Tibet another well-known trading town is *Batang*, about which, however, travellers have given us but meagre information. It is described as a large town of 200 houses at an elevation of 8000 feet, but of little commercial importance. There are only two Chinese firms at Batang, where the trade is in the hands of the lamas, who, however, make larger profits out of the "pawnbrokers' business" than they do by legitimate trade. Its geographical position near the Dré chu (Yangtse), and its command of the great eastern highroad from China both to Lhasa and to Chinese Turkestan, ensure its vitality. Batang may well be a more important town in the future than it is in the present.

The chief town in the province of Khams is *Chamdo*, which is situated at the junction of two rivers, which are frozen in winter. Here is a large monastery with 3000 priests, and a garrison. European travellers have been jealously kept out of Chamdo lately.

Government.

Though the whole of Tibet is under the suzerainty of China, the government of the country is divided into two distinct administrations, the one under the rule of the Dalai-Lama of Lhasa, the other under local kings or chiefs, and comprising a number of ecclesiastical fiefs. Both are directed and controlled by the high Chinese officials residing at Lhasa, Hsining Fu, and the capital of the Chinese province of Szechuen. North-eastern Tibet or Amdo, and also a portion of Khamdo, are under the supervision of a high official (Manchu) residing at Hsiñing Fu in Kansu, whose title is Imperial Controller-General of Koko Nor. The native chiefs of the Panaka and other Tibetan tribes of this region are styled *pömbo* ("official" or "headman") by both the natives and the Chinese. The region under the supervision of the Imperial Controller includes all the countries north of the upper course of the Dré chu (Yang-tse-kiang). The people pay a small poll-tax to China, and are exempted from any other impost; they also pay a small tax in kind, sheep, butter, &c., to their chiefs. The province of Khamdo, including all eastern Tibet, is governed by local chiefs, styled *gyalbo*, "king," and *déba*, "chief," succession to the chieftainship being usually assured to the eldest son not a lama. Each chief appoints a certain number of civil and military officers to assist in the government of the country, and each village has its headman or *besé*, also a hereditary office. None of these officials receive salaries; they are only exempt from taxation, and some have grants of land made to them. The only tax paid to China is a so-called "horse tax" of about 5d. for each family. Once in every five years the chiefs send a tribute mission to the capital of Szechuen, and once every ten years to Peking, but the tribute sent is purely nominal. The Chinese maintain a few small military posts with from six or eight to twenty men stationed in them; they are under the orders of a colonel residing at Tachienlu. There are also a few lama chiefs.

The part of Tibet under the rule of Lhasa, by far the largest and wealthiest, includes the province of Wu, Tsang, Nari, and a number of large outlying districts in southern and even in eastern Tibet. The central government of this part of the country is at Lhasa; the nominal head is the Dalai-Lama. Under him are five ministers of state (*kalön* or *shapé*), who divide among themselves, under the immediate supervision of the two Imperial Chinese residents (or Amban), the management of all secular affairs of the country. The army is under the high command of the Chinese Amban, a Tibetan generalissimo or *magpön*, and six Tibetan generals or *däpon*. Under the *däpon* are six *rüpon* or colonels, and a number of subordinate officers. The regular army consists

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[1] This enumeration of the political divisions of Tibet does not include the elevated steppes of Tsaidam (extending between the Kuen-lun and the Altyn Tagh or Nan Shan ranges), inhabited by a mixed race of marauding people, Tunguts and Mongols. Yet Tsaidam is geographically but a northern extension of the great Tibetan plateau, and in most of its essential physical features it is more closely allied to the Changtang of the south than to the great sandy depressions of Chinese Turkestan or Mongolia on the north.

(in theory) of 6000 men, on active service for three years, and at home on half-pay for three years. After the six years they pass into the reserve or militia (*yulmag*). The taxes paid to the Lhasa Government are mostly in kind, sheep, ponies, meal, butter, wool, native cloth, &c., and the coin paid is said to be about 130,000 ounces of silver a year. Chandra Das states that the Crown revenues of Lhasa amount to about 2,000,000 rupees annually. All high Tibetan officials, whether ecclesiastics or laymen, are appointed subject to confirmation by the Chinese Government. The administrative subdivisions of the Lhasa country, of which there are fifty-three, are called *djong*, or "prefecture," each of which is under the rule of two *djongpön*, the one a lama, the other a layman. They collect all taxes, are responsible for the levy of troops, the courier service, corvées, &c., and exercise judicial functions, corresponding directly with Lhasa. There are 123 sub-prefectures under *djongnyer*. Under them are village headmen or *tsopön*, headmen or *mipön*, and elders or *gyanpo*. All are appointed for indefinite periods by the prefects. (For additional data on the administration, revenues, and army see LHASA, and for the religion see LAMAISM, vol. xiv.)

Geology and mineral wealth.

But little is known of the geological structure of the central regions of Tibet. The observations of Strachey or Godwin-Austen, with the more recent observations of Griesbach and other members of the Geological Survey of India, only extend to the southern edge or rim of the great plateau where vast alluvial deposits in horizontal strata have been furrowed into deep ravines, whilst Russian explorers have as yet but superficially examined the mountain regions of the north and north-east.

The general structure of the trans-Himalayan chains appears to indicate that the main axis of upheaval of the whole vast mass of the Tibetan highlands is to be found on two approximately parallel lines, represented the one by the Kuen-lun, and the other by a line which is more or less coincident with the watershed between India and the central lake region, extending from Lake Pangong to Tengri Nor, the plateau enclosed between the two being wrinkled by minor folds, of which the relative elevation is comparatively low, averaging from 1000 to 1500 feet. The strike of these folds is usually east and west and roughly parallel to the axes of elevation of the plateau. A very remarkable economic feature is the almost universal distribution of gold throughout Tibet. Gold has been worked on the plateau for numberless centuries. The gold-digging is referred to in somewhat mythical terms by Herodotus. Every river which rises in Tibet washes down sands impregnated with gold, and it has been proved that this gold is not the product of intervening strata, but must have existed primarily in the crystalline rocks of the main axes of upheaval. In western Tibet the gold mines of Jalung have been worked since 1875. They have been visited by native explorers of the Indian Survey, who reported that much gold was produced therefrom, and that it was remitted twice a year under a Chinese guard to Peking. The Tibetan diggers collected together at the mines chiefly during the winter, when the frost assisted to bind the loose alluvial soil and render excavation easy. These mines are within 200 miles of the Ladak frontier, near the sources of the Indus, at an elevation which cannot be less than 15,000 feet above sea-level. They are said to have been lately abandoned owing to the exorbitant imposts levied on gold production by Chinese and Tibetan officials. Between the Ladak frontier and Lhasa the plateau region teems with evidences of disused and abandoned mines, which might be counted by hundreds. These mines are excavations in the alluvial soil, never more than from 20 to 30 feet deep, and the gold produced therefrom has been separated from the soil by a process of washing so crude that a great part of it must inevitably have been lost.

The researches of Prjevalsky demonstrate that gold is plentiful in northern and eastern Tibet. Here Tungus diggers were encountered who had extracted handfuls of gold in small nuggets from a stream bed at a depth which they stated to be no greater than 2 feet. Another scientific explorer, Mr W. Mesny, has observed similar evidences of the existence of gold at comparatively shallow depths in Koko Nor region, and records that he has seen nuggets, "varying from the size of a pea to that of a hazelnut," in eastern Tibet. The gold was almost pure and perfectly malleable. The Gork goldfields, which are visible from Koko Nor, are reported to have yielded to China very considerable quantities of gold as lately as 1888. They are now deserted. Prjevalsky, indeed, predicts of northern Tibet that it will prove a "second California" in course of time. But very little gold at present finds its way across the Tibetan passes to India, either by way of Ladak or Kumaon; and the export to China has diminished of late years. Until the determined official opposition to exploration, which is maintained both by Chinese and Tibetan authorities, is sufficiently relaxed to admit of the presence of European experts, it will be impossible to estimate the economic value of the enormous area of the Tibetan goldfields which are already known to exist.

Iron is found in eastern Tibet in the form of pyrites, and is rudely smelted locally. Salt and borax exist in abundance in the western lake regions. The exportation of borax to India is only limited by the comparatively small demand. Lapis-lazuli and quicksilver are amongst the minor mineral products of the country, which is, however, but very partially exploited.

Climate.

The climate of Tibet varies so greatly over the enormous area and the changing altitudes of the country, that no two travellers agree precisely in their records. Tibet is affected by the south-west monsoon, just as the Pamirs are affected, but in varying degrees according to geographical position. In western Tibet, bordering the Kashmir frontier, the climate differs but little from that of Ladak. Intense dryness pervades the atmosphere during nine months of the year; but little snow falls, and the western passes are so little subject to intermittent falls of fresh snow, as frequently to be traversable during the whole year round (see LADAK). Low temperatures are prevalent throughout these western regions, whose bleak desolation is unrelieved by the existence of trees or vegetation of any size, and where the wind sweeps unchecked across vast expanses of arid plain. All the western region is but slightly affected by the monsoon. The central lake region, extending from the Kuen-lun to the Himalaya, is also characterized by extreme dryness in autumn, winter, and spring, with an abundance of rain in summer, whilst the eastern mountain region, extending to China south of the Dang la (which, with an altitude of about 20,000 feet, stretches from 90° to 97° E. along the parallel of 33° N., and arrests the monsoon currents), is subject to much the same climatic influences as the eastern Himalaya. The southern slopes of the Dang la are deluged with rain, hail, and snow throughout the year. Northern Tibet is an arid waste, subject to intense heat in summer and intense cold in winter. In March snow still lies deep in the Tsaidam passes, whilst Wellby found the heat oppressive in June at 16,000 feet elevation on the plateau south of the Kuen-lun, and a temperate climate prevailing about the sources of the Drê chu (Yangtse) in August.

All travellers testify to the perpetual wind currents from the west, which sweep with fierce, unremitting blasts across the salt bogs of Tsaidam (9500 feet) and through the higher valleys of eastern Tibet. Wind is a prevailing feature throughout Tibet at certain seasons of the year, as it is in the Pamirs, in Turkestan, in western Afghanistan, and in Persia. The climate of southern Tibet is, however, subject to considerable modifications from that of the northern and central regions, owing doubtless to its geographical connexion with northern India. Here, at an elevation of 15,000 feet, about the great Lake Dangra, we hear of well-built villages and of richly cultivated fields of barley, indicating a condition of climate analogous to that which prevails in the districts south of Lhasa, and in sharp contrast to the monotonous sterility of the lake region generally and the nomadic character of its population. Recent travellers bear witness to a gradual progress of desiccation in the Tibetan uplands. Everywhere there are signs of the gradual diminution of the lakes and the recession of the water line—a phenomenon that has also been observed in the Pamirs. There are still enormous glaciers about the head of the Brahmaputra, but the glacial epoch of the Changtang highlands has passed away; but it has passed comparatively recently, and the last evidences of its existence are to be traced in those lakes, which are now in their turn slowly disappearing. There is nothing to be found in the records of recent exploration or travel to indicate that in western, southern, or eastern Tibet the climate of the winter months is of a severity which would render it inimical to European existence.

Flora.

Our knowledge of the flora of northern and central Tibet has been considerably increased by the collections of Prjevalsky, Wellby, Bower, and Littledale, and that of eastern Tibet by Rockhill. These and other collections have been admirably described in W. B. Hemsley's *The Flora of Tibet or High Asia*. Western and southern Tibet were fairly well explored previously to the advent of these travellers. Professor Maximowicz concludes from an analysis of the Prjevalsky collection that the flora of Tibet is extremely ancient, and that it is chiefly composed of immigrants from the Himalaya and Mongolia. There is also a large percentage of endemic species. Chinese and European plants followed in the process of immigration. Those species which are distinctive of the eastern border ridges are found to reach the plateau, but do not spread westwards, so that a botanic separation or distinction is found to exist between the true plateau of Tibet in the west and the alpine tracts of the east. Thiselton-Dyer classes the flora of Tibet on the whole as belonging to the Arctic-Alpine section of the great northern division, but containing a purely endemic element. Two typical species are *Lychnis apetala*, which extends to Spitsbergen, and the well-known edelweiss. A single fern specimen obtained by Littledale (*Polypodium hastatum*) is indicative of eastern China. Of the forty or fifty genera obtained by Littledale in central Tibet, a very large proportion are British, including many of the most characteristic mountain forms. In the higher regions of northern and western Tibet the conditions under which vegetation exists are extreme. Here there are no trees, no shrubs, nor any plants above a foot high. Wellby says he saw nothing higher than an onion. The peculiar form of tussocky grass which prevails in the Pamirs is the characteristic feature of the Tibetan Changtang of the Tsaidam plains and of the bogs north-east of Lhasa. Of grasses indeed there are many forms, some of them peculiar to Tibet, but no trees or shrubs at any elevation higher than 15,000 feet. A flowering plant (*Saussurea tridactyla*) was discovered by Bower at an elevation of 19,000 feet. In south-eastern Tibet, where Himalayan conditions of climate prevail, we have a completely different class of flora. Of the flora of Tibet Mr Rockhill writes: "In the 'hot lands' (*tsa-rong*) in southern and south-eastern Tibet, extending even to Batang, peaches, apricots, apples, plums, grapes, watermelons, &c., and even pomegranates, are raised; most of Tibet only produces a few varieties of vegetables, such as potatoes, turnips, beans, cabbages, onions, &c. The principal cereals raised are barley and buckwheat, wheat in small quantities, and a little oats. A few localities in the extreme southern portions of the country, and around Lhasa possibly, are said to produce a non-glutinous variety of rice. A variety of mountain bamboo is found in southern and parts of eastern Tibet, and is much used for basket work. Tibet produces a large number of medicinal plants much prized by the medical profession in China and Mongolia, among others the *Cordyceps sinensis*, the *Coptis teeta*, Wall., and *Pickorhiza kuwoa*, Royle, &c. Rhubarb is also found in great quantities in eastern Tibet and Amdo; it is largely exported for European use, but does not appear to be used medicinally in the country. The trees most commonly found are the plane, poplar, maple, walnut, oak, the *cupressus funebris*, and various varieties of the genera *pinus*, *abies*, and *larix*. Some valuable plants are obtained in the mountains of south and south-western Tibet, yielding the excellent yellow and red colours used to dye the native cloths."

Fauna.

The fauna of Tibet has been by no means exhaustively investigated, especially the rodents and smaller species of animals. Amongst domesticated animals are to be found the horse, mule, donkey, cattle, sheep and goats, fowls and pigs, ducks and geese. Probably no country in the world, excepting perhaps inner Africa, so abounds in wild animals as the cold solitudes of the northern plateau. Here are to be found yak, wild asses (*kiang*), several varieties of deer, musk deer, and Tibetan antelope (*pantholopo*); also wild sheep (the *burret* of the Himalaya), *Ovis ammon* and possibly *Ovis poli*, together with wild goats, bears (in large numbers in the north-eastern districts), leopards, otter, wolves, foxes, marmots, monkeys, squirrels, and wild dogs. To this list must be added the curious *Ailuropus melanoleucus*. Birds are fairly numerous, and include many varieties of waterfowl, some of which (*Anser indicus* [the bar-headed goose], for instance) breed in Tibet, whilst others are only found as birds of passage. In eastern Tibet, on the Chinese border, varieties of the pheasant tribe abound, some of which are rare. Amongst them are the "white" pheasant, the *Ceriornis Temminckii*, two kinds of eared pheasant, Anderson's pheasant, and the blood pheasant. The Tibetan sand-grouse is peculiar to the country, and the snow-partridge (a member of the Himalayan variety) is also occasionally met with. Wellby mentions eagles in the north-east of the plateau, and Rockhill enumerates, on Chinese authority, storks, larks, and swallows amongst the birds of central Tibet.

Industries and trade.

The industries are confined to the manufacture of woollen cloth of various degrees of fineness and colour, and called *truk*, *tirma*, and *lawa*, to that of small rugs, pottery of an inferior quality, utensils of copper and iron, some of which show considerable artistic skill in design, and to such other small trades as are necessary to supply the limited wants of the people. The best artisans are Nepalese and Chinese, the former being the best workers in metal and dyers.

Internal communication.

The great trade routes are, first, that which, starting from Cheng-tu, the capital of the Chinese province of Szechuen, passes by way of Tachienlu, Litang, Batang, Chamdo, Larego, Lhasa, Gyantsé, Shigatsé, reaches the Nepalese frontier at Nielam and goes thence to Khatmandu. This route is called *Gya-lam*, "the China road" (or "high road"); the great bulk of Tibetan travel goes over it. Minor roads go from Hsining Fu in the Chinese province of Kansu *viâ* Tsaidam and the Dang la pass to Nagchuka and Lhasa. This road, called the *Chang-lam* or "northern road," was much used by traders till the middle of the 19th century, since when the Mahommedan rebellions in north-western China have practically closed it. Another road starts from Sung-pan in north-western Szechuen, and, by way of the sources of the Yellow river, joins the Gya-lam at Chamdo; it is but little used, as it passes through the country of the wild marauding Golok. Still another route starts from Tachienlu, and by the valley of the Yalung and the Dré chu runs to Gyékundo, and thence to Chamdo. From this point it leads to Riwoche, and then through Gyade or Chinese province to Nagchuka and Lhasa. An important trade road starts from Likiang Fu in Yunnan, and by way of Chung-tien (Guiedam of the French missionaries) joins the Gya-lam at Batang.

Trade routes, &c.

The latest routes adopted by travellers from Darjiling to Lhasa have been those which, avoiding the Chumbi valley, have crossed the Himalaya on the north-west rather than the north-east of Sikkim, and run most directly to Shigatsé. From Shigatsé to Lhasa the route has been the same as that followed by Nain Sing in earlier days, which passes by Gyantsé and thence over the lofty Kharo la plateau through the lake basin of the Yamdok tso, across the Khambala range to the Nari chu (Tsanpo). Between Shigatsé and the mouth of the Kyi chu (on which Lhasa stands) there is still no direct communication by river. Chandra Das, travelling *viâ* Kambajong and the Kongra Lamo pass, made a twenty-eight days' journey between Shigatsé and Darjiling. The direct distance being about 160 miles, this length of time is sufficient indication of the tortuous and difficult nature of the mountain track. From Khatmandu, the capital of Nepal, a difficult mountain route runs by Kirong tso to the No la (16,600 feet), descending from which pass it strikes the Tsanpo about midway between Lhasa and Lake Mansarowar. Farther west Tibet may be reached from Kumaon by one of a group of passes (of which the best-known is the Milam) leading to Lake Mansarowar. The lake becomes a sort of obligatory point on all routes to Tibet which lie between Ladak and Nepal. The Shipki road from Simla, which strikes the Sutlej at Totling (where there is a bridge), leads up to Mansarowar, coinciding with the great high-road (*Jonglam*) after passing Totling. The Jonglam (elsewhere called Gya-lam, which traverses the whole length of Tibet from Leh to China) is the route by which Chinese officials keep up communication with western Tibet. From Leh to Gartok (14,250 feet) it follows the upper Indus valley; then crossing the lofty Kailas range (dividing the Indus from the Sutlej) it drops to Totling and follows the Sutlej to Mansarowar. The remarkable area of gold-mining industry which lies to the north-east of Gartok is reached by another route from Leh, which, crossing the Chang la close to Leh, passes by Rudok at the eastern extremity of Lake Pangong in a south-easterly direction, running north of the great mountain masses which crowd round the Indus sources. It continues through the central lake district of the Hor province to Tengri Nor and Lhasa.

Currency.

For the money of Tibet see the article LHASA. The weights and measures in use are practically those of China; the dry measures, the most commonly employed, are the *bré* or *bo* of about four pints and the *bchal* of twenty *bo*; the capacity of the *bo* varies according to localities. The most commonly used measures of length are the span (*mto*), the cubit (*kru*), and the arm's-length or fathom (*dompa*).

Foreign trade.

The principal trade with the outside world is carried on with China over the Lhasa–Tachienlu road. Mr G. L. Litton, of H.B.M. Consular Service in China, in his report on the nature and value of this trade in 1898, gives the following figures for the average value passing through Tachienlu:—

Exports from Tibet.		
	Value, Taels.	Total Taels.
Musk	500,000	
Wool	200,000	
Gold	150,000	
Fox skins	25,000	
Other skins	30,000	
Rhubarb and drugs	30,000	
		935,000
Imports to Tibet.		
Tea	1,100,000	
Cottons	10,000	
Silks and sundries	40,000	
		1,150,000
		2,085,000

The value of the Chinese tael is 1⅓ oz. avoirdupois of silver by treaty. The tea imported from Szechuen is for the most part of very inferior quality, estimated at 35 per cent. tea-leaves and 65 twigs and other material. It is compressed into large bricks, and costs two-thirds of a penny per pound. No Indian tea would compete with it. Tachienlu is the principal market, permits being issued each year from Peking to the traders. The trade between Sung-pan in north-west Szechuen and Tibet is estimated by the same writer as follows:—

	Value, Taels.	Total Taels.
Imports to Tibet.		
Tea	760,000	
Cotton and woollen goods . .	15,000	
Brass and ironware, and sundries .	5,000	
		780,000
Exports from Tibet.		
Wool	80,000	
Live sheep	20,000	
Sheepskins and furs . . .	180,000	
Medicines and musk . . .	520,000	
		800,000
		1,580,000

The trade carried over the Hsining–Tankar–Tsaidam route has not been large for many years, on account of the various Mahommedan rebellions in Kansu. Probably the value of the exports and imports over it cannot be estimated at more than 50,000 to 75,000 taels a year, including in this the value of the Mongol trade. Trade between India and Tibet is carried on at present over the road which, starting from Darjiling, crosses the Jelap la and passes by Yatung, the Chumbi valley to Khamba djong, Shigatsé, and Lhasa. Yatung (80 miles from Darjiling) was opened 1st May 1894 to foreign trade under the regulations appended to the Sikkim–Tibet Convention of 1890, concluded between the Viceroy of India and the Chinese Amban of Lhasa. An officer of the Chinese Maritime Customs is stationed at Yatung; beyond this point foreigners are not allowed to proceed. The trade over this route has steadily grown since the opening of the road. The gross value of the imports into and exports from Tibet is as follows:—

	1897.	1898.	1899.	1900.
	Rupees.	Rupees.	Rupees.	Rupees.
Imports . .	674,139	718,475	962,637	730,502
Exports . .	820,300	817,851	822,760	710,012
Total .	1,494,439	1,536,326	1,785,397	1,440,514

The total imports into British India from Tibet by all available routes are more than double the value enumerated above according to the Indian official statistics of 1898. This would allow a considerable margin for the trade *viâ* Ladak and across the Kumaon passes. Returns for the official year ending 31st March 1901 give the value of the trade between Bengal and Tibet as 6·20 lakhs of rupees. The exports consist mostly of wool, woollen cloths, musk, yaks' tails, skins, ponies, and mules. The imports comprise a large variety of articles, principally cotton and woollen goods, silks, metals, tobacco, umbrellas, matches, kerosene, clocks, watches, and quite a large quantity of Chinese goods shipped from China to Calcutta, and thence by rail to Darjiling. Tibetan woollen goods are also exported over this route to be taken to Peking by sea. No tea is allowed by the Chinese to be brought into Tibet over this road. The value of the trade between Bhutan and Tibet is not known. The native explorer R. N. states (in 1886) that "the exports from Tibet (into Bhutan) are chiefly salt, blankets, wool, skins, tea in bricks, musk pods, and earthern pots, of which salt and wool take the first place with regard to quantity exported. These are either sold for cash in the currency of Tibet, or are bartered for the following commodities, viz., *buré* (a kind of silk stuff), *khamar* (coloured silk), *yultha* (a cotton cloth), brass utensils, silver, jewellery, rice, and tobacco." Trustworthy statistics of the value of the trade maintained between Tibet and bordering countries are not obtainable. Probably the trade with Bhutan does not much exceed Rs.10,000 in value. Trade with Ladak (independent of that which passes through Leh to India) is inconsiderable, and is certainly exceeded in value by the trade with Nepal. The total foreign trade of Tibet does not probably exceed Rs.10,000,000 a year.

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(T. H. H*.; W. W. R.)

Tichborne Claimant, The.—Roger Charles Tichborne (1829–1854), whose family name became a household word on account of an attempt made by an impostor in 1868 to personate him and obtain his heritage, was the eldest grandson of Sir Edward Tichborne, the 9th baronet, of a very ancient Hampshire family. Sir John de Tichborne, sheriff of Southampton, was created a baronet by James I. in 1621, and from him his descendants inherited great wealth and the position of one of the leading Roman Catholic families in the south of England. Roger Charles, born at Paris on 5th January 1829, was the eldest son of James Francis Doughty-Tichborne (who subsequently became 10th baronet and died in 1862) by Henriette Felicité, natural daughter of Henry Seymour of Knoyle, in Wiltshire. This lady, who hated England, was intent upon bringing up her son as a Frenchman: the result was that he hardly got any education at all until he went in 1846 to Stonyhurst, whence he proceeded in 1849 to Dublin and joined the 6th Dragoon Guards. His eccentricity and his French accent made him rather a butt in his regiment, and, being disappointed of war service, he sold out in 1852, and in the following year proceeded on a trip to South America. He sailed in March 1853 from Havre for Valparaiso, whence he crossed the Andes, reaching Rio in 1854. In April of that year he sailed from Rio in the *Bella* and was lost at sea, the vessel foundering with all hands. His insurance was paid and his will proved in July 1855. The baronetcy and estates passed in 1862 to Roger's younger brother, Sir Alfred Joseph Doughty-Tichborne, who died in 1866. The only person unconvinced of Roger's death was his mother, the dowager Lady Tichborne, from whom every tramping sailor found an eager welcome at Tichborne Park. She advertised largely and in a highly injudicious manner for the long-lost wanderer, and in November 1865 she learnt, through an agency in Sydney, that a man "answering to the description of her son" had been found in the guise of a small butcher at Wagga Wagga, in Queensland. As a matter of fact, the supposed Sir Roger did not correspond at all to the long-lost heir, who was slim, with sharp features and straight black hair, whereas the claimant was enormously fat, with wavy, light brown hair. His first letter to Lady Tichborne was not only ignorant and illiterate to the last degree, but appealed to circumstances (notably a birth-mark and an incident at Brighton) of which she admitted that she had no recollection. But so great was her infatuation with her fixed idea, that she soon overcame the first qualms of distrust and advanced money for the claimant to return to Europe. Like all pretenders, this one was impelled by his *entourage*, who regarded him strictly in the light of an investment. He himself was reluctant to move, but the credulity of persons under the influence of a romantic story soon came to his aid. Thus an old friend of Sir James Tichborne's at Sydney, though puzzled by the claimant's answers, was quite convinced by a resemblance to his supposed father, "especially about the mouth." At Sydney, too, he made the acquaintance of Bogle, a negro servant of a former baronet. Bogle sailed with him for Sydney in the summer of 1866, and coached him in the rudiments of the rôle which he was preparing to sustain. On reaching London on Christmas Day 1866 the claimant paid a flying visit to Tichborne House, near Alresford, where he was soon to obtain two highly important allies in the old family solicitor, Mr Hopkins, and a Winchester antiquary named Baigent, who was intimately acquainted with the Tichborne family history. He next went over to Paris, where in a hotel bedroom on a dark January afternoon he was promptly "recognized" by Lady Tichborne. She had formerly been a beauty, and her real son had borne a striking resemblance to her. The claimant was an unwieldy "mass of flesh," scaling nearly 25 stone, and his countenance was of a repulsive coarseness. This "recognition" naturally made an enormous impression upon the English public, who were unaware that Lady Tichborne was a monomaniac. That such a term is no exaggeration is shown by the fact that she at once acquiesced in her supposed son's absolute ignorance of French. She allowed the claimant £1000 a year, accepted his wife, a poor illiterate girl, whom he had married in Queensland, and handed over to him the diaries and letters written by Roger Tichborne from South America. From these documents the claimant now carefully studied his part; he learnt much, too, from Baigent and from two carabineers of Roger's old regiment, whom he took into his service. The villagers in Hampshire, a number of the county families, and several of Tichborne's fellow-officers in the 6th Dragoons, became eager victims of the delusion. The members of the Tichborne family in England, however, were unanimous in declaring the claimant to be an impostor, and they were soon put upon the track of discoveries which revealed that Tom Castro, as the claimant had been called in Australia, was identical with Arthur Orton (born 1834), the son of a Wapping butcher, who had deserted a sailing vessel at Valparaiso in 1850, and had received much kindness at Melipilla in South America from a family named Castro, whose name he had subsequently elected to bear during his sojourn in Australia. It was shown that the claimant, on arriving in England from Sydney in 1856, had first of all directed his steps to Wapping and inquired about the surviving members of his family. It was discovered, too, that Roger Tichborne was never at Melipilla, an assertion to which the claimant, transferring his own adventures in South America to the account of the man whom he impersonated, had committed himself in an affidavit. These discoveries and the deaths of Lady Tichborne and the friendly solicitor, Hopkins, were so discouraging that the "claimant" would gladly have "retired" from the baronetage; but the pressure of his creditors, to whom he owed vast sums, was importunate. A number of "Tichborne bonds" to defray the expenses of litigation were taken up by the dupes of the imposture, and an ejectment action against the trustees of the Tichborne estates (to which the heir was the present baronet, Sir Henry Alfred Joseph Doughty-Tichborne, then two years old) finally came before Chief Justice Bovill and a special jury at the Court of Common Pleas on 11th May 1871. During a trial that lasted over one hundred days the claimant exhibited an ignorance, a cunning, and a bull-dog tenacity in brazening out the discrepancies and absurdities of his depositions, which have probably never been surpassed in the history of crime; they may have been rivalled in the case of Titus Oates, to whom in physical constitution the claimant bore a striking resemblance. Over one hundred persons swore to the claimant's identity, the majority of them, and they were drawn from every class, being evidently sincere in their belief in his cause. It was not until Sir John Coleridge, in a speech of unparalleled length, laid bare the whole conspiracy from its inception, that the result ceased to be doubtful. The evidence of the Tichbornes finally convinced the jury, who declared that they wanted no further evidence, and on 5th March 1872 Serjeant Ballantine, who led for the claimant, elected to be non-suited. Orton was immediately arrested on a charge of perjury, and was brought to trial at bar before Chief Justice Cockburn in 1873. The defendant showed his old qualities of impudence and endurance, but the furious indiscretion of his counsel, Edward Kenealy, the testimony of his former sweetheart, and Kenealy's refusal to put the Orton sisters in the box, proved conclusive to the jury, who, on the one hundred and eighty-eighth day of the trial, after half-an-hour's deliberation, found that the claimant was Arthur Orton. Found guilty of perjury on two counts, he was sentenced on 28th February 1874 to fourteen years' penal servitude. The cost of the two trials was estimated at something not far short of £200,000, and of this the Tichborne estates were mulcted of fully £90,000. The claimant's better-class supporters had deserted him before the second trial, but the people who had subscribed for his defence were staunch, while the populace were convinced that he was a persecuted man, and that the Jesuits were at the bottom of a deep-laid plot for keeping him out of his own. There were symptoms of a riot in London in April 1875, when Parliament unanimously rejected a motion (by Kenealy) for referring the Tichborne case to a royal commission, and the military had to be held in readiness. But the agitation subsided, and when Orton emerged from gaol in 1884 the fickle public took no interest in him. The sensation of ten years earlier could not be galvanized into fresh life either by his lectures or his alternate confessions of imposture and reiterations of innocence, and Orton sank into poverty and oblivion, dying in obscure lodgings in Marylebone on 2nd April 1898. (T. SE.)

Ticino, or TESSIN, one of the Swiss cantons. Its area is 1087·9 square miles. Of this 725·67 square miles are "productive," forests covering 233·8 square miles, and vineyards 30·7 square miles (the greatest vine-growing area in Switzerland), the remaining 461·1 square miles being arable or meadow land. The population was 126,751 in 1888, while in 1900 it was 138,638, or 127 inhabitants per square mile. The canton is overwhelmingly Romanist and Italian-speaking. In 1888 the episcopal see of Lugano was founded: it is at present held by the bishop of Basel, who names an administrator apostolic for Ticino. Bellinzona is now the only political capital, but the largest town in the canton is Lugano. In 1888 Locarno had 3142 inhabitants (3557 in 1900), Airolo 1697 (in 1900, 1629), and Mendrisio 2815 (in 1900, 3441). The canton is divided into seven administrative districts. In 1897 its state revenue was 3,891,293 francs (a rise of 63 per cent. since 1885), and the state expenditure

3,733,263 francs (a rise of 97 per cent. since 1885), but in 1898 there was a deficit of 110,102 francs. In 1897 the public debt was 13,235,208 francs.

The political troubles of Ticino were increased in 1888 by the foundation of the see of Lugano, considered by the Radicals as likely to advance Clericalism, though it freed Switzerland from foreign ecclesiastical rule. Hence in September 1890 the Radicals carried out a bloody revolution, which necessitated Federal intervention, but at a state trial at Zürich in July 1891 the leaders were acquitted. In 1891 proportional representation was adopted for elections for the cantonal and communal assemblies. In 1892 a new cantonal constitution was accepted, by which the executive is elected directly by the people, and proportional representation is maintained, while the Facultative Referendum, especially for certain financial bills, and an initiative in legislative matters, are given to 5000 citizens, though 7000 are required in the case of an amendment in the cantonal constitution. In 1896, by a strange anomaly only to be explained by the previous political history of the canton, non-resident citizens were given a vote in all cantonal and communal matters, though residence is strictly required for all voters in Federal matters.

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Tides.—Our knowledge of the tides has been advanced in several ways since the date of the ninth edition of this Encyclopædia. From the nature of the case the following sections do not form part of a connected whole; they are rather a collection of minor articles dealing with topics connected with the tides.

The subjects treated are:—

§ 1. Seiches, or oscillations in lakes.
§ 2. The bore in estuaries.
§ 3. The deflection of the vertical by lunar attraction.
§ 4. Tide-tables and tidal prediction.
§§ 5–10. Recent advances in the dynamical theory of the tides.

Occasion will frequently arise to refer to the article in the ninth edition of this work (vol. xxiii. pp. 353–381); we shall for brevity call it Tides. Where it may be necessary to give a reference to a book entitled *The Tides and Kindred Phenomena in the Solar System,* by G. H. Darwin (John Murray, 1898), it will be referred to as Darwin's *Tides, &c.*

§ 1. *Seiches.*

Irregularities in tide-curves.

In the article Tides (p. 370) there is reproduced a portion of a tide-curve for Bombay. The object of the figure was to show the general nature of tidal oscillations, and accordingly certain small irregularities, which probably existed in the original, were smoothed out. Such irregularities are found in most tide-curves, and the smoothing of this curve has masked an interesting phenomenon closely connected with the tides, although arising from a wholly different set of causes.

The notches which are prevalent in tide-curves indicate that the water is affected by other waves than that of the main tide. These secondary waves are observed to have periods which range from two to twenty minutes; they thus alternate very much more rapidly than does the tide, whilst their periods are very much longer than those of the waves which are visible on the surface of the sea. Waves of this kind have sometimes been called periodic tides—as, for example, in correspondence in *Nature* on 12th January and 20th April 1899; but the name is altogether inappropriate, since they are not tides, and they possess the attribute of periodicity in common with all other waves.

In order to gain some insight into the nature of the phenomenon, we must now turn our attention to certain observations which have been made on an inland lake.

Seiches on Lake of Geneva.

It has been known for several centuries that the water of the Lake of Geneva is apt to rise and fall by a few inches, sometimes irregularly and sometimes with more or less regularity. Since the water ebbs and flows, these oscillations present some resemblance to true tides, and the phenomenon is sufficiently conspicuous to have gained from the inhabitants of the shores of the lake the name of Seiche. It was discovered during the last half of the 19th century that these waves are not peculiar to the basin of Geneva, and the name seiche has been generally adopted, whether we speak of the waters of a lake or of a land-locked arm of the sea.

In the 18th century Fatio de Duillier recorded a celebrated seiche which occurred in the year 1600 on the Lake of Geneva, when the range of the wave from lowest to highest was 5 feet 4 inches; but the first man thoroughly to investigate the subject was Dr Forel of Lausanne.[1] Between the years 1876 and 1885 he published, principally in the *Archives des Sciences Physiques et Naturelles* of Geneva, a series of papers giving the results of his observations. An abstract of these papers, with illustrative diagrams, is given in Darwin's *Tides, &c.*

Forel observes and analyses Genevan Seiches.

At first Dr Forel conducted his observations by means of a simple but very sensitive apparatus, called by him a plemyrameter, which was intended to detect the periodicity of the oscillations of the water without reference to the heights of the waves. By the observation of a light float in a horizontal glass tube, which formed portion of a pipe connecting the water in the lake with that in a tank ashore, he was able to detect even the slightest current setting from the lake to the tank, or *vice versâ.* Such a current was found to occur even when the difference of levels amounted to only a fraction of a millimetre. Care was of course taken, by choking the ingress of the water into the pipe, to obliterate the effect of the visible waves and ripples on the lake, so that his attention was directed only to inequalities with a duration of at least a minute. A description of the instrument and of the records derived by means of it is contained in Dr Forel's book, and in chapter ii. of Darwin's *Tides, &c.*

A careful study of the registrations of his instrument, taken at Morges and at other places, convinced Dr Forel that the oscillations were not irregular and capricious, as they naturally appear to the casual observer. He was able, in fact, to pick out from the complex motions several rhythms which presented themselves over and over again on many occasions. It will easily be perceived that the coexistence of several rhythmical movements, presenting themselves in various intensities and in various phases relatively to one another, suffices to explain any amount of complexity in the aggregate effect.

Dr Forel then concluded that these motions are oscillations dependent on the shape and depth of the whole lake, and he announced that seiches are due to "a gigantic impulse moving the whole liquid mass of Leman throughout its length, breadth, and depth." He adds that "it is probable that the same thing would be observed in far larger basins of water."

He concluded that the principal oscillations are of two kinds, the longitudinal and the transverse. In the seiche of longest period the water was found to rock about a line drawn transversely across the lake at its centre, so that it was high water at Villeneuve when it was low water at Geneva, and conversely. Such a seiche is said to be uninodal and longitudinal, because it affects the whole length of the lake, and there is at the centre a node or place at which the water is stationary as to height. He found that seventy-three minutes elapsed between successive high waters at either end of the lake, and that this period was the same whether the seiche was of visible amplitude or whether it amounted to only a fraction of a millimetre.

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[1] His papers are collected in *Le Léman,* 2 vols. (Roux, Lausanne 1892).

A crucial test of the correctness of Dr Forel's analysis is afforded by the determination of the period of oscillation of water in a trough of the dimensions of the Lake of Geneva in accordance with the laws of moving liquid. Now it may be concluded from this consideration that if it were possible to tilt up one end of the lake, so as to make the water rock about a single central node, the period of the oscillation would be very nearly that which was observed. The irregularities in the bed of the lake are, of course, considerable, and the period cannot be determined by *à priori* reasoning with close accuracy, but the discussion demonstrated with certainty the nature of the motion in the case of these seiches of longest period.

Longitudinal and tranverse Seiches.

If the uninodal longitudinal seiche had been the only motion of the water, Dr Forel's task would have been a comparatively easy one, but, as has been already said, the motion is in reality exceedingly complex. He was, however, also able to show the existence of the binodal seiche with a period of thirty-five minutes. In this case there are two nodes which divide the lake into three parts, of which the two terminal ones are each half as long as the central part. In this kind of seiche the low water occurs simultaneously at the two ends when it is high water at the centre. The existence of multinodal longitudinal seiches was also suspected, although the complication was so great as to prohibit absolute demonstration. Besides these longitudinal oscillations, uninodal transverse seiches were picked out with certainty. In this case the water was highest at Morges on the north when it was lowest at Évian on the south, and the period was determined at about ten minutes. It was thus established that the whole water of the lake is apt to oscillate about several fixed longitudinal or tranverse nodes, but the question remained as to the manner in which the motions originate. Any cause which tends to heap up the water at one end or at one side of the lake, and then ceases to operate, must start an oscillation which will last for many hours, with gradually decreasing amplitude, until the motion finally dies out in consequence of friction. Dr Forel suggested that such a temporary local rise of water-level may be produced in various ways. Some, perhaps many, seiches are due to the tilting of the whole lake-bed by minute movements of the earth's surface. Modern investigations seem to show that this is probably a more fertile cause than Dr Forel was disposed to allow.

Their causes.

When the wind blows in one direction for many hours it heaps up the water to leeward, and when it drops a seiche must necessarily originate. Again, the height of the barometer will often differ slightly at different parts of the lake, and the water must respond to the atmospheric pressure at the rate of about a foot of water to an inch of mercury: we shall return to the consideration of this point hereafter. Dr Forel also suggested that a seiche was most frequently the result of a sudden squall, but we think that he much over-estimated the efficiency of this cause. It is thus possible to point out several causes competent to produce seiches, but it generally remains impossible to say how any particular seiche was started.

Before leaving this subject, it may be well to mention that some observations have been made on other lakes, and we may especially refer to the observations of seiches on Lake George in New South Wales, made by Mr Russell, Government Astronomer at Sydney.[1]

We commenced this discussion by referring to the notches on tide-curves, but these zigzags are in general too rapid to be entirely attributable to the seiches of a land-locked arm of the sea. There must, then, be other oscillations besides seiches, and Dr Forel found that this was also true of the Lake of Geneva. These oscillations resembled seiches in every respect except in the greater rapidity of their alternations. Some of them were perhaps multinodal seiches, but they frequently only affected a portion of the lake at a time. In order to distinguish them from proper seiches, he called them "vibrations."

Vibrations of lakes due to wind.

In all his later work Dr Forel replaced his plemyrameter by a very sensitive form of tide-gauge which he called a limnimeter. The trace was registered on a very open scale, so that an interval of a minute was clearly legible. This would not be the case with an ordinary tide-curve. He found then that, when there is much wind, vibrations make their appearance which are quite distinct from ordinary wave motion, inasmuch as their periods range from forty-five seconds to four minutes. It is probable that there is a complete gradation of waves extending from the shortest ripple up to vibrations with a period of four or five minutes. However this may be, the form of instrument adapted for the observation of short waves would be quite different from one appropriate for waves with a period a hundred times as great, and thus the consideration of vibrations naturally separates itself from that of waves.

Vibrations due to steamers.

Dr Forel found that the wind always produced vibrations, and that it was most efficient when it blew from certain definite directions; but he also found that steamers produced movements so closely resembling those due to wind, that it was only possible to study the wind-vibrations at night, when there were no steamers plying on the lake, and the steamer-vibrations in calm weather. As a steamer is approaching the place of observation the vibrations become visible on the trace of the limnimeter as much as twenty-five minutes before its arrival, and they continue to be visible during two or three hours after the boat has passed. The antecedent vibrations have a shorter period of oscillation than the subsequent ones. The lengths of these waves may be concluded from their periods, and it appears that they may be from 1000 yards to a mile in length, and are therefore quite distinct from the visible waves generated by the boat as it ploughs through the water. Dr Forel gives a trace of the limnimeter as affected by these steamer-vibrations in his paper "Les Seiches" (*Annales de Chimie et de Physique*, 1876); this figure is reproduced in chapter ii. of Darwin's *Tides, &c.*

Seiches and vibrations in the sea.

Dr Forel was aware that similar vibrations exist in the sea, and he remarks that they cannot be due to seiches if these are defined as oscillations of the whole sheet of water about fixed nodes. It appears to us probable, however, that true seiches do occur in land-locked harbours or estuaries, since the seaward opening may often be narrow enough to make the water oscillate almost as though the mouth of the harbour were completely blocked. It seems almost certain, then, that the zigzags observable in tide-curves are due partly to seiches proper to the harbour and partly to vibrations.

There is a good deal of obscurity as to the manner in which vibrations originate. It is obvious that they are caused by the wind and by steamers, but it is not easy to understand how such insignificant causes can produce waves of such great length. But we know that they do so, and certain considerations are adduced in chapter ii. of Darwin's *Tides, &c.*, which show to some extent how the result may be brought about. However this may be, we shall now give some account of another investigation which may perhaps ultimately be found to throw much light on the subject.

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[1] *Nature*, 9th July 1885.

Atmospheric waves.

Helmholtz has pointed out (*Preuss. Akad. der Wiss.*, 25th July 1889) that when a layer of one fluid flows over another the surface of separation is necessarily unstable, so that waves will be generated between them. The most familiar instance of this is to be found in the waves generated on the sea by the wind. Another but less obvious case must occur when the air aloft is blowing from a different point of the compass from that near the earth's surface. But it might appear that this should not be considered as an example of the relative motion of two fluids, since the air is all of the same kind. We shall now show, however, that it is proper to regard the atmosphere as consisting of two fluids of different kinds. If the atmosphere were rigorously in that condition which is called adiabatic equilibrium,[1] its temperature and its density would fall at certain definite and uniform rates as we ascend above the earth's surface. But such a uniform rate of fall of temperature and density only represents the average of what would be found to occur in many ascents, and in any individual ascent an abrupt change would occur at the moment of passing from a lower current into an upper one. Hence it follows that, from a mechanical point of view, an upper current should be regarded as consisting of a fluid of a different density from that of the lower current. In this case the instability pointed out by Helmholtz must inevitably follow, and a series of air waves, strictly analogous to those in a rough sea, must be generated. A mackerel sky is the visible proof of the truth of this conclusion, for the moisture is condensed into cloud at the crests of the waves and reabsorbed in the hollows.

Lengths of atmospheric waves determined by comparison with oceanic waves.

It altogether transcends the power of the mathematician to determine what length of wave will be generated by a given wind blowing on a given sheet of water during a given time, but we do know that like circumstances produce like results, so that, for example, a gale in the Atlantic always produces waves of nearly the same length. It is often found that the comparison of similar dynamical systems will lead to interesting conclusions, even when the motion of either system presents a problem intractable by mathematical reasoning. Now, Helmholtz has shown how the waves generated in the surface separating two fluids must be dependent on their relative densities and velocities. He has in this way used the known lengths of sea-waves for obtaining a measure of the lengths of the air-waves aloft. Fairly accurate estimates have been obtained of the effective change of density in passing from the lower to the upper of two currents in the air, and this, together with the relative velocities, affords the data needed for the comparison. In this way he showed that the lengths of the air-waves must be very great, so that in a gale of wind we may expect the waves to have a period of from ten minutes to half an hour; in the latter case the whole visible sky would be occupied by a single crest. This accords exactly with the more or less regular intermission of the furious gusts in a gale, and with the sinuous line marked by the continuous record of a barometer on these occasions.

Vibrations of water probably due to action of atmospheric waves.

Mr Napier Denison has sought to apply this theory to the explanation of some, or many, of the vibrations of lakes and of the sea.[2] He points out that the sea must respond to the alternations of atmospheric pressure, and that the vibrations so generated, when propagated into land-locked bays and harbours, are in fact recorded as zigzags on tide-curves. He has commenced an extensive analysis of the vibrations of the sea in comparison with the oscillations of the barometer. For this purpose he has devised a very sensitive form of barometer which registers the variations of pressure on a large and open scale. The evidence appears favourable to his view, and if his theory shall be ultimately confirmed we shall have obtained an interesting insight into at least one important cause of these vibrations.

At several places Mr Denison believes that the vibrations tend to become manifest at an earlier time than the oscillations of the barometer. If this is so, the water-waves have outrun the advancing atmospheric disturbance, and it thus appears not impossible that the study of vibrations may prove of service in forecasting the weather. The theory is still under trial, and it will need much patient analysis to confirm or refute this interesting speculation.

§ 2. *The Bore in Estuaries.*

Causes of Bore.

In the general description of tidal phenomena in the article on Tides, it is stated that in estuaries, where large expanses of sand or mud are laid bare at low water, the rising tide sometimes advances in the form of a steep slope of water called a Bore. The rising tide acquires this remarkable shape under the influence of two causes: the first of these is the change of form to which every wave is subject as it progresses in shallow water, the advancing slope becoming steeper and the backward slope less steep. This is exemplified, but in a less exaggerated form, in the figure on p. 362 of Tides. The second cause is that the natural current of the river holds back the advancing flood until there is a considerable head of water at the mouth of the estuary, and the equilibrium then breaks down suddenly. It does not seem possible to apportion the relative importance of these two causes in the production of the observed effect.

Tidal currents in estuaries.

In order to explain more exactly how the latter cause operates, let us consider, in the first place, the tidal currents in a very sluggish river. At any point on the river bank mean water-mark is at such a height that the tide rises above it to the same amount that it falls below it. Then the law governing the tidal currents is simple; it is that whenever the water stands above mean water-mark the current is upstream, and whenever it stands lower it is down-stream. This result follows at once from the formulæ (54) § 21 of the article Tides (p. 362) When the water is at mean level it is stagnant, except for the natural current of the river, which we for the moment consider to be so sluggish as to be negligible. At high water the current is most rapid up-stream, and at low water most rapid down-stream. Hence the tidal current "flows" landwards for a long time after high water, and continues to do so, but with diminishing speed, until the water has fallen to mean water-mark. Similarly, the water ebbs seawards from the moment at which the level falls below mean water-mark, with an increasing speed and falling level until low water is reached, and then with a diminishing speed and rising level until mean water is attained.

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[1] In the adiabatic expansion of a gas the pressure varies as the density raised to the power γ, where γ is the ratio of the two specific heats. But pressure also varies jointly as the first powers of the density and of the absolute temperature. Hence the absolute temperature varies as the density raised to the power $\gamma - 1$. From this it easily follows that as we ascend in an atmosphere in adiabatic equilibrium the fall of temperature is proportional to the height of ascent. The law of fall of density is easily deducible from that of the temperature.

[2] *Proc. Canadian Institute*, 16th January and 6th February 1897; *Canadian Engineer*, October and November 1897; *Brit. Assoc. Rep.* (Dover), 1899.

At a station on the open coast the water flows landwards during the whole of the rise, ebbs seawards during the whole of the fall, and is slack at mean water. The law of tidal currents on the open coast is thus very different from that which holds good in a sluggish river. Now the estuaries of actual rivers broaden and deepen as the sea is approached and a large volume of water is delivered into the sea. Hence the currents in an actual estuary are intermediate between those which would be observed on the open coast and in a river of uniform breadth. It is, of course, to be noted that, whatever may be the state of currents due to the tides, we must superpose on them the proper current of the river. Hence in actual rivers the resultant current continues to flow up-stream after high water is reached, with falling water-level, but ceases flowing before mean water-level is reached, and the resultant current ebbs down-stream after low water, and continues to ebb with the rising tide until mean water is reached, and usually for some time afterwards. The downward stream, in fact, lasts longer than the upward one. The moments at which the currents change will differ in each river according to the depth, the rise and fall of the tide at the mouth of the river, and the amount of water delivered by it into the sea. An obvious consequence of this is that in rivers the tide rises quicker than it falls, and this effect is accentuated by the change of form natural to all waves during their progress in shallow water.

The conditions under which the tide-wave rises and falls in an actual estuary are very complex, and it would hardly be possible to submit them to rigorous mathematical treatment. But this is the less to be regretted, in that the scientific results which might be attained by such treatment would hardly repay us for the great labour inevitable in the attempt. We may then well rest satisfied merely to point out the general principles involved. The bore presents, however, so curious a natural phenomenon as to merit careful observation.

Bore of the Tsientang-Kiang.

The tide-wave rises as a bore in the Severn, the Wye, the Seine, and the Garonne; perhaps also in other rivers in England and France. But its appearance is capricious, and it is usually conspicuous only at spring-tides and with the wind in certain directions. There is indeed, as far as we know, only one river in which the bore occurs at every tide without exception; that is the Tsientang-kiang, which flows into the China Sea about 60 miles south of the great Yangtse-kiang. Some interesting observations of the bore in the Tsientang were made in 1888 and 1892 by Captain Moore, R.N., when in command of H.M.S. *Rambler*. His survey of the estuary was attended by some danger from the extreme violence of the currents—dangers which experience has taught the navigators of Chinese junks how to avoid. Captain Moore's two reports[1] give many interesting details, and present a graphic description of the bore, together with careful measurements of the rise and fall of the tide in this estuary. It may here suffice to say that the bore is from 12 feet to 15 feet in height, and progresses up the estuary at a speed of about 12 knots. An abstract of these reports is given in Darwin's *Tides, &c.*, chapter iii., together with a reproduction of some previously unpublished photographs which were given to the author by Captain Moore himself.

Bore of the Petitcodiac.

Mr W. Bell Dawson has also made observations at Moncton, on the Petitcodiac river, in the Bay of Fundy, of a bore only slightly less remarkable than the Chinese example. Careful observations of the rise of water at a fixed spot, together with measurements of the rate of progress of the bore up-stream, have enabled Mr Dawson to draw the profile of the tide-wave. The bore itself consists of a precipitous slope of water; and this is succeeded by a more gradual slope, which is, however, interrupted at intervals by several steps or minor bores. An account of Mr Dawson's observations is contained in the "Report of the Tidal Department of the Survey of Canada for 1898," and an abstract of the paper, together with a drawing of one of the profiles, is published in *Nature* of 15th June 1899.

§ 3. *Lunar Deflection of Gravity.*

Formulæ were given in § 8 of TIDES (p. 357) for the deflection[2] from the vertical of a pendulum under the lunar attraction, and the section ended with a statement that George and Horace Darwin had made an abortive attempt to measure the lunar deflection of gravity. We shall now give a short account of some more recent investigations bearing on this subject.[3]

Lunar deflection of gravity and rigidity of earth.

It is clear that, if the earth were to yield to the tidal forces to the same degree as a fluid, the movement of the pendulum would be masked from the observer by the simultaneous deflection of the ground on which he stood. Hence a comparison between the observed deflection and that computed on the hypothesis of the absolute rigidity of the earth would afford the means of determining the amount by which the solid earth itself yields to the tidal force. The attainment of such accuracy as to furnish satisfactory numerical results by means of such a comparison is yet distant, but something has already been done in this direction.

When a pendulum is under observation, there is nothing to tell the observer whether it has moved under changes in the direction of gravity relatively to the earth, or of the earth relatively to gravity, or whether both kinds of movement have occurred together. In the experiment referred to above, George and Horace Darwin concluded that almost the whole of the movements were due to motion of the ground. The causes of such a motion are complex; it arises from minute earthquakes, slower earth-movements of obscure origin, the effects of changes of temperature and of the percolation of subterranean water, mixed together in indeterminate proportions. All other observers have noted similar phenomena, and their results are important in the science of seismology, but fall outside the scope of this article.

Experiments of Paschwitz.

Amongst many experimenters, there is only one who has been able to adduce any good evidence in favour of the belief that a lunar periodicity can be detected amidst the wandering movements of the pendulum. This is Dr von Rebeur-Paschwitz, whose early death was a great loss to science. Paschwitz made use of a form of instrument called a horizontal pendulum, the nature of which we will now indicate. A door swinging on an absolutely vertical door-post will rest in any position, but a slight tilt to the door-post imparts to the door a definite position of rest. The mechanical principle of the horizontal pendulum is the same as that of the door; but a horizontal boom replaces the door, and the hinges are steel points resting in agate cups. Observations of the position of rest of the boom and of its period of oscillation determine the direction and magnitude of the inclination to the vertical of the line passing through the points of the two steel pivots. It is easy to see then that movements of the bed of the instrument will be shown by a motion of the boom, and that a continuous record of the motion may be obtained by photography. Two horizontal pendulums in planes at right angles to one another are needed to give a complete record of the motion of the ground.

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[1] *The Bore of the Tsientang-kiang*, 1888, and Further Report, &c., 1893. Potter, London.

[2] There was a mistake in that section as to the amount of deflection calculated for the latitude of Cambridge. The angle 0·0216″ there given is the total range, not the semi-range as stated.

[3] For further details see Darwin's *Tides, &c.*, chaps. vi. and vii.

Paschwitz made prolonged observations in the prime vertical with this form of instrument at Wilhelmshaven, Potsdam, and Orotava, and in the meridian at Strasburg.[1] He almost convinced himself that he could detect a lunar periodicity amidst the wanderings of the pendulum, but a more searching analysis seemed to him to leave the result open to some doubt. After Paschwitz's death his meridional observations were continued at Strasburg by M. Ehlert,[2] who also died young, through a lamentable Alpine accident. The deflections of the pendulum were registered by him during nine months, and the results are in close agreement with those of Paschwitz. Moreover, M. Kortazzi[3] made two series of meridional observations at Nikolaieff, the first lasting sixteen and the second nine months, and found the lunar inequalities to be very clearly marked. It now seems hardly possible to doubt the genuineness of the results of these observers.

We shall now show, however, that even if we assume the lunar periodicity to be a reality, there is still room for doubt as to the extent to which it is due to such a deflection of the vertical as is under consideration in this section.

Flexure of elastic surface by superincumbent load.

A weight resting on a thick horizontal slab must lie in a shallow dimple formed by the elastic yielding of the solid bed. The slope of this dimple must obviously decrease rapidly as we recede from the centre, and mathematical investigation proves that the slope due to pressure at a single point diminishes inversely as the square of the distance from the centre of the depression. The attraction of gravity also obeys the law of the inverse square, and therefore the slope is everywhere proportional to the gravitational attraction. If a number of particles be resting on the slab, each must produce its own dimple and its own attraction, and we conclude that if any weights rest on an elastic horizontal plane, the slopes of the hills and dales into which the originally flat surface is distorted will be everywhere proportional to the attraction; moreover, the direction of steepest slope will be that of the resultant attraction of the weights. The same will be true of weights lying on the earth's surface, because the curvature of the earth will make no material difference in the result.

If the effect of weights imposed on the earth's surface is observed by means of a pendulum, it is clear that the slope of the aggregate of dimples will render itself manifest by a deflection of the pendulum. But we have seen that the gravitational attraction of the weights is proportional to the slope, and therefore attraction must produce a real deflection of the pendulum strictly proportional to the slope of the distorted surface. Thus the total apparent deflection of the pendulum must consist of two parts—one due to slope, and the other to attraction; and there is nothing in the phenomenon itself to tell us how much is produced by one cause and how much by the other. It may, however, be proved by mathematical investigation that the relative importance of the two effects depends on the degree of elasticity of the solid bed. It appears that if the bed has the same elasticity as very stiff glass, the attraction would contribute one-fifth of the whole effect, and if the glass were of the most yielding quality the fraction would be one-eighth. Most rocks are somewhat stiffer than stiff glass, and we shall probably be not far wrong in assuming that with a rock bed of average stiffness the attraction of the load would contribute one-quarter of the total apparent deflection of a pendulum.

Flexure of earth's surface by varying tidal load.

When the tide rises and falls on the sea-coast many millions of tons of water are brought alternately nearer to and farther from the land. There is thus a shifting load which must inevitably affect a pendulum erected on the land, principally through the bending of the rock, but partly also through the direct attraction of the tidal load. The tide oscillates with lunar periodicity in obedience to the tidal forces, and it follows that the lunar periodicity of a pendulum should only be attributed solely to the direct lunar attraction when the observations are made at a great distance from the sea-coast.

Estimate of deflection of pendulum by varying tidal load.

It would be very difficult to compute the changes in the deflections on any actual coast as high and low tides alternate, even if the elasticity of rock were accurately known. It is, however, possible to formulate a problem of ideal simplicity which may serve to give some notion as to the amount of effect to be expected. From the consideration of such an ideal case G. H. Darwin has concluded that at one kilometre from the sea-coast we might expect the total range of oscillation of the pendulum between low and high water to amount to 0·15″; at 10 kilometres the computed range is 0·10″, and at 100 kilometres it is 0·05″.[4] We should note, however, that it is contended by Paschwitz that this ideal problem is not truly representative of actuality. He adduces the irregularity of European coast-lines, and the differences in the time of high water and of the rise of the tide at various places, as reasons for maintaining that G. H. Darwin's numerical estimates are untrustworthy except in close vicinity to the coast. The fact that the results at Nikolaieff present much the same character as those at Strasburg tends to confirm his contention. M. Kortazzi adopts the view of Paschwitz, and thinks that his own observations show the elastic tide of the solid earth to be of such magnitude that the actual deflection of the vertical is reduced to about one-half of the amount as computed for a perfectly rigid earth. Whatever view may ultimately prevail as the general or local character of the deflections of the vertical with lunar periodicity, there is evidence that the weight of the tidal load is responsible for some part of such deflection, at least near the coast.

Observations of d'Abbadie and of Paschwitz.

For M. d'Abbadie erected a special form of instrument at his château, about a mile from the Bay of Biscay and close to the Spanish frontier, and observed that the vertical was generally deflected towards the sea at high water and away from it at low water. These normal oscillations were, however, occasionally interrupted and even reversed, and it seems probable that they were then masked by those slower movements, analogous to earthquakes, which are occupying the attention of seismologists.[1] Paschwitz also at Wilhelmshaven noted similar deflections, which were of surprising magnitude; this may perhaps be explained by the peaty nature of the soil which prevails in that district.

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[1] Paschwitz, "Das Horizontalpendel," *Nova Acta Leop. Carol. Akad.* 1892, vol. lx. No. 1, p. 213; also *Brit. Assoc. Rep.* 1893; *Beiträge zur Geophysik*, 1895, vol. ii. pp. 211–536.

[2] Ehlert, "Horizontalpendelbeobachtungen," *Beiträge zur Geophysik*, vol. iii. p. 1, 1896. He explains the diurnal inequality as a thermal tide due to the expansion by heat of the half of the earth which is exposed to sunshine. For other references, see Darwin's *Tides, &c.*

[3] *Isvestiya Russk. Astron. Obshtchestra.*, Part iv. 1895; Part v. 1896.

[4] G. H. Darwin, "Appendix to Second Report on the Lunar Disturbance of Gravity," Brit. Assoc., Southampton, 1882; or reprint in *Phil. Mag.* Chree, *Phil. Mag.* vol. xliii. 1897, pp. 173–200.

The earth's surface has to bear another variable load besides that of the tide, for every square yard has to support half a ton more when the barometer is very high than when it is very low. Paschwitz, in fact, found that the deflections of the pendulum at Wilhelmshaven showed a connexion with the oscillations of the barometer.

§ 4. *Tide-Tables and the Degree of Accuracy in Tidal Prediction.*

In the article on Tides, prediction was considered principally from the mathematical point of view,[2] and the practical use of tide-tables and the degree of their success were hardly mentioned. The latter side of the subject will be considered in the present section.

Empirical tide-tables.

The connexion between the tides and the movements of the moon and sun is so obvious that tidal predictions were regularly made and published long before mathematicians had devoted their attention to them; and these predictions attained considerable success, although they were founded on empirical methods. During the 18th century, and even in the earlier part of the 19th, the art of prediction was regarded as a valuable family secret to be jealously guarded from the public. The best example of this kind of tide-table was afforded by Holden's tables for Liverpool, founded on twenty years of observation by a harbour-master named Hutchinson.[3] In about the year 1832 the researches of Whewell and of Lubbock (senior) pointed the way to improvement on the empirical tables prepared by secret methods, and since that time the preparation of tide-tables has become a branch of science.

Prediction for each day.

A perfect tide-table would tell the height of the water at the place of observation at every moment of the day, but such a table would be cumbrous; it is therefore usual to predict only the times and heights of high water and of low water. The best kind of tide-table contains definite forecasts for each day of a definite year, and we may describe it as a special table. Although the table is only made for one definite place, yet it is often possible to give fairly accurate predictions for neighbouring ports by the application of corrections both for time and height. These corrections should not be constant, but should vary according to the positions of the sun and moon. Special tide-tables are published by all civilized countries for their most important harbours.

Prediction by reference to time of moon's transit.

But there is another kind of table, which we may describe as a general one, where the heights and times are given by reference to the time at which the moon crosses the meridian. Although such a table is only applicable to a definite place, yet it holds good for all time. In this case it is necessary to refer to a nautical almanac for the time of the moon's transit, and a simple calculation then gives the required result. In a general tide-table the heights and times are tabulated according to the hour of the clock at which the moon will cross the meridian at the place of observation. Corrections have to be applied to allow for the effects of the declinations of the moon and sun, and for the lunar parallax. Moreover, at places where there is much diurnal inequality in the tides the moon's visible transit must be treated apart from its transit below the horizon. A considerable degree of elaboration has to be given to the table, in order that it may give accurate results, and it would occupy some half-dozen to a dozen pages of a book, its extension varying according to the degree of accuracy aimed at. It might occupy about five minutes to extract a prediction from the more elaborate form of such a table. There are many ports of considerable commercial importance where, nevertheless, it would hardly be worth while to incur the great and repeated expenditure involved in the publication of special tables. But this kind of elaborate general table has as yet been used in very few cases,[4] and the information furnished to mariners usually consists either of a full prediction for every day of a future year, or of a meagre statement as to the average rise and interval, which must generally be almost useless.

Meteorological disturbance of prediction.

The success of tidal predictions varies much according to the place of observation. In stormy regions the errors are often considerable, and the utmost that can be expected of a tide-table is that it shall be correct with a steady barometer and in calm weather. But such conditions are practically non-existent, and therefore errors are inevitable. The former of these sources of error is due to the fact that the sea responds to atmospheric pressure, falling with high pressure and rising with low pressure, at the rate of about a foot of water to an inch of mercury. As regards the second cause, a landward wind usually raises the sea-level; in estuaries the rise is sometimes very great, and even on the open coast it may be considerable. But both these effects seem to be more or less capricious, and it seems only possible to formulate certain rules of probability, the application of which will generally lead to improvement in the prediction as to the height of the water; occasionally, however, such empirical corrections will be found to augment the error.

Amount of error at Portsmouth.

Notwithstanding these perturbations, tide-tables are usually of surprising accuracy even in northern latitudes; this may be seen from the following table showing the results of comparison between prediction and actuality at Portsmouth. The importance of the errors in height depends, of course, on the range of the tide; it is well, therefore, to note that the average ranges of the tide at springs and neaps are 13 feet 9 inches and 7 feet 9 inches respectively.

Amount of error at Aden.

Prediction at such a place as Portsmouth is difficult, on account of the instability of the weather, but, on the other hand, the tides in themselves are remarkably simple in character. Let us now turn to such a port as Aden, where the weather is very uniform, but the tides very complex on account of the large diurnal inequality, which frequently obliterates one of two successive high waters. The short series of comparisons between actuality and prediction which we give below may be taken as a fair example of what would hold good when a long series is examined. The results refer to the intervals 10th March to 9th April and 12th November to 12th December 1884.

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[1] D'Abbadie, "Recherches sur la verticale," *Ann. de la Soc. Scient. de Bruxelles*, 1881.

[2] References may be given to two papers by G. H. Darwin on this subject, viz., "Tidal Prediction," *Phil. Trans. Roy. Soc.*, A. 1891, pp. 159–229; and "An apparatus for facilitating the reduction of tidal observations," *Proc. Roy. Soc.*, vol. lii. 1892. For a general account without mathematics see Darwin's *Tides, &c.*; this section is founded on chapters xiii. and xiv. of that book. For mathematical methods see Maurice Lévy, *Théorie des Marées*, Gauthier Villars, Paris, 1898.

[3] Whewell, *History of Inductive Sciences*, vol. ii. p. 248; Darwin's *Tides, &c.*, chapter iv.

[4] Darwin, "Tidal Prediction," quoted above. This kind of table has been applied with some success at Cairns in North Queensland, where there is a large diurnal inequality.

In these two periods there should have been 118 high waters, but the tide-gauge failed to register on one occasion, so that one comparison is lost. We thus have 117 cases to consider, but on one occasion the diurnal inequality obliterated a high water, leaving 116 actual comparisons. The maximum range of the tide at Aden is 8 feet 6 inches, and this serves to give a standard of importance for the errors in height.

Table of Errors in the Prediction of High Water at Portsmouth in the months of January, May, and September 1897.

Time.		Height.	
Magnitude of Error.	Number of Cases.	Magnitude of Error.	Number of Cases.
		Inches.	
0^m to 5^m	69	0 to 6	89
6^m to 10^m	50	7 to 12	58
11^m to 15^m	25	13 to 18	24
16^m to 20^m	10	19 to 24	6
21^m to 25^m	11	...	...
26^m to 30^m	7	...	...
31^m to 35^m	4	...	...
52^m	1	...	...
...	177	...	177

Errors in Height for the year 1892, *excepting part of July.*

Magnitude of Error.	Number of Cases.
Inches.	
0 to 6	381
7 to 12	228
13 to 18	52
19 to 24	8
31	1
...	670

N.B.—The comparison seems to show that these predictions might be much improved, because the predicted height is nearly always above the observed height, and because the diurnal inequality has not been taken into account sufficiently, if at all.

Table of Errors of the Prediction of High Water at Aden in March–April and November–December 1884.

Time.		Height.	
Magnitude of Error.	Number of Cases.	Magnitude of Error.	Number of Cases.
		Inches.	
0^m to 5^m	35	0	15
5^m to 10^m	32	1	48
10^m to 15^m	19	2	28
15^m to 20^m	19	3	14
20^m to 25^m	5	4	11
26^m and 28^m	2	No high water.	1
33^m and 36^m	2	...	..
56^m and 57^m	2	...	...
No high water.	1	...	...
...	117	...	117

It would be natural to think that when a prediction is erroneous by as much as fifty-seven minutes it is a very bad one, but we shall show that such a conclusion may be unjust. There was one case in which the high water was completely obliterated by the diurnal inequality, but there were many others in which there was nearly complete obliteration, so that the water stood nearly stagnant for several hours. A measure of the degree of stagnation is afforded by the amount of rise from low to high water. Now, on examining all the eleven cases where the error of time was equal to or over twenty minutes, we find five cases in which the range from low to high water was less than 8 inches, and these include the errors of fifty-six and of fifty-seven minutes. There is one case of a rise of 13 inches with an error of thirty-six minutes; one case of a rise of 17 inches with an error of twenty-two minutes; one of 19 inches rise with thirty-three minutes error. The remaining three cases have rises of 2 feet 10 inches, 3 feet 9 inches, 3 feet 11 inches, and errors of twenty-two, twenty-three, twenty minutes. Thus all the very large errors of time correspond with approximate stagnation, and are quite unimportant. It is fair to conclude, therefore, that the predictions as to time are very good. The predictions as to height are obviously good, for more than half were within 1 inch, and only eleven had an error of as much as 4 inches.

When it is considered that the incessant variability of the tidal forces, the complex outlines of the coast, the depth of the sea, the earth's rotation, and the perturbations by meteorological influences are all involved, it should be admitted that the success of tidal prediction is very remarkable. If further evidence were needed, we might appeal to tidal prediction as a convincing proof of the truth of the theory of gravitation.

DYNAMICAL THEORY OF TIDES.

§ 5. *Oversight in the Article on "Tides" (vol. xxiii. p.* 358).

The dynamical equations for tidal oscillations are established in § 11 of the article TIDES, but in the endeavour to obtain succinctness one of the steps in the proof was given without sufficient explanation.

The equations (16) purport to give the accelerations in the radial, colatitudinal, and longitudinal directions. They should have been written as follows :—

$$R=\frac{d^2\rho}{dt^2}-2n\sin^2\theta\,\frac{d\eta}{dt}-n^2r\sin^2\theta,$$
$$\Xi=\frac{d^2\xi}{dt^2}-2n\sin\theta\cos\theta\,\frac{d\eta}{dt}-n^2r\sin\theta\cos\theta,$$
$$H=\sin\theta\,\frac{d^2\eta}{dt^2}+2n\cos\theta\,\frac{d\xi}{dt}.$$

The oversight referred to consists in the omission of the last term in Ξ. It is true that this term does disappear, as will be shown below, but it should not have been omitted without further explanation.

Equations of motion.

If Ω denotes the potential of the external forces under which the particle whose accelerations are R, Ξ, H moves, but inclusive of the potential corresponding to a uniform angular velocity n, it is clear that the actual potential is $\Omega-\frac{1}{2}n^2r^2\sin^2\theta$. Then the differentials $\frac{d}{dr}$, $\frac{d}{rd\theta}$, $\frac{d}{r\sin\theta d\phi}$ of the last-named function must be equal to R, Ξ, H respectively, and it becomes obvious that $n^2r\sin^2\theta$ and $n^2r\sin\theta\cos\theta$ will disappear from the first and second equations.

Now Ω is the potential of the forces when the system has been rendered statical by the addition of a rotation potential, and the arguments adduced in the article show that $\Omega=-g(\mathfrak{h}-\mathfrak{e})r^2/a^2$. Also the radial motion, being excessively small compared with the horizontal motion, need not be considered ; thus the equations of motion have the form shown in (17) of the article in the ninth edition of this work.

As we are referring to errors in the article in the ninth edition, it may be well to note that there is a misprint on p. 368, § 30, in the formula for 2μ ; for H_m should occur in the denominator in all the terms on the right excepting the first.

§ 6. *Recent Advances in the Dynamical Theory of the Tides.*

In two papers contained in the second volume of Liouville's *Journal* (1896) M. Poincaré has considered the mathematical principles involved in the tidal problem where the ocean is interrupted by land, as in actuality. He has not sought to obtain numerical results applicable to any given configuration of land and sea, but he has rather aimed at pointing out the methods by which it may be some day possible to obtain such solutions. It would hardly be in place to attempt in this article to follow the details of an investigation of this character ; but we may say that it affords a conspicuous example of M. Poincaré's power of reaching the very heart of a difficult problem, and exhibits his consummate skill in the treatment of mathematical analysis.

We shall, however, notice in some detail two other still more recent papers[1] by Mr S. S. Hough, in which he has carried the solution of our problem considerably farther than the point at which it was left by Laplace.

In the article on TIDES we were compelled to follow Laplace in treating the ocean as deprived of the power of attracting itself, but Mr Hough has been able, by the use of spherical harmonic analysis, to include in his results the effects of the mutual gravitation of the water. The physical results are not profoundly affected by this addition, and so far the principal interest lies in the improvement of the mathematical method. But the author has also made a far more fundamental advance. In the tides, as in all other dynamical problems, the determination of the oscillations which the system is capable of executing when free from the action of external causes affords the only clue whereby it is possible to discuss completely the oscillations executed under external forces. Now oceanic tides are "forced oscillations" due to the moon and sun, and although Laplace showed how such tides were determinable on an ocean-covered planet, he failed to give a complete analysis of the various modes of "free oscillation." Mr Hough has now succeeded, by very skilful analysis, in finding a complete solution of the problem, and he has thus placed the theory on a far more satisfactory basis than that on which it stood before.

We shall in the following sections give Mr Hough's investigation in outline, but shall confine our attention more to "free" than to "forced" oscillations.

§ 7. *Equation of Tidal Oscillation.*

This would not be an appropriate place in which to follow the author in his careful discussion of the nature of the approximations by which the problem is treated. It may suffice to say that he confirms Laplace's results, which were reproduced in § 11 of the article on TIDES. It is only necessary to point out how the effects of the mutual gravitation of the ocean may be included in the equation.

We denoted the height of the dynamical tide by $\mathfrak{h}$, and that of the equilibrium tide by $\mathfrak{e}$. These two quantities are of course functions of the co-latitude θ and of the longitude ϕ, and may obviously be expanded in spherical harmonics, so that we may write

$$\mathfrak{h}=\Sigma\,\mathfrak{h}_i, \quad \mathfrak{e}=\Sigma\,\mathfrak{e}_i,$$

where each term in the series is a spherical harmonic of θ, ϕ of the order indicated by the suffix.

Mutual attraction of water.

It is easy to prove, by a process exactly similar to that pursued in § 6 of the article on TIDES, that if the equation to the surface of the ocean be $r=a+\mathfrak{h}_i$ or $\mathfrak{e}_i$, it is in equilibrium under the action of external forces of which the potential is

$$g\frac{r^i}{a^i}\left(1-\frac{3\sigma}{(2i+1)\,\delta}\right)(\mathfrak{h}_i \text{ or } \mathfrak{e}_i).$$

In this formula g is gravity, σ the density of water, δ the mean density of the earth, and r is the radius vector.

Let us write for brevity

$$b_i=1-\frac{3\sigma}{(2i+1)\,\delta}, \quad . \quad . \quad . \quad . \quad (1)$$

where the subscript i is not to be taken as denoting a spherical harmonic. In the article on TIDES we assumed b_i to be unity because we virtually took σ/δ as zero. It was shown in that article that the whole of the forces due to fluid pressure and to external attractions might be included by supposing that an element of the ocean moved under the influence of a potential $-g\,(\mathfrak{h}-\mathfrak{e})\,r^2/a^2$. But it is now obvious that when the attraction of the water is included this potential will become $-\Sigma b_i g\,(\mathfrak{h}_i-\mathfrak{e}_i)r^2/a^2$. Accordingly, the right-hand side of the two equations (18) should be $-\Sigma b_i\dfrac{g}{a}\dfrac{d}{d\theta}(\mathfrak{h}_i-\mathfrak{e}_i)$ and $-\dfrac{\Sigma b_i g}{a\sin\theta}\dfrac{d}{d\phi}(\mathfrak{h}_i-\mathfrak{e}_i)$ respectively. The equation of continuity (19) remains unchanged.

The next step was to assume that $\mathfrak{e}$, $\mathfrak{h}$, ξ were proportional to $\cos(2nft+k\phi+\alpha)$, and that η was proportional to $\sin(2nft+k\phi+\alpha)$. We should assume, for example,

$$\mathfrak{e}=\Sigma\mathfrak{e}_i=\Sigma e_i\cos\,(2nft+k\phi+\alpha).$$

Here $\mathfrak{e}_i$ is a spherical harmonic of order i, and e_i is the "associated function" of co-latitude such that $e_i\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}k\phi$ is a harmonic of order i. It is obvious that k is the rank of the tesseral harmonic in which e_i is the associated function. As it has been usual to denote the rank of a tesseral harmonic by the letter s, we shall now replace k by s.

Differential equation of tidal oscillation.

The next step was the determination of x, y (which replace ξ,η) from the equations of motion; and it is clear that in the new solution x, y should be replaced by $\Sigma b_i\text{x}_i$, $\Sigma b_i\text{y}_i$. The substitution in the equation of continuity gave the equation (24), which we may now write

$$\frac{1}{\sin\theta}\frac{d}{d\theta}\left[\frac{\gamma\left(\sin\theta\dfrac{d}{d\theta}+\dfrac{s}{f}\cos\theta\right)(h-e)}{f^2-\cos^2\theta}\right]-\frac{s\gamma\left(\dfrac{\cos\theta}{f}\dfrac{d}{d\theta}+\dfrac{s}{\sin\theta}\right)(h-e)}{\sin\theta(f^2-\cos^2\theta)}$$
$$+4mah=0 \quad . \quad . \quad (2)$$

The only effect of the introduction of mutual gravitation will be that in the first two terms $(h-e)$ should be replaced by $\Sigma b_i(h_i-e_i)$. We may then continue to use the equation in the above form, if we bear in mind that the factors b_i are to be introduced at the stage where the spherical harmonics are first used.

It will be well to remind the reader of the meaning of the several symbols.

The ratio of centrifugal force at a distance equal to the earth's radius a to gravity g is denoted by m, so that $m=n^2a/g$.

The depth of the ocean, covering the whole planet, is γ; and, as we shall only consider the case of an ocean of uniform depth, γ is a constant. The "speed of the tide" is $2nf$, so that $2f$ is the frequency of the tide in the sidereal day. The rank of the tesseral harmonic is denoted by s. Lastly, h and e are the semi-amplitudes of the actual and of the equilibrium tides; they are functions of co-latitude θ.

§ 8. *Zonal Oscillations.*

Zonal oscillations.

We might treat the general harmonic oscillations first, and proceed to the zonal oscillations by putting $s=0$. These waves are, however, comparatively simple, and it is well to begin with them. The zonal tides are those which Laplace describes as of the first species, and are now more usually called the tides of long period; they were treated in § 17 of the article on TIDES.

In this case $s=0$, and our equation (2) becomes

$$\frac{d}{d\theta}\left(\frac{\sin\theta\dfrac{d}{d\theta}(h-e)}{f^2-\cos^2\theta}\right)+\frac{4ma}{\gamma}h\sin\theta=0.$$

This may be written

$$\frac{d}{d\theta}(h-e)+\frac{4ma}{\gamma}\frac{f^2-\cos^2\theta}{\sin\theta}\int^\theta h\sin\theta d\theta+A=0, \quad . \quad . \quad (3)$$

where A is a constant. It must be remembered further that when the first term is expanded in spherical harmonics the term h_i-e_i must be multiplied by the factor b_i.

Let us assume

$$h=\Sigma C_iP_i, \quad \mathfrak{e}=\Sigma E_iP_i$$

where P_i denotes the ith zonal harmonic of $\cos\theta$. The coefficients C_i are unknown, but the E_i are known because the system oscillates under the action of known forces.

If the term involving the integral in this equation were expressed in terms of differentials of harmonics, we should be able to equate to zero the coefficient of each $dP_i/d\theta$ in the equation, and thus find the conditions for determining the C's.

The task then is to express $\dfrac{f^2-\cos^2\theta}{\sin\theta}\displaystyle\int^\theta P_i\sin\theta d\theta$ in differentials of zonal harmonics.

It is well known that P_i satisfies the differential equation

$$\frac{d}{d\theta}\left(\sin\theta\frac{dP_i}{d\theta}\right)+i(i+1)P_i\sin\theta=0. \quad . \quad . \quad (4)$$

Therefore $$\int P_i\sin\theta d\theta=-\frac{1}{i(i+1)}\sin\theta\frac{dP_i}{d\theta}, \text{ and}$$

$$\frac{f^2-\cos^2\theta}{\sin\theta}\int P_i\sin\theta d\theta=-\frac{1}{i(i+1)}(f^2-\cos^2\theta)\frac{dP_i}{d\theta}$$
$$=-\frac{1}{i(i+1)}(f^2-1)\frac{dP_i}{d\theta}-\frac{1}{i(i+1)}\sin^2\theta\frac{dP_i}{d\theta}.$$

Another well-known property of zonal harmonics is that

$$\sin\theta\frac{dP_i}{d\theta}=\frac{i(i+1)}{2i+1}(P_{i+1}-P_{i-1}) \quad . \quad . \quad . \quad (5)$$

If we differentiate (5) and use (4) we have

$$\frac{i(i+1)}{2i+1}\left(\frac{dP_{i+1}}{d\theta}-\frac{dP_{i-1}}{d\theta}\right)+i(i+1)P_i\sin\theta=0 \quad . \quad (6)$$

Multiplying (5) by $\sin\theta$, and using (6) twice over

$$\sin^2\theta\frac{dP_i}{d\theta}=\frac{i(i+1)}{2i+1}\left\{-\frac{1}{2i+3}\left(\frac{dP_{i+2}}{d\theta}-\frac{dP_i}{d\theta}\right)+\frac{1}{2i-1}\left(\frac{dP_i}{d\theta}-\frac{dP_{i-2}}{d\theta}\right)\right\}.$$

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[1] *Phil. Trans. Roy. Soc.*, vol. 189 A. (1897), pp. 201–258, and vol. 191 A. (1898), pp. 139–185.

Therefore
$$\frac{f^2-\cos^2\theta}{\sin\theta}\int P_i\sin\theta d\theta=\frac{1}{(2i-1)(2i+1)}\frac{dP_{i-2}}{d\theta}$$
$$-\left\{\frac{f^2-1}{i(i+1)}+\frac{2}{(2i-1)(2i+3)}\right\}\frac{dP_i}{d\theta}+\frac{1}{(2i+1)(2i+3)}\frac{dP_{i+2}}{d\theta}.$$
This expression, when multiplied by $4ma/\gamma$ and by C_i and summed, is the second term of our equation.

The first term, with the introduction of the factors b_i, is
$$\Sigma b_i(C_i-E_i)\frac{dP_i}{d\theta}.$$

In order that the equation may be satisfied, the coefficient of each $dP_i/d\theta$ must vanish identically. Accordingly we multiply the whole by $\gamma/4ma$ and equate to zero the coefficient in question, and obtain
$$\frac{b_i\gamma}{4ma}(C_i-E_i)+\frac{C_{i-2}}{(2i-1)(2i-3)}-\left\{\frac{f^2-1}{i(i+1)}+\frac{2}{(2i-1)(2i+3)}\right\}C_i$$
$$+\frac{C_{i+2}}{(2i+3)(2i+5)}=0 \quad . \quad (7)$$
This equation (7) is applicable for all values of i from 1 to infinity, provided that we take C_0, E_0, C_{-1}, E_{-1} as being zero.

The equation amongst the C's presents a close analogy with (45) of § 18 of the article on TIDES, and is treated in a similar manner. We shall not, however, pursue the investigation of the tides of long period, merely stating that Mr Hough's results are confirmatory of those obtained in § 18 of the article on TIDES.

Free zonal oscillations.

The free oscillations of the ocean of the zonal type may be treated by means of this equation, and since in this case there is no disturbing force, all the E's vanish.

If we write for brevity
$$L_i=\frac{f^2-1}{i(i+1)}+\frac{2}{(2i-1)(2i+3)}-\frac{b_i\gamma}{4ma},$$
the equation (7) is
$$\frac{C_{i+2}}{(2i+3)(2i+5)}-L_iC_i+\frac{C_{i-2}}{(2i-3)(2i-1)}=0 \quad . \quad . \quad (8)$$
The problem is to eliminate the C's from an infinite series of these equations and to determine f the semi-frequency of oscillation. Since the dimensions and mean density of the earth, the density of sea-water, and the depth of the ocean are known, the last term in L_i is known.

With respect to this result Mr Hough writes:—"The equations divide themselves into two groups, in one of which only even suffixes, and in the others of which only odd suffixes, are involved. We conclude, therefore, that the types of oscillation divide themselves into two classes, in the former of which the height of the surface waves will be expressible entirely by harmonics of even order, and in the latter by harmonics of odd order alone. An exactly similar treatment is applicable to each of these classes; we shall therefore select for discussion the former set."

Remembering that C_0 is to be regarded as zero, the first three equations of the even set are
$$C_2L_2+\frac{C_4}{7.9}=0,$$
$$\frac{C_2}{5.7}-C_4L_4+\frac{C_6}{11.13}=0,$$
$$\frac{C_4}{7.9}-C_6L_6+\frac{C_8}{15.17}=0.$$
It would seem at first sight that these equations would serve to determine C_4, C_6, C_8 . . . in terms of C_2, but the same difficulties arise as were found to occur in § 16 of the article on TIDES, and they are to be met in a similar manner.

If we write for brevity
$$a_i=\frac{1}{(2i+1)(2i+3)^2(2i+5)}$$
the equation amongst the C's may be written in the alternative forms
$$\frac{C_{i-2}/C_i}{(2i-3)(2i-1)}=L_i-\frac{\dfrac{a_i}{C_i/C_{i+2}}}{(2i+1)(2i+3)},$$
$$\frac{C_{i+2}/C_i}{(2i+3)(2i+5)}=L_i-\frac{\dfrac{a_{i-2}}{C_i/C_{i-2}}}{(2i-1)(2i+1)}.$$
By successive applications of these formulæ the right-hand side may, in each case, be expressed as a continued fraction.

Let us express the following continued fractions by a single symbol, and write
$$H_{i-2}=\frac{a_i}{L_{i+2}-}\;\frac{a_{i+2}}{L_{i+4}-}\;\frac{a_{i+4}}{L_{i+6}-}\ldots,$$
$$K_{i+2}=\frac{a_{i-2}}{L_{i-2}-}\;\frac{a_{i-4}}{L_{i-4}-}\;\frac{a_{i-6}}{L_{i-6}-}\ldots.$$
Then
$$\left.\begin{aligned}\frac{C_{i-2}/C_i}{(2i-3)(2i-1)}&=L_i-H_{i-2}\\ \frac{C_{i+2}/C_i}{(2i+3)(2i+5)}&=L_i-K_{i+2}\end{aligned}\right\} \quad . \quad . \quad . \quad (9)$$

Frequency equation.

By substitution in the equation (8) we have as the general condition
$$L_i-H_{i-2}-K_{i+2}=0.$$
The C's have disappeared, and we are left with an equation for determining f, the frequency of oscillation.

The equation may be written in many other forms, but the object attained by this particular form is that a selected portion, namely, L_i, stands out by itself.

The values 2, 4, 6, &c., are to be attributed successively to i, and the equation solved in the manner indicated below. When the similar series of equations corresponding to the odd harmonics are solved, we shall have a systematic solution of the whole, containing all the possible modes of oscillation.

Reverting, however, to the even series, the solution is effected as follows:—

We first compute the numerical portion of all the L's, and obtain a series of equations such as
$$L_i=\frac{1}{i(i+1)}(f^2-A_i),$$
where A_i is a number.

Solution.

As a first approximation we assume that one particular L, say L_i, vanishes; then $f=\sqrt{A_i}$. With this value of f we compute L_2, L_4, L_6 . . . up to a pretty high order, and one of the series, namely L_i, will be zero.

The continued fractions H_{i-2}, K_{i+2} are then computed. They are so rapidly convergent that a few terms suffice to give them with all necessary accuracy. If B be the value of $H_{i-2}+K_{i+2}$, we shall have the function $L_i-H_{i-2}-K_{i+2}$ equal to $-B$, when f is equal to $\sqrt{A_i}$.

We next assume that $L_i=B$, so that $f=\sqrt{(A_i+i(i+1)B)}$, and go through the same process as before, finding $L_i-H_{i-2}-K_{i+2}$ equal, say, to $+C$.

By interpolation it is easy to find the exact value of f, which causes $L_i-H_{i-2}-K_{i+2}$ to vanish. If $-B$ and C are found to differ too widely from one another it is, of course, easy to repeat the process of approximation.

In this way Mr Hough has found the frequencies of all the modes of oscillations expressible by the harmonics of orders 1 to 12, for depths of ocean equal to once, twice, four times, and eight times 7260 feet.

In the case of a non-rotating planet each harmonic forms a fundamental mode of oscillation capable of existing by itself, but this is not the case for a rotating planet. The next task is then to determine the nature of the waves which correspond to each of the frequencies; this entails the determination of the C's.

Since $L_i-H_{i-2}=K_{i+2}$ and $L_i-K_{i+2}=H_{i-2}$ the equations (9) give us

Form of waves.

$$\frac{C_{i-2}}{C_i}=(2i-1)(2i-3)K_{i+2},$$
$$\frac{C_{i+2}}{C_i}=(2i+3)(2i+5)H_{i-2}.$$

In the course of finding the frequency the H, K continued fractions have been determined, and therefore we can find C_{i-2} and C_{i+2} in terms of C_i.

By putting $i-2$ for i in the first formula and $i+2$ for i in the second, we can find C_{i-4} in terms of C_{i-2}, and thence of C_i; also C_{i+4} in terms of C_{i+2} and thence of C_i. By continuing this process all the C's are determinable as multiples of C_i, which is the arbitrary constant of the solution
$$\mathfrak{h}=C_i\left\{\ldots+\frac{C_{i-2}}{C_i}P_{i-2}+P_i+\frac{C_{i+2}}{C_i}P_{i+2}+\ldots\right\}\cos(2nft+a).$$
It appears that when i is considerable the coefficients of the P's on each side of P_i are not very large, so that the i^{th} harmonic stands out from the rest. If the planet did not rotate the corresponding solution would be $C_iP_i\cos(2nft+a)$, and $2nf$ would not differ much in the two cases. But this is by no means the case for small values of i; for example, when $i=1$ and the depth of ocean 7260 feet, the solution is
$$\mathfrak{h}=C_1\{P_1-1{\cdot}5058P_3+{\cdot}7106P_5-{\cdot}1673P_7\ldots\}\cos(2nft+a),$$
and the period π/nf is $30^{\text{h}}\ 29^{\text{m}}$.

But for the non-rotating globe the corresponding solution is $\mathfrak{h}=C_1P_1\cos(2nft+a)$, with π/nf equal to $59^{\text{h}}\ 17^{\text{m}}$.

In the rotating planet the third harmonic has a greater coefficient than the first, and the fifth has nearly as much importance. This perhaps tends to explain the great discrepancy between the periods of oscillation in the two cases.

We refer the reader to Mr Hough's first paper (*Phil. Trans.* A.

1897, pp. 201–257) for a valuable series of numerical results illustrative of the theory.

Steady currents of ocean.

In the latter part of his paper Mr Hough shows that there are other solutions of the differential equations which do not correspond to oscillations, but to steady motions.

The differential equations of motion and the equation of continuity are given in (17) and (18) of § 11 of the article on TIDES. If there be no disturbing force they are as follows:—

$$\frac{d^2\xi}{dt^2} - 2n\sin\theta\cos\theta\,\frac{d\eta}{dt} = -\frac{g}{a}\frac{d\mathfrak{h}}{d\theta},$$

$$\sin\theta\,\frac{d^2\eta}{dt^2} + 2n\cos\theta\,\frac{d\xi}{dt} = -\frac{g}{a\sin\theta}\frac{d\mathfrak{h}}{d\phi},$$

$$a\frac{d\mathfrak{h}}{dt} + \frac{d}{d\theta}\left(\gamma\sin\theta\,\frac{d\xi}{dt}\right) + \frac{d}{d\phi}\left(\gamma\sin\theta\,\frac{d\eta}{dt}\right) = 0.$$

In the previous solutions we have supposed γ to be a function of co-latitude only, and indeed, where the solution has been considered in detail, to be constant. This restriction will now be removed. Let us suppose, if possible, that there is a condition of steady motion which will satisfy these equations. Then the velocities and the elevation of the surface are not functions of the time, so that the equations reduce to

$$\left.\begin{aligned} \sin\theta\,\frac{d\eta}{dt} &= \frac{g}{2an\cos\theta}\frac{d\mathfrak{h}}{d\theta} \\ \frac{d\xi}{dt} &= -\frac{g}{2an\cos\theta}\frac{d\mathfrak{h}}{\sin\theta d\phi} \end{aligned}\right\} \quad . \quad . \quad . \quad (10)$$

Therefore the equation of continuity becomes

$$\frac{d}{d\theta}\left(\frac{\gamma}{\cos\theta}\frac{d\mathfrak{h}}{d\phi}\right) = \frac{d}{d\phi}\left(\frac{\gamma}{\cos\theta}\frac{d\mathfrak{h}}{dt}\right) \quad . \quad . \quad . \quad (11)$$

The equation of continuity is satisfied if $\mathfrak{h}$ and γ are functions of co-latitude only, and the first of the equations of motion then shows what velocity must be imparted to the fluid in order to give the figure of the ocean any arbitrary form, provided it is a figure of revolution. The distribution must, however, be symmetrical with respect to the equator, for if $\mathfrak{h}$ were to involve any odd harmonic the necessary velocity would be infinite at the equator.

Reverting, however, to the general case, where the depth of the ocean may vary in longitude as well as in latitude, it is clear that if, starting from any point, we pursue a line along which $\mathfrak{h}$ is constant, we must have

$$\frac{d\mathfrak{h}}{d\theta}\,\delta\theta + \frac{d\mathfrak{h}}{d\phi}\,\delta\phi = 0.$$

Therefore

$$\left(\sin\theta\,\frac{d\eta}{dt}\right)\delta\theta - \frac{d\xi}{dt}\,(\sin\theta\delta\phi) = 0.$$

But $\sin\theta d\eta/dt$ is the eastward velocity, and $d\xi/dt$ is the southward velocity, so that the displacements $\delta\theta$, $\delta\phi$ indicate motion with the fluid. Hence $\mathfrak{h}$ is constant along a stream line, or $\mathfrak{h}$ is a stream function. In this statement we have omitted the attraction of the water on itself, but from what has gone before it is obvious that when the attraction is included the stream function is $\Sigma b_i\mathfrak{h}_i$. In the same way in (11) $\mathfrak{h}$ must be replaced by $\Sigma b_i\mathfrak{h}_i$, and it follows from this equation that $\gamma/\cos\theta$ is constant along a stream line. Therefore the stream lines are determined by the consideration that the depth of the ocean multiplied by the secant of the co-latitude is constant. It would thus be possible to draw the stream lines for these oceanic currents on an actual chart. However, the fact that the ocean consists of fluid of slightly different densities in different places would introduce effects resulting in a total subversion of the theoretical arrangements of currents. The driving forces which overcome friction must be sought in precipitation, evaporation, and the wind, and the whole circumstances of the actual problem are so complex that mathematical treatment becomes almost impossible. The reader is referred to Mr Hough's paper for further consideration of the subject.

Stream lines of ocean currents.

§ 9. *Tesseral Oscillations.*

Tesseral oscillations. Transformation of equation.

The oscillations which we now have to consider are those in which the form of surface is expressible by the tesseral harmonics. The results will be applicable to the diurnal and semidiurnal tides—Laplace's second and third species.

If we write $\sigma = \frac{s}{f}$ the equation becomes

$$\frac{d}{d\theta}\left[\frac{\left(\sin\theta\frac{d}{d\theta} + \sigma\cos\theta\right)(h-e)}{s^2 - \sigma^2\cos^2\theta}\right] - \frac{\left(\sigma\cos\theta\frac{d}{d\theta} + s^2\operatorname{cosec}\theta\right)(h-e)}{s^2 - \sigma^2\cos^2\theta}$$
$$+\frac{4ma}{\gamma\sigma^2}\,h\sin\theta = 0.$$

It must be borne in mind that when h and e are expressed in harmonics, $h - e$, as it occurs in the first two terms, must be replaced by $\Sigma b_i(h_i - e_i)$, where h_i, e_i are the associated functions of the co-latitude, such that h_i or e_i multiplied by $\cos s\phi$ or $\sin s\phi$ are tesseral harmonics. If we write D for the operation $\sin\theta\frac{d}{d\theta}$, the middle term may be arranged in the form

$$-\frac{\sigma\cot\theta\,(D + \sigma\cos\theta)(h-e)}{s^2 - \sigma^2\cos^2\theta} - \frac{h-e}{\sin\theta}.$$

Therefore on multiplying by $\sin\theta$ the equation becomes

$$(D - \sigma\cos\theta)\left[\frac{(D + \sigma\cos\theta)(h-e)}{s^2 - \sigma^2\cos^2\theta}\right] - (h-e) + \frac{4ma}{\gamma\sigma^2}\,h\sin^2\theta = 0 \quad (12)$$

All the terms except the last will need multiplication by b_i when the attraction of the water is included.

We now introduce two auxiliary functions, such that

$$\begin{aligned} h - e &= \Sigma b_i\,(h_i - e_i), \\ &= (D - \sigma\cos\theta)\,\Psi + (s^2 - \sigma^2\cos^2\theta)\,\Phi \quad . \quad . \quad (13) \end{aligned}$$

It is easy to prove that

$$\left.\begin{aligned} (D + \sigma\cos\theta)(D - \sigma\cos\theta) &= D^2 - s^2 + \sigma\sin^2\theta + (s^2 - \sigma^2\cos^2\theta), \\ (D - \sigma\cos\theta)(D + \sigma\cos\theta) &= D^2 - s^2 - \sigma\sin^2\theta + (s^2 - \sigma^2\cos^2\theta). \end{aligned}\right\} . \quad (14)$$

Also

$$\begin{aligned} (D + \sigma\cos\theta)(s^2 - \sigma^2\cos^2\theta)\,\Phi = (s^2 - \sigma^2\cos^2\theta)(D + \sigma\cos\theta)\,\Phi \\ + 2\sigma^2\sin^2\theta\cos\theta\,\Phi \quad . \quad (15) \end{aligned}$$

Now perform $D + \sigma\cos\theta$ on (13), and use the first of (14) and (15), and we have

$$\begin{aligned} (D + \sigma\cos\theta)(h-e) = (D^2 - s^2 + \sigma\sin^2\theta + s^2 - \sigma^2\cos^2\theta)\Psi \\ + (s^2 - \sigma^2\cos^2\theta)(D + \sigma\cos\theta)\Phi + 2\sigma^2\sin^2\theta\cos\theta\,\Phi \quad (16) \end{aligned}$$

The functions Ψ and Φ are as yet indeterminate, and we may impose another condition on them. Let that condition be

$$\frac{1}{\sin^2\theta}(D^2 - s^2 + \sigma\sin^2\theta)\Psi = -2\sigma^2\cos\theta\,\Phi \quad . \quad . \quad (17)$$

Then (16) may be written

$$\frac{(D + \sigma\cos\theta)(h-e)}{s^2 - \sigma^2\cos^2\theta} = \Psi + (D + \sigma\cos\theta)\Phi.$$

Substituting from this in (12), and using the second of (14), the function Ψ disappears and the equation reduces to

$$(D^2 - s^2 - \sigma\sin^2\theta)\Phi + \frac{4ma}{\gamma\sigma^2}h\sin^2\theta = 0 \quad . \quad . \quad (18)$$

Since by (17) $-\sigma^2\cos^2\theta\,\Phi = \frac{1}{2}\frac{\cos\theta}{\sin^2\theta}(D^2 - s^2 + \sigma\sin^2\theta)\Psi$, (13) may be written

$$\Sigma b_i(h_i - e_i) = \left[D - \sigma\cos\theta + \tfrac{1}{2}\frac{\cos\theta}{\sin^2\theta}(D^2 - s^2 + \sigma\sin^2\theta)\right]\Psi + s^2\Phi \quad (19)$$

The equations (17), (18), and (19) define Ψ and Φ, and furnish the equation which must be satisfied.

If we denote $\cos\theta$ by μ the zonal harmonics are defined by

$$P_i = \frac{1}{2^i i!}\left(\frac{d}{d\mu}\right)^i(\mu^2 - 1)^i.$$

The following are three well-known properties of zonal harmonics—

$$\frac{d}{d\mu}\left[(1 - \mu^2)\frac{dP_i}{d\mu}\right] + i(i+1)P_i = 0, \quad . \quad . \quad (20)$$

$$(i+1)P_{i+1} - (2i+1)\mu P_i + iP_{i-1} = 0, \quad . \quad . \quad (21)$$

$$\frac{dP_{i+1}}{d\mu} - \frac{dP_{i-1}}{d\mu} = (2i+1)P_i. \quad . \quad . \quad . \quad (22)$$

If $P_i^s{\scriptstyle\begin{matrix}\cos\\ \sin\end{matrix}}\,s\phi$ are the two tesseral harmonics of order i and rank s, it is also known that

$$P_i^s = (1 - \mu^2)^{\frac{1}{2}s}\frac{d^sP_i}{d\mu^s} \quad . \quad . \quad . \quad . \quad (23)$$

Let us now assume

$$h = \Sigma C_i^sP_i^s, \quad e = \Sigma E_i^sP_i^s, \quad \Psi = \Sigma a_i^sP_i^s, \quad \Phi = \Sigma\beta_i^sP_i^s.$$

These must now be substituted in our three equations (17), (18), (19), and the result must be expressed by series of the P_i^s functions. It is clear then that we have to transform into P_i^s functions the following functions of P_i^s, namely

$$\frac{1}{\sin^2\theta}(D^2 - s^2 \pm \sigma\sin^2\theta)P_i^s, \quad \cos\theta P_i^s,$$

$$\left[D - \sigma\cos\theta + \tfrac{1}{2}\frac{\cos\theta}{\sin^2\theta}(D^2 - s^2 + \sigma\sin^2\theta)\right]P_i^s.$$

If we differentiate (20) s times, and express the result by means of the operator D, we find

$$(D^2 - s^2)P_i^s + i(i+1)P_i^s\sin^2\theta = 0 \quad . \quad . \quad . \quad (24)$$

Again, differentiating (21) s times and using (22), we find

$$(i-s+1)P_{i+1}^s-(2i+1)\cos\theta P_i^s+(i+s)P_{i-1}^s=0 \quad . \quad (25)$$

Lastly, differentiating (23) once and using (20), (22), and (25)

$$DP_i^s=\frac{i(i-s+1)}{2i+1}P_{i+1}^s-\frac{(i+1)(i+s)}{2i+1}P_{i-1}^s \quad . \quad . \quad (26)$$

By means of (24), (25), and (26) we have

$$\frac{1}{\sin^2\theta}(D^2-s^2\pm\sigma\sin^2\theta)P_i^s=[-i(i+1)\pm\sigma]P_i^s,$$

$$\cos\theta\, P_i^s=\frac{i+s}{2i+1}P_{i-1}^s+\frac{i-s+1}{2i+1}P_{i+1}^s,$$

$$\left[D-\sigma+\tfrac{1}{2}\frac{\cos\theta}{\sin^2\theta}(D^2-s^2+\sigma\sin^2\theta)\right]P_i^s=-\frac{(i-s+1)[\sigma+i(i-1)]}{2(2i+1)}P_{i+1}^s$$
$$-\frac{(i+s)[\sigma+(i+1)(i+2)]}{2(2i+1)}P_{i-1}^s.$$

Therefore the equations (17), (18), (19) give

$$\Sigma\left[\alpha_i^s\{-i(i+1)+\sigma\}P_i^s+2\sigma^2\beta_i^s\left\{\frac{i+s}{2i+1}P_{i-1}^s+\frac{i-s+1}{2i+1}P_{i+1}^s\right\}\right]=0,$$

$$\Sigma\left[\beta_i^s\{-i(i+1)-\sigma\}P_i^s+\frac{4ma}{\gamma\sigma^2}C_i^sP_i^s\right]=0,$$

$$\Sigma\left[b_i(C_i^s-E_i^s)P_i^s+\alpha_i^s\left\{\frac{(i-s+1)(\sigma+i(i-1))}{2(2i+1)}P_{i+1}^s\right.\right.$$
$$\left.\left.+\frac{(i+s)(\sigma+(i+1)(i+2))}{2(2i+1)}P_{i-1}^s\right\}-\beta_i^ss^2P_i^s\right]=0.$$

Since these equations must be true identically, the coefficients of P_i^s in each of them must vanish. Therefore

$$\left.\begin{aligned}&\alpha_i^s\{\sigma-i(i+1)\}+2\sigma\left\{\beta_{i+1}^s\frac{i+s+1}{2i+3}+\beta_{i-1}^s\frac{i-s}{2i-1}\right\}=0,\\&-\beta_i^s\{\sigma+i(i+1)\}+\frac{4ma}{\gamma\sigma^2}C_i^s=0,\\&b_i(C_i^s-E_i^s)+\alpha_{i-1}^s\frac{(i-s)[\sigma+(i-1)(i-2)]}{2(2i-1)}\\&\qquad+\alpha_{i+1}^s\frac{(i+s+1)[\sigma+(i+2)(i+3)]}{2(2i+3)}-\beta_i^ss^2=0.\end{aligned}\right\} \quad . \quad (27)$$

Solution for tesseral oscillations.

If we eliminate the α's and β's from the third equation (27) by means of the first two, we find

$$\xi_{i-2}^sC_{i-2}^s-L_i^sC_i^s+\eta_{i+2}^sC_{i+2}^s=\frac{\gamma b_i}{4ma}E_i^s, \quad . \quad . \quad (28)$$

where

$$L_i^s=\frac{s^2}{\sigma^2[\sigma+i(i+1)]}+\frac{(i^2-s^2)[\sigma+(i-1)(i-2)]}{(4i^2-1)[\sigma-(i-1)i][\sigma+i(i+1)]}$$
$$+\frac{[(i+1)^2-s^2][\sigma+(i+2)(i+3)]}{[4(i+1)^2-1][\sigma-(i+1)(i+2)][\sigma+i(i+1)]}-\frac{\gamma b_i}{4ma}$$

$$\xi_{i-2}^s=\frac{-(i-s)(i-s-1)}{(2i-1)(2i-3)[\sigma-(i-1)i]},$$

$$\eta_{i+2}^s=\frac{-(i+s+1)(i+s+2)}{(2i+3)(2i+5)[\sigma-(i+1)(i+2)]}.$$

This equation amongst the C's is available for all values of i, provided that C_{-1}, E_{-1}, C_0, E_0 are regarded as being zero.

As in the case of the zonal oscillations, the equations with odd suffixes separate themselves from those with even suffixes, so that the two sets may be treated independently of one another.

The equation (28) might be treated by a process exactly parallel to that followed in § 8, but as the numerical computations would then become very laborious, it is well to adopt a modification of the procedure.

Second form of solution.

It is obvious that the function L_i^s may be split up into partial fractions containing σ^2, σ, $\sigma-i(i-1)$, $\sigma-(i+1)(i+2)$ in the denominators, and ξ_{i-2}^s, η_{i+2}^s are already clothed in that form. When this is done it will be found that the equation may be written as follows :—

$$\frac{i-s}{(2i-1)[i(i-1)-\sigma]}\left\{\frac{i-s-1}{2i-3}C_{i-2}^s+\frac{(i-1)^2}{i^2}\frac{i+s}{2i+1}C_i^s\right\}$$
$$-\left\{\frac{s^2}{\sigma^2}\frac{[i(i+1)-\sigma]}{i^2(i+1)^2}-\frac{\gamma b_i}{4ma}\right\}C_i^s$$
$$+\frac{i+s+1}{(2i+3)[(i+1)(i+2)-\sigma]}\left\{\frac{i+s+2}{2i+5}C_{i+2}^s+\frac{(i+2)^2}{(i+1)^2}\frac{i-s+1}{2i+1}C_i^s\right\}$$
$$=\frac{\gamma b_i}{4ma}E_i^s.$$

If now we write for brevity

$$M_i^s=\frac{s^2}{\sigma^2}[i(i+1)-\sigma]-i^2(i+1)^2\frac{\gamma b_i}{4ma},$$

$$N_i^s=i(i+1)-\sigma,$$

and define a new function D_i^s by the equation

$$\frac{(i+1)^2(i-s)}{2i-1}C_{i-1}^s-N_i^sD_i^s+\frac{i^2(i+s+1)}{2i+3}C_{i+1}^s=0, \quad . \quad (29)$$

our equation may be written

$$\frac{(i+1)^2(i-s)}{2i-1}D_{i-1}^s-M_i^sC_i^s+\frac{i^2(i+s+1)}{2i+3}D_{i+1}^s=i^2(i+1)^2\frac{\gamma b_i}{4ma}E_i^s \quad (30)$$

Free waves.

As in the case of the zonal oscillations, we shall in the first instance only consider the free oscillations. Accordingly, it will now be assumed that there is no disturbing force, so that E_i^s will be zero.

If for brevity we write

$$a_i^s=\frac{i^2(i+2)^2(i+s+1)(i-s+1)}{(2i+1)(2i+3)},$$

the equations (29) and (30) may be written in the alternative forms

$$\frac{(i+1)^2(i-s)}{2i-1}\left(\frac{C_{i-1}^s}{D_i^s}\text{ or }\frac{D_{i-1}^s}{C_i^s}\right)$$
$$=(N_i^s\text{ or }M_i^s)-\frac{a_i^s}{\dfrac{(i+2)^2(i-s+1)}{2i+1}\left(\dfrac{D_i^s}{C_{i+1}^s}\text{ or }\dfrac{C_i^s}{D_{i+1}^s}\right)} \quad . \quad (31)$$

By continued application of these two formulæ alternately

$$\frac{(i+1)^2(i-s)}{2i-1}\frac{D_{i-1}^s}{C_i^s}=M_i^s-\frac{a_i^s}{N_{i+1}^s-}\;\frac{a_{i+1}^s}{M_{i+2}^s-}\;\frac{a_{i+2}^s}{N_{i+3}^s-\dots} \quad . \quad (32)$$

Again, the same two equations may be written

$$\frac{i^2(i+s+1)}{2i+3}\left(\frac{C_{i+1}^s}{D_i^s}\text{ or }\frac{D_{i+1}^s}{C_i^s}\right)$$
$$=(N_i^s\text{ or }M_i^s)-\frac{a_{i-1}^s}{\dfrac{(i-1)^2(i+s)}{2i+1}\left(\dfrac{D_i^s}{C_{i-1}^s}\text{ or }\dfrac{C_i^s}{D_{i-1}^s}\right)} \quad . \quad (33)$$

By continued application of these two formulæ alternately

$$\frac{i^2(i+s+1)}{2i+3}\frac{D_{i+1}^s}{C_i^s}=M_i^s-\frac{a_{i-1}^s}{N_{i-1}^s-}\;\frac{a_{i-2}^s}{M_{i-2}^s-}\;\frac{a_{i-3}^s}{N_{i-3}^s-\dots} \quad . \quad (34)$$

But the second general equation of condition (30), with $E_i^s=0$ is

$$\frac{(i+1)^2(i-s)}{2i-1}\frac{D_{i-1}^s}{C_i^s}+\frac{i^2(i+s+1)}{2i-1}\frac{D_{i-1}^s}{C_i^s}-M_i^s=0.$$

Therefore

$$M_i^s-\frac{a_i^s}{N_{i+1}^s-}\;\frac{a_{i+1}^s}{M_{i+2}^s\dots}\text{ ad inf.}$$
$$-\frac{a_{i-1}^s}{N_{i-1}^s-}\;\frac{a_{i-2}^s}{M_{i-2}^s-\dots}=0 \quad . \quad . \quad . \quad (35)$$

This is the equation from which the frequency of the oscillations may be determined. It may, however, be arranged in another form, for if we had proceeded from (33) we should have obtained a formula like the foregoing in which every M would be replaced by an N, and every N by an M.

In both of these forms the fraction with ascending suffixes extends to infinity, and that with descending suffixes ends with M_s^s or N_s^s.

For the symmetrical types of oscillation, if we use (35) we must suppose $i-s$ to be even, whereas if we use the second form $i-s$ must be supposed odd. The reverse will of course be the case for the unsymmetrical types.

Frequency equation.

Let us write

$$e_i^s=\frac{a_{i-1}^s}{M_i^s-}\;\frac{a_i^s}{N_{i+1}^s-}\;\frac{a_{i+1}^s}{M_{i+2}^s-\dots}\text{ ad inf.}$$

f_i^s = the same with M and N interchanged.

$$E_i^s=\frac{a_i^s}{M_i^s-}\;\frac{a_{i-1}^s}{N_{i-1}-}\;\frac{a_{i-2}^s}{M_{i-2}-\dots}.$$

F_i^s = the same with M and N interchanged.

The E_i^s used here is merely an abbreviation for a certain continued fraction, and must not be confused with the previous E_i^s.

Then the two forms of the frequency equation are

$$\left.\begin{aligned}M_i^s-F_{i-1}^s-f_{i+1}^s=0\\N_i^s-E_{i-1}^s-e_{i+1}^s=0\end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (36)$$

The periods of oscillation are determinable from either of these. As a first approximation, the E, F, e, f fractions may be taken as zero, so that $M_i^s=0$, $N_i^s=0$. We shall see that these two afford, in fact, first approximations to different roots of the equation.

Then, since $\sigma=\frac{s}{f}$, these approximate equations are

$$\left.\begin{aligned} f^2\left[i(i+1)-\frac{s}{f}\right]-i^2(i+1)^2\frac{\gamma b_i}{4ma}=0,\\ i(i+1)-\frac{s}{f}=0.\end{aligned}\right\} \quad . \quad . \quad (37)$$

The first is a quadratic equation, with a positive and a negative root; the second has the solution $\frac{s}{i(i+1)}$.

We now denote the "speed" of the tide by λ, so that $\lambda=2nf$. Then since m is n^2a/g, it follows that the first of (37) may be written

$$i(i+1)\lambda^2-2ns\lambda-i^2(i+1)^2\frac{\gamma b_i g}{a^2}=0. \quad . \quad . \quad (38)$$

If, therefore, n vanishes we still have two roots, but they become numerically equal to one another.

But the second of (37) may be written $\lambda=\frac{2ns}{i(i+1)}$, and this root vanishes with n.

Since the positive root corresponds to a westward wave, and the negative root to an eastward wave, we see that there are eastward and westward waves which tend to become identical in period as the rotation slackens. But there is also a westward wave which tends to have an infinite period when the rotation vanishes; that is to say, it becomes a steady motion. We have already adverted to the case of steady motion in the case of the zonal oscillations, but that steady motion differs from the one which we are now considering, in that it can subsist as such without supposing the diurnal rotation to vanish. When the E, F, e, f are not treated as zero, that is to say, when we go on to a second approximation, the motions are found to possess the same characteristics as in these two first approximations.

Form of waves.

In order to find the type of motion we have the two equations (32) and (34), which may be written

$$\left.\begin{aligned} \frac{(i+1)^2(i-s)}{2i-1}\frac{D_{i-1}^s}{C_i^s}=M_i^s-f_{i+1}=F_{i-1}^s,\\ \frac{i^2(i+s+1)}{2i+3}\frac{D_{i+1}^s}{C_i^s}=M_i^s-F_{i-1}^s=f_{i+1}^s.\end{aligned}\right\} \quad . \quad . \quad (39)$$

It is clear from the manner in which the equations (39) were derived that there are two other similar equations with the C's in the numerators. We thus have the four equations

$$\left.\begin{aligned} \frac{C_i^s}{D_{i-1}^s}=\frac{2i+1}{(i-1)^2(i+s)}e_i^s=\frac{(i-s)(i+1)^2}{(2i-1)F_{i-1}^s}.\\ \frac{C_i^s}{D_{i+1}^s}=\frac{2i+1}{(i+2)^2(i-s+1)}E_i^s=\frac{(i+s+1)i^2}{(2i+3)f_{i+1}^s}.\end{aligned}\right\} \quad . \quad . \quad (40)$$

From these it is easy to deduce

$$\left.\begin{aligned} C_{i-2}^s=C_i^s\frac{(2i-1)(2i-3)}{(i-s)(i-s-1)i^2(i+1)^2}E_{i-2}^s F_{i-1}^s,\\ C_{i+2}^s=C_i^s\frac{(2i+3)(2i+5)}{(i+s+1)(i+s+2)i^2(i+1)^2}e_{i+2}^s f_{i+1}^s.\end{aligned}\right\} \quad . \quad . \quad (41)$$

By successive applications of (41) all the C's of the series C_{i-2r}, C_{i+2r}, may be expressed in terms of C_i^s, which is the arbitrary constant of the solution. It seems natural to adopt this form for the solutions corresponding to the type $M_i^s=0$. It is clear that for the symmetrical oscillations $i-s$ must be even, whilst for the unsymmetrical ones it must be odd.

If we are finding the solution of the type $N_i^s=0$, it will be best to proceed as follows. Writing $i+1$ for i in (41), we obtain C_{i-1}^s and C_{i+3}^s in terms of C_{i+1}^s.

Now

$$C_{i+1}^s=D_i^s\frac{2i+3}{i^2(i+s+1)}e_{i+1}^s=D_i^s\frac{(i-s+1)(i+2)^2}{(2i+1)F_i^s},$$

and therefore we may express C_{i-1}^s and C_{i+3}^s in terms of D_i^s. Hence all the C's of the series C_{i-2r-1}^s, C_{i+2r+1}^s may be expressed as terms of D_i^s, which is the arbitrary constant of the solution. In this case the symmetrical oscillations correspond with $i-s$ an odd number, and the unsymmetrical with $i-s$ an even number.

The numerical solutions obtained by Mr Hough show that for a shallow ocean and for the higher harmonics the eastward and westward wave of the first class (derived from the M_i^s form) have periods which tend to equality as the order of the harmonic increases. This result may be foreseen from the form of the quadratic (38), because the augmentation of i tends to make the first and last terms important compared with the middle term; thus the increase of i gives a result similar to that due to the diminution of n, and if n, the angular velocity, vanishes, the two roots become numerically identical. But for the harmonics of low order the velocities of the two waves are very different. For example, in an ocean 7260 feet deep the westward wave corresponding to $i=2$, $s=2$, has a period of eighteen hours, whilst the period of the eastward wave is thirty-eight and a half hours. But the westward wave of the second class (derived from the N_i^s form) has in all cases a long period, and the period increases with the order. This result is clearly in accordance with what was to be expected from the first approximation $\lambda=2ns/i(i+1)$. For example, for the ocean of 7260 feet in depth when $s=1$, $i=1$, the period is one day thirteen hours, but when $s=1$, $i=3$ the period is 26½ days.

§ 10. *Forced Oscillations or Tides.*

Forced tesseral oscillations.

We will now consider, but without going into details, the forced oscillations which correspond with the tides generated by the moon and sun.

The equation of condition amongst the C's is given in (28), namely,

$$\xi_{i-2}^s C_{i-2}^s-L_i^s C_i^s+\eta_{i+2}^s C_{i+2}^s=\frac{\gamma b_i}{4ma}E_i^s,$$

and all the E's excepting, say, E_i^s are to be zero.

Omitting the superscript s for brevity, the equations are

$$\begin{aligned} -L_s C_s+\eta_{s+2}C_{s+2} \qquad &=0,\\ \xi_s C_s-L_{s+2}C_{s+2}+\eta_{s+4}C_{s+4} &=0,\end{aligned}$$

and so on; one of the series having the zero on the right replaced by $\frac{\gamma b_i}{4ma}E_i$.

It follows from the same arguments as were adduced in the article on TIDES, § 16, that the limit of C_j is zero when j is infinity.

The equations amongst the C's may be written in the two forms

$$\left.\begin{aligned} \xi_{j-2}\frac{C_{j-2}}{C_j}=L_j-\xi_j\eta_{j+2}\left\{\frac{1}{\xi_j C_j/C_{j+2}}\right\},\\ \eta_{j+2}\frac{C_{j+2}}{C_j}=L_j-\xi_{j-2}\eta_j\left\{\frac{1}{\eta_j C_j/C_{j-2}}\right\},\end{aligned}\right\} \quad . \quad . \quad (42)$$

in every case except when $j=i$, and then the right-hand side of each equation contains the term $+\frac{\gamma b_i}{4ma}\frac{E_i}{C_i}$.

By continued application of these formulæ we may write the right-hand sides in the form of continued fractions—say H_{j-2}, K_{j+2}.

Thus

$$\xi_{j-2}\frac{C_{j-2}}{C_j}=L_j-H_{j-2},$$

$$\eta_{j+2}\frac{C_{j+2}}{C_j}=L_j-K_{j+2},$$

provided that j is not equal to i.

In the particular case where $j=i$ the right-hand side of each equation may still be expressed by the continued fractions H, K, but the additional term must be added. Thus the equation corresponding to $j=i$ is

$$C_i(H_{i-2}-L_i+K_{i+2})=\frac{\gamma b_i E_i}{4ma}.$$

Hence C_i is determined, and then all the other C's are easily determinable as multiples of it.

Factor of kinetic augmentation.

It follows from this that h, the semi-range of the tide, will have a common factor $\frac{\gamma b_i E_i}{4ma(H_{i-2}-L_i+K_{i+2})}$; and we see that $\frac{1}{H_{i-2}-L_i+K_{i+2}}$ must be regarded a coefficient of kinetic augmentation, so that if the period of the force coincides with that of any one of the free oscillations the amplitude of the tide becomes infinite. We refer the reader to Mr Hough's paper for the numerical results exemplifying the lunar and solar tides in oceans of various depths. As we have already said, they do not differ more widely from those obtained in the article on TIDES than was to be expected from the introduction of the attraction of the ocean on itself; but the fact that Mr Hough's solution contains that factor of kinetic augmentation, which must occur in every complete solution of a problem involving forced oscillations, renders his solution immensely superior to the older one.

(G. H. D.)

Tidore, an island of the East Indian Archipelago, situated in 0° 45′ N. and 127° 23′ E. In area, volcano, liability to earthquakes, climate, and products it resembles Ternate. By an agreement of 1879 the sultan exercises authority over some parts of Jilolo, the Papoea Islands, the western half of New Guinea, and the islands in

Geelvink Gulf. The town of Tidore is the seat of the sultan and of a Dutch Controleur (Resident or Commissioner or Agent). The inhabitants live by agriculture (jagung, cotton, tobacco, and nutmegs) and fishing.

Tiele, Cornelis Petrus (1830–1902), Dutch theologian and scholar, was born at Leyden on the 16th of December 1830. He was educated at Amsterdam, first studying at the Athenæum Illustre, as the communal high school of the capital was then named, and afterwards at the seminary of the Remonstrant Brotherhood. He was destined for the pastorate in his own brotherhood, which, after steadily declining for a considerable period, increased its influence in the second half of the 19th century by widening the somewhat inelastic tenets of the original Dutch Methodists, which had caused many of the advanced clergymen of the Lutherans and Calvinists to secede and go over to the Remonstrants. Tiele certainly had advanced religious views himself, which he early enunciated as a Remonstrant pastor from the pulpit, both at Moordrecht (1853) and at Rotterdam (1856). His earnest eloquence and deep learning attracted attention, and upon the removal of the seminary of the brotherhood from Amsterdam to Leyden in 1873, Tiele was appointed one of its leading professors. In 1877 followed his appointment at the University of Leyden as professor of the science of religion, a chair specially created for him. Of the many learned works which have constituted Tiele one of the leading authorities in Europe upon these matters, the *Vergelijkende Geschiedenis van de Egyptische en Mesopotamische Godsdiensten* ("Comparative History of the Religions of Egypt and Mesopotamia," Amsterdam, 1872), and the *Geschiedenis van den Godsdienst* ("History of Religion," Amsterdam, 1876; new edition, Amsterdam, 1891), have been translated into English, the former by James Ballingall (London, 1878–1882), the latter by J. E. Carpenter (London, 1877), under the title of "Outlines of the History of Religion" (French translation, Paris, 1885; German translation, Gotha, 1895). A French translation of the *Comparative History* was published in Paris in 1882. Other works by Tiele are:—*De Godsdient van Zarathustra, van het Ontstaan in Baktrië, tot den Val van het Oud-Perzische Rijk* ("The Religion of Zoroaster, from its origin in Bactria to the Fall of the old Persian Empire," Amsterdam, 1864) [this work is now embodied, but much enlarged and improved by the latest researches of the author, in the *History of Religions* (vol. ii. part ii., Amsterdam, 1901), a part which appeared only a short time before the author's death]; *Die Assyriologie und ihre Ergebnisse für die vergleichende Religionsgeschichte* (Leipzig, 1877); *Babylonisch-Assyrische Geschichte* (in two parts, Leipzig, 1886–88); *Western Asia, according to the most Recent Discoveries* (London, 1894). A volume of Tiele's sermons appeared at Haarlem in 1865, and a collection of his poems in 1863. He also edited the poems of his friend, the genial and witty de Genestet. Tiele was best known to English students by his *Outlines* and the Gifford Lectures "On the Elements of the Science of Religion," which he delivered in 1896–98 at Edinburgh University, and which attracted a good deal of attention at the time. They subsequently appeared simultaneously in Dutch at Amsterdam, in English in London and Edinburgh (1897–1899, 2 vols.). Edinburgh University in 1900 conferred upon Tiele the degree of D.D. *honoris causâ*, an honour bestowed upon him previously by the Universities of Dublin and Bologna. He was also a fellow of at least fifteen learned societies in Holland, Belgium, France, Germany, Italy, Great Britain, and the United States. He died on 11th January 1902. In 1901 he had resigned his professorship at Leyden University. Tiele's zeal and power for work were as extraordinary as his vast knowledge of ancient languages, peoples, and their religions, upon which his researches, according to the undisputed testimony of his lifelong friend and fellow-worker in England, Max Müller, have shed an entirely new and most vivid light. Equally remarkable were the breadth of his religious views, his command over facts, and the gift of exposition, whether writing or speaking. With Kuenen and Scholten, amongst others, he founded the "Leyden School" of modern theology.

His brother, Pieter Anton Tiele (1834–1888) acted for many years as the librarian of Utrecht University, and distinguished himself by his bibliographical studies, more especially by his several works on the history of colonization in Asia. Among these the most noteworthy are: *De Opkanst van het Nederlandsch Gezay in Oost-Indie* ("The Rise of Dutch Power in Netherlands India," 1886); *De Vestiging der Portugeezen in Indie* ("The Portuguese in India," 1873), and other books on the early colonization struggles of the Portuguese in the Malay Archipelago. (H. Ti.)

Tientsin, a treaty port in the province of Chihli, China, 70 miles south-east of Peking, of which it is the port. It occupies a position of great importance as the seat of the trade of north China. The importance of this position has been enhanced by the railways connecting it with Peking on the one hand and with Shanhaikuan and Manchuria on the other. It will be still further enhanced by the prospective opening of the main trunk line from Peking southwards. In 1899 the total trade of the port was H. taels 77,604,000 (£11,640,000). The native population is stated to be 950,000, but this is probably over the mark. Among local industries the distillation of spirits, usually called Chinese wine, made from millet, holds a principal place, as does also the manufacture of carpets and rugs made of camels' wool. The chief exports are wool, coal, bristles, skins, furs, &c. The British concession, in which the trade centres, is situated on the right bank of the river Peiho below the native city, and occupies an area of some 200 acres. It is held on a lease in perpetuity granted by the Chinese Government to the British Crown, which sublets plots to private owners in the same way as is done at Hankow. The local management is entrusted to a municipal council organized on lines similar to those which obtain at Shanghai. Besides the British concession there are a French concession and a German concession, situated the one above the other below the British. The German concession was negotiated in 1895, but so far has not been utilized to any great extent. During the long period 1874–94, when Li Hung Chang was viceroy of Chihli and *ex officio* superintendent of trade, he made Tientsin his headquarters and the centre of his experiments in military and naval education. As a consequence the city became the chief focus of enterprise and foreign progress. Having arrogated to himself the practical control of the foreign policy of the nation, his yamen became the scene of many important negotiations, and attracted distinguished visitors from all parts of the globe. The loss of prestige consequent on the Japanese war brought about the retirement of Li, and with it the political importance of Tientsin ceased. Both the foreign concessions and the native city suffered severely during the hostilities resulting from the Boxer movement in June–July 1900. (For a fuller account of these events see China: *History*.)

Tierra del Fuego.—The boundary between the Argentine Republic and Chile has been settled in such a manner that the Argentine holds that part of the great island, or Tierra del Fuego properly so-called, which is situated to the east of the meridian of Cape Espiritu Santo, up to the middle of Beagle Channel; and Chile holds all the western part of that island and the other numerous islands to the west and to the south of Beagle Channel. The archipelago to the south of Magellan Strait and to the north of Cape Horn, known by the general name of Tierra del Fuego, is controlled by both countries, the Argentine side as the Territory of Tierra del Fuego, and the Chilian as part of the Territory of Magallanes. Knowledge of these lands has increased considerably, and their reputation for dreariness has been favourably modified. The climate in the eastern and southern regions is not so rigorous as was believed, there are no barren lands, the soil is fertile and can support fruitful industries, and the aborigines are far from being so dangerous as they were once generally considered to be.

The western part of the archipelago of Tierra del Fuego, *i.e.*, to the south of Magellan Strait, constituted by the continuation to the south of the Cordillera de la Costa of Chile and of the Cordillera of the Andes, has not been explored lately, and there is very little to be told concerning it. Small surveys on these fjords have shown that several of the larger islands are cut by channels which separate them into smaller ones, while in other cases the low valleys which unite the mountains and hills are only the result of post-Glacial deposits that have filled part of the former channels, these islands being only the summits of an old continuous half-submerged mountain chain. Sir Martin Conway ascended Mount Sarmiento (7200 feet) and ascertained that it is not a volcano as it is sometimes called. At Dawson Island the Chilian Government has established some settlements, and the Roman Catholic mission there tries to civilize the Alakaluf Indians by means of school and workshop.

The eastern and greater island has been better explored. In its principal extension it is formed by the continuation of the Tertiary beds of the Patagonian tableland cut by the transversal depression of Magellan Strait and by the low land extending from Useless Bay on the west to San Sebastian Bay on the east, of so recent origin that there exist still some salt lakes, this depression being represented in the old charts as an inter-oceanic passage for small boats. This tableland is covered with morainic material, and as the climate is damper here than in the northern lands of eastern Patagonia, it is more useful for colonization. However, although in 1880 numerous prospectors discovered extensive deposits of alluvial gold, its exploitation has not been generally successful, and farms have taken the place of mines. At the end of 1899 1200 square miles had been occupied by cattle and sheep on the Argentine side, and about the same extent on the Chilian. The price of land has reached £100 per square mile, the results of the first experiments on the farms showing that the cattle industry is very profitable. The gold industry is limited now to very small areas, principally in the southern part of the island.

The undulating tableland has an average height of 300 feet above the sea, and its climate, however cold in winter—in 1892 and 1893 the temperature reached 12·6° F.—allows of the cultivation of barley, oats, and occasionally potatoes, which, however, grow better in Beagle Channel. To the south the tableland is higher and more broken, being drained by the rivers Silva and Grande, amongst other smaller ones, the Grande being navigable in some parts by small craft. To the west and south-west the general character of the land changes; the ends of the Tertiary beds are raised in small hills and Mesozoic rocks appear, forming broken ridges of the Pre-Cordillera, a name given on the continent to the ridges which precede, to the east, the Andes. There appears the Antarctic forest in which predominates the *Fagus antarctica* and *F. betuloides*, *Drymis Winteri*, *Berberis ilicifolia*, *Pernettia*, *Desfonteinia* and *Philesia buxifolia*. Two lakes receive the waters of these mountains and hills, Lake Solier and Lake Fagnano. Lake Fagnano is only 180 feet above the sea, and its depth reaches 700 feet. To the south of the lake rises the south-eastern prolongation of the Cordillera of the Andes, with ridges of a uniform height of 3500 feet, in which predominate crystalline schists which do not seem to be very old. Some peaks due to Tertiary granite break the uniformity, such as Mount Sarmiento, Mount Darwin, of which two peaks have been measured (6201 and 7054 feet), and Mount Olivaia (4324 feet). Deep valleys, which seem to be only the prolongation of fjords, penetrate into the chain in the southern slope where exist several ports in which settlements have commenced. Yendegaia, Lapatia, and Ushuaia Bays are among the larger, and present magnificent landscapes, with their glaciers and woods. Ushuaia, being the site of the capital of the Argentine Territory, is developing rapidly, having regular communication by monthly steamers with Buenos Aires, while smaller steamers serve the different settlements along the coast. Cattle farms prosper along Beagle Channel, the timber industry is growing, lignite seams have been discovered, and alluvial gold is washed principally at Slogget Bay. These regions, as they become more known, will invite the attention of tourists by their proximity to the most sublime scenery. South of the Beagle Channel partial exploration was conducted by the French Mission du Cap Horn in 1882–83, and the geological foundations are better known, being there granite and basic volcanic rocks. Staten Island to the east of Tierra del Fuego has been settled by the Argentine Government, and there are a prison and lighthouse in St John Harbour. A first-class permanent meteorological and magnetic station is being established there by the same Government.

The aborigines are decreasing rapidly in the whole archipelago, and the Rev. Thomas Bridges, who, as missionary first and then as farmer, resided thirty years there, says that when he arrived he calculated the population to be 10,000, but in 1892 there were only about 1000 (Alakalufs, 100; Yagans, 320; Onas, 600). With the settlement of the great island, which is now generally called Onisia, leaving the name of Tierra del Fuego to the archipelago, the Onas tribe is becoming better known. Undoubtedly, however, among these Indians are many that recall some Patagonian types; it seems that they are not the same as the Tehuelche type generally known, but that they pertain to one of the races that in earlier times existed in Patagonia. Their language is closely allied with the one called Old Tehuelche. The Onas live only in the island of Onisia. The Yagans seem less distantly related to the Onas than has been supposed, and probably are a mixed race composed of Alakalufs and Onas. The languages of the Yagans and the Alakalufs are alike in many particulars.

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Tietjens, Thérèse Johanne Alexandra (1831–1877), Hungarian soprano vocalist, was born at Hamburg on 17th July 1831. Her voice was trained at Hamburg, where she made a successful *début* in 1849 as Lucrezia Borgia in Donizetti's opera. Thence she proceeded to Frankfort and Vienna. She sang for the first time in London in 1858, appearing as Valentine in *Les Huguenots.* Her success was so great that for the rest of her life she made England her home, and soon gained as brilliant a reputation in concert and oratorio work as she had already won upon the stage. Her voice was a dramatic soprano of magnificent quality, and her gifts as an actress were unequalled. Her most famous parts were Fidelio, Medea (in Cherubini's opera), Donna Anna (in *Don Giovanni*), but she touched nothing that she did not adorn. She had endeared herself to the English people as much by her virtues as by her artistic gifts, and her death in London on 3rd October 1877 was deplored as a national calamity.

Tiffin, a city of Ohio, U.S.A., capital of Seneca county, on the Sandusky river, and the Baltimore and Ohio, the Cleveland, Cincinnati, Chicago, and St Louis, and the Pennsylvania railways, in the northern part of the state, at an altitude of 746 feet. Heidelberg

University, situated here, had in 1899 a faculty of 28 teachers, and was attended by 308 students, of whom 104 were women. Population (1890), 10,801; (1900), 10,989, of whom 1168 were foreign-born.

Tiflis, a government of Transcaucasia, Russia, occupying the eastern portion of the great valley which stretches between the main Caucasus range and the Transcaucasian plateau from the Mesques Mountains eastwards, comprising within its boundaries both the southern slopes of a long stretch of the Caucasus Mountains and the northern slopes of the Anti-Caucasus, which rise to from 5000 to 10,000 feet. A portion of it, namely, the district of Akhaltsykh, penetrates, indeed, right over the Transcaucasian plateau, including the high valley of the Upper Kura, between the Wakhan Mountains and the Anticaucasus. The land is rich in minerals, but hitherto most of them have been allowed to remain practically idle. Only copper is extracted at Alaverd and Akhtal. The government is watered by the Kura and its tributaries, Lyakhva, Aragva, Iora, and Alazañ, all of whose waters are largely used for irrigation; but in the lower parts of the great valley there are extensive waterless steppes, Shirak and Kara-ez, on the left bank of the Kura, which are chiefly inhabited by nomad Tatars. The area of the government is 15,306 square miles (16,847 with the Zakataly district), and the population, which was 599,300 in 1869, numbered 1,040,943 (domiciled only) in 1897, 470,173 of whom were women, and 207,294 urban. The inhabitants are very mixed in race: the bulk of them are Georgians, whose numbers were estimated by Caucasian statisticians at 396,673 out of a total population of 808,143 in 1894–96, and to whom belong also in reality the Pshaves (9155), the Imeretians (8970), the Tushins (5624), the Khevzurs (6560), the Gurians, the Mingrelians, &c.; Armenians were estimated to number 193,610, Ossets 72,420, Azerbaijan Tatars 68,345, Russians 35,750, Greeks 22,171, Germans 5066, and west and east Caucasian mountaineers 4700. The annual birth-rate is 36 per 1000, the death-rate 23 per 1000; hence the natural increase of population is nearly 12,400 yearly. The government is divided into nine districts, the chief towns of which are: Tiflis (see below), Akhalkalaki (5443), Akhaltsykh (15,387), Dusheti (2456), Gori (10,457) Signakh (8998), and Telav (11,810). The districts of Borchala and Zioneti have no towns. Agriculture is the main occupation of the people, and has reached a very high standard. Land is sold and rented at very high prices, such as are obtained only in the most populous parts of western Europe. The crops of 1897, which may be considered as an average year, were: wheat, 769,000 qrs.; rye, 2600 qrs.; oats, 11,550 qrs.; barley, 413,000 qrs.; millet, 18,800 qrs.; Indian corn, 143,600 qrs.; rice, 3900 qrs.; various cereals, 18,700 qrs.; also potatoes, 71,000 qrs. Large portions of the cultivated area are covered with vineyards. Cattle-breeding is extensively carried on in the steppes. There is a great variety of domestic industries, and the natives attain a high degree of perfection in the manufacture of leather and metallic goods, felt, woollen stuffs, and gold embroidery. Factories, however, are of little importance; the 3800 industrial establishments employ only 7350 workers, and their aggregate yearly returns amount to little more than 10,000,000 roubles. (P. A. K.)

Tiflis, the capital of Caucasia and of the above government. It is now connected by rail with Poti and Batum (217 miles) on the Black Sea, with Baku on the Caspian Sea (341 miles), with Kars (185 miles) on the Transcaucasian plateau, and, *viâ* Baku and Petrovsk, with the railway system of European Russia, which it joins at Beslan, near Vladikavkaz (723 miles). Omnibuses also run regularly across the main range to Vladikavkaz, which by this route is only 133 miles distant. The city has considerably developed, and had, in 1897, 160,645 inhabitants, as compared with 104,024 in 1883. The central part is well built, and contains many handsome structures. There are monuments to the Russian writers Griboyedoff and Lermontoff. It carries on an important trade with Russia, Western Europe, and Persia. (See CAUCASUS.)

Tigré. See ABYSSINIA.

Tigris, a river of Turkey in Asia. Navigation is carried on by large rafts from Diarbekr to Baghdad, and below the latter city by river steamers and sailing craft. The last ascend as far as Samara, but at present no steamers run above Baghdad. The river commences to rise about the middle of November, and is highest in May and June, when its current is about four miles an hour. It is lowest in September, October, and November. Its tributaries, the Khabúr and the Lesser Zab, are navigable for rafts over portions of their courses, and the Diala for sailing vessels as far as Bakuba. During the flood season the Shatt el-Hai canal is navigable for native boats, and the Isa canal, which runs from the Euphrates to the Tigris, for small steamers. During the time of the Abbaside khalifs the Tigris flowed down the Shatt el-Hai canal, and, below Wasit, passed through several channels to the great swamp, el-Batiha, whence its waters ran out through a canal to the Shatt el-Arab. At that period, too, a large canal on the left bank of the river, dating from the time of Chosroes, left the river at Dur, below Tekrít, and re-entered it below the site of Kut el-Amara; whilst the lands on the right bank, north of Baghdad, were irrigated by the Ishakíyeh and Dujeil canals.

Tikhvin, a district town of Russia, in the government of Novgorod, 86 miles north-east of Chudovo station, on the St Petersburg–Moscow railway. It is the head of the Tikhvin system of canals, which connects the Volga with St Petersburg. Over 11,000 vessels, carrying goods valued at £5,000,000, pass through these canals every year, and during the summer the town becomes very animated, its population for a few months being double its normal size. It has several flour-mills and distilleries; also a monastery which has acquired a great reputation in northern Russia. Population (1897), 6631.

Tilburg, a town in the Dutch province of North Brabant, 13 miles east by south of Breda. A railway to 's Hertogenbosch (Bois-le-Duc) was opened in 1881, and there is railway connexion also with Nimeguen, &c., and a steam tramway to Waalwijk. The town has a cloth hall, a new Gothic church, and a higher burgher-school. There are 70 steam and 110 other factories, 80 of them woollen, and 30 leather factories. Population (1901), 41,518.

Tillicoultry, a police burgh of Clackmannanshire, Scotland, at the foot of the Ochil Hills, on the river Devon, 3¾ miles north-north-east of Alloa. There are about a dozen woollen factories, tweeds and shirtings being the staple product. Coal-mining and agriculture are also pursued. It has an institute and library, a session-house and hall in connexion with the parish church, an orphanage, and a public park. Population (1891), 3939; (1901), 3337.

Tilsit, a town of Prussia, province of east Prussia, on the river Niemen, 57 miles by rail south-east of Memel. It has considerable trade, and manufactures of machinery, soap, oil, vinegar, shoes, tobacco, glass, cheese, &c., besides iron foundries, tanneries, breweries, saw-mills and flour-mills. A bronze statue of the native poet Von Schenkendorf was unveiled in 1890. Population (1885), 22,422; (1900), 34,538.

Timbuktu, chief town of the territory of Timbuktu, southern Sahara, West Africa, on the border of the gently-rising tableland to the north of the swamps and channels connecting with the Niger, and some 9 miles north of the main stream. Its position, which was given by Caillié and Barth at 17° 29′ N. and 5° 27′ W., has been astronomically determined at 16° N. and 5° W. It was occupied by the French in December 1893, and has since formed part of their Sudanese domain. The neighbouring reaches of the Niger had already been visited by gunboats in 1887 and 1890, and after the reduction of Segu and Massina by Colonel Archinard early in 1893, the permanent occupation of Timbuktu became inevitable. Indeed the townspeople, wearied with the internecine strife of the rival Tuareg and Fulah tribes, freely opened their gates to Lieutenant Boiteux as soon as he reached the riverside port of Kabara in command of a small flotilla on 12th December 1893. This first success was followed by some severe reverses at the hands of the turbulent nomads; but since February 1894 the French rule has not been seriously challenged. At that time the population, which had probably exceeded 50,000 under the Mandingan and Songhai empires, had fallen to about 8000, and even now scarcely exceeds 10,000. In 1895 the place was still described as little more than a vast ruin, but under the new order steady revival set in. The people no longer fear to repair their dilapidated dwellings; new streets have been opened; European schools, churches, and other establishments have sprung up; the fortifications, including a fort at Kabara, have been greatly strengthened, and it is proposed to connect the city with the Niger by a regular canal running through the occasionally flooded backwaters of the intervening district. The local industries—cotton-weaving, earthenware, leather work, and embroidery—are of subordinate importance, and the great bulk of the people continue as formerly to be occupied exclusively with trade. The whole traffic of the surrounding lands still converges on Timbuktu, which is described as a vast "exchange" for the products of the north and south, with a transit trade estimated at over £800,000. Considerable quantities of British and German fabrics, hardware, beads, &c., are conveyed across the Sahara from Mogador (Morocco), while two great caravans of 3000 or 4000 camels are yearly charged with salt from the Taudeni district. The imports *viâ* the Sahara average close upon £50,000 annually, and by the way of Senegal £20,000 to £25,000. From the south come cereals, gold, wax, ivory, coarse native cotton goods, now brought from the heart of Sudan by steamers plying on the Upper Niger. Cowries, the former currency (2500=5 francs), have already been generally replaced by French money, and efforts are being made to oust British and German goods by French wares introduced by the Senegal route. Since 1899 Timbuktu has been the capital of the Territoire de Tombouctou (the French spelling), a very large administrative division which is organized on a military base and is directly dependent on the Governor-General of French West Africa.

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(A. H. K.)

Timor, in the Malay (or Indian) Archipelago, the most easterly and the largest of the Lesser Sunda Islands, with a length of 300 miles and a fairly regular breadth of about 60 miles. Though visited by several explorers, (Reinwardt, Muller, Riedel, Forbes, and Wichmann), its physical features are imperfectly known, and there is considerable divergence of opinion as to the character of the mountain system of the island, the existence or non-existence of volcanoes, and the geological formations. Little progress has been, or is likely to be, made in the development of the island. How much the climate militates against cultivation will be seen when it is stated that at Kupang, on the south coast, the number of rainy days per month in the six months May to October dwindles from 4 to 1, and finally 0, while the monthly rainfall gradually sinks from a little less than 2 inches to *nil;* the northern districts are somewhat better off, and might do fairly well under a vigorous rule. Though the mineral products are varied, the supply of ores has hitherto proved scanty; besides which the exploitation of the resources of the island in this respect is rendered difficult by the lack of labourers and of water and wood. The area is estimated at about 12,500 square miles, whilst the population is variously placed at 600,000 (Wagner and Supan) and more than 750,000 (Reclus and Vaquinhas). Politically the north-eastern half of the island is Portuguese, as are two small enclaves in the south-western half, the remainder being Dutch.

PORTUGUESE TIMOR includes the neighbouring isle of Pulo Kambing, and has an area of about 7450 square miles. Estimates of the population vary from about 300,000 to over half a million. Dilli, on the north coast, the administrative headquarters and chief settlement, is a very poor little place of some 3000 inhabitants, containing hardly any Europeans apart from the official population. Macao was administratively united to Portuguese Timor till 1896, and still pays a contribution to the revenue. The estimated revenue for 1901–1902 was £25,196 (£7200 from Macao), and the estimated expenditure £36,532. Scarcely any ships visit the colony, except some of the Dutch vessels trading in the archipelago, which call regularly at Dilli. Exports (principally coffee) were valued at £110,000 in 1888, £72,000 in 1890, and £55,000 in 1897, when the imports were valued at about £70,000.

DUTCH TIMOR has an area of a little over 5000 square miles, and a population of about 250,000. Kupang, the chief town not only in the island but in the whole residency, contains some 8000 inhabitants, of whom 145 are Europeans living in well-built houses, 594 Chinese, and 43 Arabs. In agriculture, European plants have not been successful, and of native products the supply is only sufficient for the home consumption. The export of sandalwood, ponies, cattle, pinang nuts, &c., amounts in a year to the value of only about £8500. Dutch Timor gives its name to a residency consisting of, besides its own territory, the small adjacent islands, Roti, Peman, &c., the Savu islands, Sumba or Sandalwood island, the Solor and the Allor group of islands, and the eastern half of Flores, the whole lying between 8° 5′ and 11° 5′ S. and 119° 3′ and 125° 15′ E., the total area being 17,698 square miles. It is divided into four administrative districts—Timor, Roti and Savu, Larantuka (eastern Flores), and Sumba. In 1897 the population was officially returned as (approximately) 119,239, of whom 256 were Europeans, 1314 Chinese, and 182 Arabs; but other estimates have placed it as high as 400,000, and even 1,800,000. The number of natives is indeed only conjectural. (See also MALAY ARCHIPELAGO: *Dutch East Indies,* for general information as to government, defence, &c.)

The Anglo-Portuguese Boundary Treaty of 1859 was replaced by one signed at Lisbon in June 1893. The old treaty had proved irksome in many ways, especially in that it left portions of the territory belonging to protected chieftains of both Powers as enclaves within the boundaries of the Portuguese or Dutch parts of the island. This led to frequent disputes and complaints on both sides. In order to obviate such complications in the future, a mixed boundary commission was appointed under the new treaty, which commission has determined new boundaries in Timor that are more satisfactory to the contracting parties than the old ones were. The new treaty contains, moreover, the important stipulation (alluded to under Holland, *Recent History*), that all future disputes relating to the possessions of either Power in Timor, or the decisions of the International Boundary Commission, will be referred to arbitration. Equally important is the declaration, signed by the contracting parties at the same time as the Lisbon treaty, to the effect that either Power will favour the subjects of the other in granting concessions, &c., to the exclusion of all other aliens. Thus Portugal and Holland have mutually secured the exclusive possession of Timor to themselves. Both principles are new, certainly as far as the Malay Archipelago is concerned, and might be applied with advantage in other parts of the Malay Archipelago, where more than one European Power possesses territories and territorial rights. Timor is no longer connected with New Guinea (compare Ternate).

Authorities.—Prof. P. A. van der Lith's *Netherlands India* (1893–94, in 2 vols.), published in Dutch at Leyden; and H. O. Forbes, *Wanderings of a Naturalist in the Eastern Archipelago.* Some of the problems connected with the physical features of Timor are discussed in Zondervan's "Timor en de Timoreezen," *Tijdschr. Aardr. Gen.*, v., 1888 (with bibliography).—Martin and Wichmann. *Sammlungen des Geologischen Reichsmuseums.* Leyden, 1881–84.—Wichmann. "Bericht über eine Reise nach dem Indischen Archipel.," *Tijdschr. Aardr. Gen.*, 1890–92, with sketches of Timor, map, &c. For the remarkable flying survey of the south coast by the commandant of the *Siboga* expedition, exploring the deep seas and fauna of the Archipelago, see *Bulletin (No. 35) of the Maatschappij ter bevordering van het natuurkun onderzoek der N. I. Koloniën.* In the earlier maps much of the south coast is laid down too far to the south.

(E. de V.; C. M. K.; H. Ti.)

Timor Laut (in Dutch, *Timor Laoet*), or Tenimbar, a group of islands in the Malay Archipelago, to the S.W. of the Aru islands, between 6° 20′ and 8° 30′ S. and 130° 40′ and 132° 5′ E. They are politically divided into two districts. One is Larat, including the inhabited islands of Larat, Vordate, Molu, and Maro, together with many other islands uninhabited; the other is Sera, including the Sera islands, Selaru, and the southern part of Yamdena, all inhabited. Only Yamdena and Selaru are by the natives called Timor Laut; all the others they call Tenimbar. Vordate, Molu, and south-eastern Yamdena have a maximum height of 820 feet; the rest are low and flat. Ritabel in Larat is the only safe roadstead during the east and west monsoons. The population is estimated at from 12,000 to 13,000 by Riedel, and at 19,342 by Van Hoëvell. The only means of subsistence is the natives' primitive agriculture on a stingy soil, turtle and trepang fishery, and cattle-rearing. The yearly export (trepang, turtle, and kamuning wood) is valued at only from £850 to £1650.

See Forbes. "Three Months' Explorations in the Tenimbar Islands," in *Proceedings of R. G. S.* 1884.—Riedel. *De sluik en kroesharige rassen tusschen Selebes en Papua.* 1886.—Van Hoëvell. "Tanimbar en Timor Laoet-Eilanden," in *Tijdschr. Bat. Gen.*, xxxiii. 1889.

Tin.—Since 1875 a remarkable expansion has occurred in the production and consumption of this metal, which is still the rarest of what are known as the "common" metals. In the year named the world's total production was some 40,000 tons, of which 10,000 tons were produced by Cornwall, 10,000 by the Straits Settlements, about 8000 tons by Banka and Billiton, and about 11,000 tons by Australasia, the greater portion of the latter coming from New South Wales. At present the world's annual production is about 75,000 tons, of which about 46,000 tons come from the Straits Settlements, 14,000 from the Dutch East Indies, 5000 from Australasia (Tasmania now taking the first place among these states), 5000 tons from Cornwall, and 5000 tons from Bolivia. There are a few other places where tin is met with, but they are practically unimportant. Tinstone occurs in its matrix, either in or closely associated with fissure veins or disseminated through rock masses. It is also found in the form of rolled lumps and grains in alluvial gravels; it need hardly be said that the latter are secondary deposits, the products of the disintegration of the first-named primary deposits. Throughout the world, primary deposits of tinstone are in or closely connected with granite or acid eruptive rocks of the same type, its mineral associates being tourmaline, fluorspar, topaz, wolfram, and arsenical pyrites, and the invariable gangue being quartz: the only exception to this mode of occurrence is to be found in Bolivia, where the tin ore occurs intimately associated with silver ores, bismuth ores, and various sulphides, whilst the gangue includes barytes and certain carbonates. Over five-sixths of the world's total production is derived from secondary alluvial deposits, but all the tin obtained in Cornwall and Bolivia is from vein mining, while a small portion of that yielded by Australasia comes from veins, and from granitic rocks carrying disseminated tinstone.

Mining and Dressing.—The alluvial deposits are almost invariably worked opencast, those of the Malay Peninsula and Archipelago chiefly by Chinese labour: in a few instances hydraulic mining has been resorted to, and in other cases true underground mining is carried on; but the latter is both exceptional and difficult. The alluvial extracted, which in the Malay Peninsula and Archipelago carries from 5 to 60 ℔ of tinstone (or "black tin," as it is termed by Cornish miners) to the cubic yard of gravel, is washed in various simple sluicing appliances, by which the lighter clay, sand, and stones are removed, and tinstone is left behind comparatively pure, containing usually 65 to 75 per cent. of metallic tin (chemically pure tinstone containing 78·7 per cent.). Lode tin, as tinstone derived from primary deposits is often termed, is mined in the ordinary method, the very hard gangue in which it occurs necessitating a liberal use of explosives. The veinstuff is broken small either by hand or in rock-breakers, and stamped to fine powder in stamp mills, which are practically large mechanically-worked pestles and mortars, the stamp proper weighing from 500 to 1000 ℔. The mineral, crushed small enough to pass a sieve with perforations $\frac{1}{20}$ inch in diameter, leaves the stamps in suspension in water, and passes through a series of troughs in which the heavier mineral is collected; this then passes through a series of washing operations, which leaves a mixture consisting chiefly of tinstone and arsenical pyrites, which is calcined and washed again, until finally black tin containing about 60 to 65 per cent. of metal is left. The crude tinstuff raised in Cornwall carries on an average a little over 2 per cent. of black tin. The Bolivian tin ore is treated by first extracting the silver by amalgamation, &c., and afterwards concentrating the residues; there are, however, great difficulties in the way of treating the poorer of these very complex ores, and several chemical processes for extracting their metallic contents are in course of being worked out.

Smelting.—The dressed ore is smelted by one of two main methods, viz., either in the shaft furnace or the reverberatory; the former is the better suited to stream tin, the latter to lode tin, but either ore can be smelted in either way. Shaft furnace smelting is confined to those parts of the world where charcoal can still be obtained in large quantities at moderate prices. The furnace consists of a shaft, circular (or more rarely rectangular) in plan, into which alternate layers of fuel and ore are charged, an air blast being generally injected near to the bottom of the furnace through one or more tuyeres. This was the primitive process all over the world; in the East, South America, and similar regions, it still holds its own. In Europe, Australasia, and one large works at Singapore it has been practically replaced by the reverberatory furnace process, first introduced into Cornwall about the year 1700. All tin, except a small quantity produced by the shaft furnace process from exceptionally pure stream tin ore, requires refining by liquation and "boiling" before it is ready for the market.

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(H. L*.)

Tinnevelly, a town and district of British India, in the Madras Presidency. The town is on the left bank of the Tambraparni river, on the other side of which is Palamcotta, the administrative headquarters of the district. It is the terminus of a branch of the South Indian railway, 444 miles S.W. of Madras. Population (1881), 23,221; (1891), 24,780; municipal income (1897–98), Rs.28,160. It has two cotton mills, with 31,740 spindles, employing 1327 hands. The two colleges, Hindu and Church Mission, had 131 students in 1896–97; the two high schools, 797 pupils. There are also five printing-presses.

The district of TINNEVELLY has an area of 5387 square miles. Population (1881), 1,699,747; (1891), 1,916,095, showing an increase of 13 per cent. after the famine of 1876–78; average density, 356 persons per square mile. In 1891 the native Christians, chiefly Protestants, numbered 145,569, or nearly 8 per cent., a far higher proportion than in any other district of India. In 1901 the population was 2,060,759, showing a further increase of nearly 8 per cent. The land revenue and rates in 1897–98 were Rs.35,69,011, the incidence of assessment being R.1.10.7 per acre; cultivated area, 1,145,900 acres, of which 282,818 were irrigated from tanks, wells, &c., including 44,611 from Government canals; number of police, 1037; boys at school (1896–97), 55,149, being 39·4 of the male population of school-going age, the highest proportion in the province; girls at school, 9418, being 6·4 per cent.; registered death-rate (1897), 25·2 per 1000. The principal crops are rice, millet, other food-grains, cotton, and oil-seeds, with a little tobacco. Coffee is grown on 1284 acres on the slopes of the Travancore hills. The palmyra palm, whose juice yields toddy as well as a coarse sugar, flourishes in certain tracts. The Shanans, or caste of toddy-drawers, have supplied many converts to Christianity. In 1899 their treatment by the Vellalars, or cultivating caste, led to serious riots and bloodshed. The chief irrigation work is the Srivaikuntam anicut, or dam, on the Tambraparni river, on which the capital outlay has been Rs.14,71,924. In 1897–98 the area irrigated was 41,668 acres, and the net profit was Rs.25,527. The South Indian railway runs through the district, with its maritime terminus at Tuticorin, the chief seaport. In 1897–98 the total sea-borne trade was valued at Rs.3,08,03,307, being just one-tenth of the trade of the province. The chief exports are rice to Ceylon and cotton to Japan and Europe. There are thirteen factories for ginning and pressing cotton, and one rice-cleaning mill.

Tippera (*Tripura*), a native state and British district of India, in the north-east of Bengal. The state is known as Hill Tippera. It represents that portion of the raja's territory that was never conquered by the Mahommedans. The dynasty, which is of great antiquity, was converted to Hinduism many centuries ago; but the people, called Tipperas, still profess an aboriginal religion, similar to the neighbouring hill tribes.

The raja owns an estate of 589 square miles in the British district, where he ranks as an ordinary *zamindar*. His residence is at Agartalla, just within the boundary of Hill Tippera. Area of the state, 4086 square miles; population (1881), 95,637; (1891), 137,442, showing an apparent increase of 43 per cent., due to more accurate enumeration; average density, 34 persons per square mile. In 1901 the population was 167,441, showing a further increase of 22 per cent. The expenditure in 1897–98 was Rs.6,87,430, of which Rs.1,38,000 was devoted to public works. Tolls are levied upon exports of forest produce, cotton, and oil-seeds. The raja's palace and other public buildings at Agartalla were seriously damaged by the earthquake of 12th June 1897.

The British district of TIPPERA (the administrative headquarters are at Comilla) has an area of 2491 square miles; population (1881), 1,514,361; (1891), 1,782,935, showing an increase of nearly 18 per cent., by far the highest rate of increase in Bengal; average density, 716 persons per square mile. Classified according to religion, Mahommedans in 1891 numbered 1,224,336; Hindus, 557,079; Christians, 182, of whom 57 were Europeans; "others," 1338. In 1901 the population was 2,124,869, showing a further increase of 19 per cent., again the highest rate in the province. The land revenue and rates in 1897–98 were Rs.11,77,084; number of police, 377; boys at school (1896–97), 57,435, being 4·19 per cent. of the male population of school-going age; registered death-rate (1897), 26 per 1000. The eastern border of the district is traversed by the Assam-Bengal railway, with a cross branch from Laksam to Chandpur; but waterways still remain the chief means of communication. The exports are mostly rice, jute, and betel-nuts.

Tipperary, an inland county of Ireland, province of Munster.

Population.—The area of the administrative county in 1900 was 1,050,130 acres, of which 246,353 were tillage, 623,874 pasture, 403 fallow, 26,469 plantation, 35,788 turf bog, 9819 marsh, 67,471 barren mountain, and 39,953 water, roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, includes the portions of the towns of Clonmel and Carrick-on-Suir formerly situated in Waterford. The population in 1881 was 199,612; in 1891, 173,188; and in 1901, 159,754, of whom 81,075 were males and 78,679 females, divided as follows among the different religions: Roman Catholics, 149,903; Protestant Episcopalians, 8689; Presbyterians, 444; Methodists, 550; and other denominations, 168. The decrease of population between 1881 and 1891 was 13·24, and between 1891 and 1901, 7·7 per cent. The average number of persons to an acre in 1891 was ·16, and of the total population, 133,213 persons inhabited the rural districts, being an average of 99 to each square mile under crops and pasture. The following table gives the degree of education for the principal creeds in 1891:—

	Males.	Females.	Total.	Percentage.			
				Roman Catholics.	Protestant Episcopalians.	Presbyterians.	Methodists.
Read and write .	60,684	58,092	118,776	74·5	93·7	93·1	95·4
Read only . .	6,856	7,788	14,644	9·7	2·9	4·4	2·2
Illiterate . .	11,077	12,630	23,707	15·8	3·4	2·5	2·4

The percentage of illiterates among Roman Catholics in 1881 was 22·7. In 1891 there were 14 superior schools with 750 pupils (Roman Catholics, 662; and Protestants, 88), and 355 primary schools with 27,469 pupils (Roman Catholics, 26,234; and Protestants, 1235). The number of pupils on the rolls of the National Schools on 31st December 1900 was 26,674, of whom 25,518 were Roman Catholics and 1156 Protestants. The following table gives the number of births, deaths, and marriages in various years:—

Year.	Births.	Deaths.	Marriages.
1881	4523	3428	708
1891	3661	3046	659
1900	3296	3053	612

In 1900 the birth-rate per 1000 was 20·6, and the death-rate 19·1. The rate of illegitimacy was 2·3 per cent. of the total births. The total number of emigrants who left the country between 1st May 1851 and 31st December 1900 was 206,377, of whom 106,542 were males and 99,835 females. The chief towns in the county are Clonmel, Carrick-on-Suir, Tipperary, and Nenagh.

Administration.—The county is divided into four parliamentary divisions—North, South, Mid, and East—the number of registered electors in 1901 being respectively 5994, 5190, 6613, and 6234. The rateable value in 1900 was £686,396. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the two grand juries were transferred to two county councils (one for each Riding), urban and rural district councils were established, and under that act the county now comprises eight urban and twelve rural sanitary districts.

Agriculture.—The following tables give the acreage under crops, including meadow and clover, and the amount of live stock in 1881, 1891, 1895, and 1900. The figures for 1900 are for the new administrative county:—

Year.	Wheat.	Oats.	Barley, Rye, &c.	Potatoes.	Turnips.	Other Green Crops.	Meadow and Clover.	Total.
1881	14,658	54,848	17,490	84,430	19,892	6612	118,371	265,801
1891	6,275	40,888	22,038	80,316	20,189	8047	116,673	244,426
1895	1,914	42,547	21,131	27,195	20,654	8084	129,191	250,716
1900	2,938	38,699	19,114	24,834	19,789	9466	131,513	246,858

For 1900 the total value of the cereal and other crops was estimated at £1,551,209. The number of acres under pasture in 1881 was 602,912; in 1891, 621,394; and in 1900, 623,874.

Year.	Horses and Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	28,987	12,371	244,029	205,850	74,540	12,952	681,816
1891	33,910	15,091	280,810	272,969	87,695	16,796	661,263
1895	35,226	15,716	268,476	221,859	82,274	15,532	688,476
1900	32,889	17,412	297,218	251,202	73,797	16,050	755,706

The number of milch cows in 1891 was 85,532, and in 1900, 86,505. It is estimated that the total value of cattle, sheep, and pigs for 1900 was £4,311,730, Cork being the only county with a higher figure. In 1900 the number of holdings not exceeding 1 acre was 3625; between 1 and 5, 2714; between 5 and 15, 4413; between 15 and 30, 4801; between 30 and 50, 4035; between 50 and 100, 3414; between 100 and 200, 1480; between 200 and 500, 507; and above 500, 92; total, 25,081. The number of loans issued (the number of loans being the same as the number of tenants) under the Land Purchase Acts, 1885, 1891, and 1896, up to 31st March 1901, was 2585, amounting to £1,152,679. The number of loans for agricultural improvements sanctioned under section 31 of the Land Act, 1881, between 1882 and 1901 was 1095, and the amount issued £77,785. The total amount issued on loan for all classes of works under the Land Improvement Acts from the commencement of operations in 1847 to 31st March 1901 was £235,249.

Tipperary, a town and urban sanitary district in the above county, 110 miles S.W. of Dublin by rail. There are condensed milk and mineral water factories. New Tipperary, which was founded outside the town by Mr William O'Brien during the Plan of Campaign on the Smith-Barry estate, is now practically deserted. Population (1891), 6391; (1901), 6216.

Tipton, a city of Indiana, U.S.A., capital of Tipton county, a little north of the centre of the state, on the Lake Erie and Western railroad, at an altitude of 872 feet. It is in an agricultural and natural gas region, and has considerable trade. Population (1880), 1250; (1890), 2697; (1900), 3764; of whom 85 were foreign-born.

Tirah Campaign.—The sudden outbreak in 1897 of the Afridi tribes required to be promptly met in order to avert a general conflagration on the Indian frontier. The Afridis had for sixteen years received an annual subsidy from the Indian Government for the safeguarding of the Khyber Pass, in addition to which the Government had maintained for this purpose a local regiment entirely composed of Afridis, who were stationed in the pass. Suddenly, however, the tribesmen rose, captured all the posts in the Khyber held by their own countrymen, and attacked the forts on the Samana Ridge, near Peshawar, one of which, Saraghari, made a memorable defence, the entire garrison (composed of Sikhs) dying at their posts. It was estimated that the Afridis and Orakzais could, if united, bring from 40,000 to 50,000 men into the field. The preparations for the expedition occupied some time, and meanwhile the Mohmand rising north-west of the Khyber Pass was first dealt with (see Mohmand Expedition).

The general commanding was General Sir William Lockhart (*q.v.*), commanding the Punjab Army Corps; he had under him 34,882 fighting men, officers and men, British and native, in addition to 20,000 followers.

Tirah is a fertile valley about 30 miles to the south-west of Peshawar, but cut off almost entirely by ranges of mountains. The district, which no white man had penetrated, was the summer home of the Afridis, whither they retire with their flocks and herds for pasture and agriculture. The frontier post of Kohat was selected as the base of the campaign, and it was decided to advance along a single line. On 18th October the operations commenced, fighting ensuing immediately. The Dargai heights, which commanded the line of advance, were captured without difficulty, but abandoned owing to the want of water. On the 20th the same positions were gallantly stormed, with a loss of 199 killed and wounded. The progress of the expedition, along a wretched track through the mountains, was obstinately contested on 29th October at the Sampagha Pass leading to the Mastura valley, and on the 31st at the Arhanga Pass from the Mastura to the Tirah valley. The force, in detached brigades, now proceeded to traverse the Tirah district in all directions, and to destroy the walled and fortified hamlets of the Afridis. The two divisions available for this duty numbered about 20,000 men. A force about 3200 strong commanded by Brigadier-General (afterwards Major-General Sir Richard) Westmacott was first employed to attack Saran Sar, which was easily carried, but during the retirement the troops were hard pressed by the enemy, and the casualties numbered sixty-four. On 11th November Saran Sar was again attacked by the brigade of Brigadier-General (afterwards Sir Alfred) Gaselee. Experience enabled better dispositions to be made, and the casualties were only three. The traversing of the valley continued, and on the 13th November Brigadier-General Kempster's brigade visited the Waran valley *viâ* the Tseri Kandao Pass. Little difficulty was experienced during the advance, and several villages were destroyed; but on the 16th, during the return march, the rearguard was hotly engaged all day, and had to be relieved by fresh troops next morning. The casualties numbered seventy-two. Almost daily the Afridis, too wise to risk general engagements, waged a perpetual guerilla warfare, and the various bodies of troops engaged in foraging or survey duties were constantly attacked. On 21st November a brigade under Brigadier-General Westmacott was detached to visit the Rajgul valley. The road was exceedingly difficult, and steady opposition was encountered. The objects were accomplished, and the casualties during the retirement alone numbered twenty-three. The last important work undertaken was the punishment of the Chamkannis-Mamuzais and Massozais. This was carried out by Brigadier-General Gaselee, who joined hands with the Kurram movable column ordered up for the purpose. The Mamuzais and Massozais submitted immediately, but the Chamkannis offered resistance on 1st and 2nd December, the British casualties numbering about thirty. The Kurram column then returned to its camp, and Sir W. Lockhart prepared to evacuate Tirah, despatching his two divisions by separate routes—the 1st under Major-General W. P. Symons (d. 1899) to return *viâ* the Mastura valley, destroying the forts on the way, and to join at Bara, within easy march of Peshawar, the 2nd division under Major-General Yeatman Biggs (d. 1898), and, accompanied by Sir W. Lockhart, to move along the Bara valley. The base was thus to be transferred from Kohat to Peshawar. The return march began on the 9th December. The cold was intense, 21 degrees of frost being registered before leaving Tirah. The movement of the 1st division though arduous was practically unopposed, but the 40 miles to be covered by the 2nd division were contested almost throughout. The actual march down the Bara valley (34 miles) commenced on the 10th, and involved four days of the hardest fighting and marching of the campaign. The road crossed and recrossed the icy stream, while snow, sleet, and rain fell constantly. On the 10th the casualties numbered about twenty. On the 11th some fifty or sixty casualties were recorded among the troops, but many followers were killed or died of exposure, and quantities of stores were lost. On the 12th the column halted for rest. On the 13th the march was resumed in improved weather, though the cold was still severe. The rearguard was heavily engaged, and the casualties numbered about sixty. On the 14th, after further fighting, a junction with the Peshawar column was effected. The 1st division, aided by the Peshawar column, now took possession of the Khyber forts without opposition. Negotiations for peace were then begun with the Afridis, who under the threat of another expedition into Tirah in the spring at length agreed to pay the fines and to surrender the rifles demanded. The expeditionary force was broken up on the 4th April 1898. This campaign was the greatest since the Indian Mutiny, not excepting the Afghan war of 1878–80. A memorable feature was the presence in the fighting line of the Imperial Service native troops under their own officers, while several of the best known of the Indian princes served gallantly on Sir W. Lockhart's staff.

The total casualties were—

Killed, all ranks	287
Wounded	853
Missing	10
British Officers in addition.	
Killed	23
Wounded	56
Native Officers in addition.	
Killed	4
Wounded	16

besides very many followers. (C. J. B.)

Tiraspol, a district town of Russia, in the government of Kherson, on the left bank of the Dniester, 73 miles by rail north-west of Odessa. It is surrounded by gardens, has a number of steam flour-mills and tobacco factories, and carries on a considerable trade with Rumania. Population (1897), 27,585.

Tireh, the ancient *Teira*, a town of Asia Minor, situated in the valley of the Kuchuk Mendere (*Caystrus*) at the foot of Mount Messogis. It is connected with Smyrna by railway, and has a trade in raisins, wheat, rice, tobacco, and cotton. The population consists of 8000 Moslems and 6000 Christians.

Tirnovo (Bulgarian, *Trnovo*), the chief town of a department, Bulgaria, on the Jantra, an affluent of the Sistova, on the Sofia–Varna railway, at the junction of the branch line from Rustchuk, 124 miles E.N.E. of Sofia. The town consists of two divisions—the Christian quarter, situated chiefly on a high rocky plateau, and the Turkish quarter, on the lower ground. On the Tsarevetz Hill above the town are the remains of the ancient fortress. The Husardjaini mosque is now used as a military powder and dynamite factory. In the old Christian quarter there are some interesting churches of the Middle Ages. Numerous antiquarian remains have also been discovered. There are a gymnasium and a high-class girls' school. The town possesses large dye-works, and important manufactures of copper utensils.

Tirnovo was the ancient capital of Bulgaria, and from 1186 until its capture by the Turks, 17th July 1394, the residence of the Bulgarian Tsars of the house of Aiden. From the beginning of the 13th century it was also the seat of the patriarchate of Bulgaria, until the suppression of the patriarchate in 1767. In 1877 it was taken from Turkey by the Russians, and in 1879 Alexander of Battenberg was there elected Prince of Bulgaria. Population (1892), 12,858.

Tirol, a province of the Austrian Empire. It may be roughly described as the mountainous region intervening between Munich and Verona, so that, owing to the Brenner Pass connecting those two cities, Tirol has always been of extreme military importance. It comprises all the highest summits of the Austrian Alps, which culminate in the Ortlerspitze (12,802 feet). The German-speaking north and central Tirol are sharply distinguished in many respects from the Italian-speaking south Tirol, the latter including the now well-known group of Dolomite mountains. North Tirol sends its waters to the Black Sea, while those of south Tirol flow to the Adriatic. The area of Tirol (excluding Vorarlberg, often counted with it) is 10,300 square miles, of which about 4000 square miles are covered by forests. In 1890 the total population was 812,696, and in 1900, 850,062. The inhabitants are mostly Roman Catholic. More than one-half are German-speaking, and of the remainder the vast majority speak either Italian or the ancient and curious Ladin dialect. From an administrative point of view Tirol forms twenty-one districts (*Bezirke*). Its capital and largest town is Innsbruck. The other most important towns are Trent (24,908 in 1900), Bozen (13,632), and Rovereto (10,180).

The mountain pastures ("Almen") are less carefully looked after than those in Switzerland, one reason being that they often belong not to the neighbouring villages, but to far-distant places, so that those who in Switzerland would be their owners are helpless. The vine-growing area is about 40,500 acres (of which 26,750 acres are in south Tirol), of which the mean annual produce may be put at 8,360,000 gallons. The silk industry has fluctuated greatly, rising from 1,400,000 kilogrammes in 1881 to 2,150,000 kilogrammes in 1888, but falling in 1890 to 1½ million kilogrammes.

See in general vol. xiii., *Tirol* (Vienna, 1893), of the great official work entitled *Die oesterreichisch-Ungarische Monarchie in Wort und Bild.* The following more special works may be consulted:—W. A. BAILLIE-GROHMAN. *Tirol and the Tirolese* (London, 1876); *Gaddings with a Primitive People*, 2 vols. (London, 1878); and *Sport in the Alps* (London, 1896).—Miss R. H. BUSK. *The Valleys of Tirol.* London, 1874.—J. EGGER. *Geschichte Tirols*, 3 vols. Innsbruck, 1872–80.—J. GILBERT and G. C. CHURCHILL. *The Dolomite Mountains.* London, 1864.—MAX HAUSHOFEN. *Tirol.* Bielefeld and Leipzig, 1899.—ALFONS HUBER. *Geschichte d. Vereinigung Tirols mit Oesterreich.* Innsbruck, 1864.—L. PURTSCHELLER and H. HESS. *Der Hochtourist in den Ostalpen*, 2 vols. Leipzig and Vienna, 1894 (2nd edition in 3 vols. in 1899).—E. RICHTER. *Die Erschliessung der Ostalpen*, 3 vols. Berlin, 1893–94. —A. SCHAUBACH. *Deutsche Alpen*, 5 vols. Jena, 1865–71.—CHR. SCHNELLER. *Landeskunde von Tirol.* Innsbruck, 1872.—F. A. SINNACHER. *Beiträge z. Geschichte d. bischöfl. Kirche Säben und Brixen* (really a special territorial history of Tirol), 10 vols. Brixen, 1821–37.—I. V. ZINGERLE. *Sagen, Märchen, und Gebräuche aus Tirol.* Innsbruck, 1859.—I. V. ZINGERLE and K. TH. VON INAMA-STERNEGG. *Die tirolischen Weisthümer*, 4 vols. Vienna, 1875–88. (W. A. B. C.)

Tirupati, or TRIPETTY, a town of British India, in the North Arcot district of Madras, 84 miles north-east of Madras, with a station on the Madras railway. Population (1891), 14,238; municipal income (1897–98), Rs.1,84,840. It is famous for a pagoda or temple on a neighbouring hill, 2500 feet above the sea, which is one of the most frequented places of pilgrimage in southern India. Two high schools are maintained, one by a German mission, the other by the high priest of the temple.

Tisserand, François Félix (1845–1896), French astronomer, was born at Nuits-Saint-Georges, Côte-d'Or, on the 13th January 1845. In 1863 he entered the École Normale Supérieure, where his remarkable talents were soon recognized, and on leaving he went for a month as professor at the lycée at Metz. Le Verrier, however, who had formed a just estimate of his abilities, offered him a post in the Paris Observatory, which he accordingly entered as *astronome adjoint* in September 1866. In 1868 he took his doctor's degree with a brilliant thesis on Delaunay's Method, which he showed to be of much wider scope than had been contemplated by its inventor. Shortly afterwards he went out to Malacca to observe the famous solar eclipse of 18th August 1868. In 1873 he was appointed director of the observatory at Toulouse, whence he published his *Recueil d'exercices sur le Calcul infinitésimal*, and in 1874 became corresponding member of the Académie des Sciences. He took part in the French expeditions of 1874 to Japan and of 1882 to Martinique to observe the transits of Venus. In 1878 he was elected a member of the Académie des Sciences in succession to Le Verrier, and became a member of the Bureau des Longitudes. In the same year he was appointed *professeur suppléant* to Liouville, and in 1883 he succeeded Puiseux in the chair of celestial mechanics at the Sorbonne. In the midst of so many occupations Tisserand always found time to continue his important researches in mathematical astronomy, and the pages of the *Comptes Rendus* bear witness to his surprising activity. His writings relate to almost every branch of celestial mechanics, and are always distinguished by rigour and simplicity in the solution of the most difficult problems, and by a clearness and elegance peculiarly French. He treated in a masterly manner (*Bulletin Astronomique*, 1889) the theory of the capture of comets by the larger planets, and in this connexion published his valuable *Criterion* for establishing the identity of a periodic comet, whatever may have been the perturbations brought about in its orbit, between successive appearances, by the action of a planet. His principal work, *Traité de Mécanique céleste*, is the noblest and most lasting monument to his memory, and is worthy to stand beside the *Mécanique céleste* of his fellow-countryman, Laplace. In this treatise, published in four quarto volumes, the last of which appeared only a few months before his death, he fused into one harmonious whole the researches of Laplace and those of other workers in the same field since his time. It furnishes a faithful and complete *résumé* of the state of knowledge in that department of astronomy at the end, as Laplace's great work did for the beginning, of the 19th century. In 1892 he succeeded Mouchez as director of the Paris Observatory, and as president of the committee of the photographic chart of the heavens he contributed largely to the success of that great project. Under his direction the revision of Lalande's catalogue was brought almost to completion, and four volumes of the *Annales de l'Observatoire de Paris* exhibit the progress made in this important undertaking. He was also editor of the *Bulletin Astronomique* from the beginning, and contributed many important articles to its pages. He died suddenly, in the fulness of his power, of congestion of the brain, on 20th October 1896. (A. A. R.)

Tissot, James Joseph Jacques (1836–1902), French painter, was born at Nantes on 15th October 1836. He studied at the École des Beaux Arts in Paris under Ingres, Flandrin, and Lamothe, and exhibited in the Salon for the first time at the age of twenty-three. In 1861 he showed "The Meeting of Faust and Marguerite," which was purchased by the State for the Luxembourg Gallery. At this period he was a follower of the classical tradition, a careful draughtsman with a sense of composition but no particular originality of idea. His first characteristic period made him a painter of the charms of women. His models were of the worldly type —*demimondaine* would be more strictly accurate as a description of the series of studies which he called "La Femme à Paris." He fought in the Franco-German war, and then, falling under suspicion as a Communist, he left Paris for London. Here he studied etching with Sir Seymour Haden, drew caricatures of public men for *Vanity Fair*, and painted portraits as well as *genre* subjects. It was many years before he turned to the chief labour of his career—the production of a series of 700 water-colour drawings to illustrate the life of Christ and the Old Testament. Some sudden shock or bereavement was said to have turned his thoughts from ideals of the café and the boulevard into a more serious channel. He disappeared from Paris, whither he had returned after a stay of some years in England, and went to Palestine to begin the task which occupied him during the rest of his life. In 1895 the series of 350 drawings of incidents in the life of Christ was exhibited in Paris, and the following year found them on show in London. They were then published by the firm of Lemercier in Paris, who had paid him 1,100,000 francs for them. After this he turned to the scenes of the Old Testament, upon which he was still engaged at the abbey of Buillon, in the department of Doubs, France, when he died on 8th August 1902. The merits of Tissot's Bible illustrations lay rather in their imaginative power and in the care with which he studied the details of scenery than in any quality of religious emotion. He seemed to aim, above all, at accuracy, and, in his figures, at a vivid realism which was far removed from the conventional treatment of sacred types. His achievement called forth admiration for his genius, but it was the genius that is an infinite capacity for taking pains, not the genius of insight and inspiration that is found in the greatest art.

Tisza, Koloman von (1830–1902), Hungarian statesman, was sprung from a noble Hungarian family whose estates were situated in the county of Bihar, and was born at Geszt on the 16th of December 1830. After studying law, in the year 1848 he received an appointment in the ministry of education under Baron Eotvos. He took no part in the revolution, retired from the public service, and for some years lived in seclusion on his estates. He first came prominently before the public notice in 1859. In this year he took the leading part in the agitation which was aroused by the attempt of the Government to interfere in the autonomy of the Hungarian Protestant Church. In 1861 he was elected a member and first vice-president of the new Diet, and from this time was leader of the Left Centre in the Lower House. While he was opposed to the demands of the extreme Kossuth and Republican party, he was not always prepared to accept all Deák's proposals for arranging a compromise with the emperor. The differences were however small, and in the crisis of 1865–66 he and his followers worked in close harmony with Deák. He was a loyal supporter of the *Ausgleich*, in the discussions on which he had taken a large part. He had also made himself known as a supporter of free trade and other Liberal reforms, which he advocated in the press. After 1866 he was for many years leader of the parliamentary Opposition to the administration of Andrassy. After several times refusing office, he accepted the post of minister of the interior in 1875, and in the end of the same year became president of the ministry. This post he held till the year 1890. For a history of his administration the reader is referred to the article on Hungary. The strong measures which he took to further Magyar nationality in the German and Slavonic districts won him great popularity among his own countrymen, and enabled him to surmount the crisis caused by the occupation of Bosnia. In foreign policy he took little interest, but he was successful in the financial administration, and did much to develop the material resources of the country. From 1887 to 1889 he was minister of finance. He resigned in March 1890 and died on 23rd March 1902. His brother LUDWIG (born 1832) held many important posts in the internal administration, and on two occasions, from 1871 to 1873 and from 1892 to 1894, was a member of the ministry. He received the title of count in 1883. This title descended to STEPHAN, the eldest son of Koloman, who became leader of the Liberal party in the Lower House of the Hungarian Parliament.

Titan Cranes.—Probably no branch of engineering has developed more rapidly of recent years than that which is concerned with the design and construction of harbours. Breakwaters were in earlier days generally constructed of masonry walls or of plain "rubble mounds," *i.e.*, of heaps of rough large stones thrown into the sea and left to be consolidated by the action of the waves. But, owing to the increased depth of water and the more exposed sites in which they are now built, new methods have gradually been evolved. Amongst the most noteworthy has been the employment of Portland cement, from which are made artificial blocks of stone that have many advantages over the natural blocks previously used. Breakwaters are now mostly built up of such concrete blocks, either directly from the bottom, or on a low rubble mound foundation, the top of which is kept such a distance below the surface as to be out of the reach of the greatest wave action. The blocks are generally of very large size, seldom weighing less than 10 tons, and often as much as 40 or 50 tons or even more.

The typical method of block-setting formerly was to construct over the whole extent of the site a timber staging, resting on heavy piles driven into the bed of the sea; this staging supported lines of railway placed at a very wide gauge apart, and on the rails ran "travellers," spanning the whole width of the breakwater. The traveller beams carried other rails placed at right angles to the former, and these carried in their turn a powerful lifting crab, which could be traversed across from side to side. The whole machine could be moved forward on the staging as the work proceeded, and thus the whole area within the lines of staging could be perfectly commanded for the purpose of block-setting. The concrete blocks were brought from the land along "service roads" laid along the staging; when they came under the travellers they were lifted by the crab off the railway truck, and after being travelled and traversed to the correct position were lowered to the divers, who saw that they were accurately placed in their final situation. Within wide limits this method was an exceedingly convenient one, and it is still largely made use of for certain situations, with of course the improvement of substituting steam or other motive power for hand. Certain difficulties, however, arise with the stagings, especially in exposed sites, for they are very expensive to construct, and very liable to damage from storms. In every breakwater there must of necessity be during the period of construction an unfinished or so-called "scar end," which, with the staging around and in front of it, is particularly liable to damage by the sea, more especially in those works which can only be carried on during a fine season and have to be left during the winter in an unfinished state exposed to heavy storms. A single winter storm has often done enormous injury by washing away the greater portion of the staging and the plant carried on it, thus involving the expenditure of very large sums for restoration and the loss of much working time. In view of these facts, it gradually came to be recognized that instead of relying on a temporary staging placed in the most exposed situation for the support of the block-setting machinery, it was quite possible to utilize the finished work itself; and this idea, coupled with the further one of making the whole block-setting plant self-contained and portable, resulted in the introduction of the "Block-setting Titan" of the present day.

All the early Titans were what may be called "rectangular" or "non-revolving" machines, in distinction to the latter "revolving" machines. They consist essentially of a portable structure which travels on wheels running on rails laid at a very wide gauge on the surface of the completed portion of the work, this substructure or carriage being sufficiently raised in the centre of its breadth to leave a clear passage-way beneath it for the trucks with concrete blocks to pass right up to the end of the work. The upper part of the carriage is extended forwards in the form of two great projecting arms or cantilever girders, which reach out over the water and carry a travelling crane of similar construction to those previously used on the timber staging. The traveller is worked by a steam engine and boiler placed at the rear end. At the back of the machine is also placed the counterpoise required to balance the weight of the concrete block and of the traveller when they are run out over the water; for this counterpoise a large tank filled with sea-water has often been used, though latterly blocks of concrete are more usually adopted. The driving engine is so designed that it can be disengaged from the shafting which actuates the traveller, and coupled to the mechanism which propels the Titan along the rails laid on the breakwater. The operation of the Titan is very simple. The block is lifted in the blockyard on to a truck, and run down the railway until it comes within reach of the traveller. It is then raised just sufficiently to free it from the truck and travelled forwards over the water, into which it is lowered in order that the partial buoyancy of the water may relieve the Titan of a portion of the overhanging weight. The next operation is to travel it farther forward or traverse it to either side as far as may be necessary to bring it exactly over the position where it is desired to set it, and finally it is lowered until it takes a bearing on the rubble mound or on the blocks which were laid before it. All these operations are controlled by signals received from the divers who are working below the surface. When a sufficient length has emerged above high-water mark the railway is lengthened and the Titan moved forward to construct another section.

It will thus be seen that the essential features of this type of Titans are powerful lifting machinery, the capacity of running out heavy weights over the water horizontally, and portability. But while they proved very successful and useful pieces of plant, and may still be efficiently employed in places where the water is not too deep and the section of wall is suitable, they have several disadvantages or limitations. Their overhang is comparatively short, and is further reduced to a certain extent by the necessity of leaving sufficient space at the front end for the truck carrying the blocks to get within reach of the lifting gear. A still more serious objection is that they are quite unable to deal with material which, as is very often the case, has to be placed outside the line of rails on which they run. It seems to us now very simple to suggest that the whole upper part of the Titan should be made to revolve round a centre pivot, but curiously enough the machine underwent a whole series of intermediate stages before it settled down to its present form, all of which were dictated by the primary object of setting blocks outside the normal range. Special "side-setting machines" were designed with the overhanging members placed at right angles to the pier instead of parallel to it; these followed behind the main machine, to put in the side blocks after the principal work was done. Titans were also constructed which could be twisted round bodily, the railway wheels being made to swivel like castors. Others had a superstructure which was connected to the under-carriage at the back end by a fixed pivot, and rested at the front on rollers running on a "roller path" of segmental shape; these machines could be radiated through an arc of a circle sufficiently great to enable the requisite range sideways to be attained. The final step was the very obvious one of placing the pivot in the centre of the truck, and extending the roller path until it formed a complete circle, thus producing a Titan that could be turned right round.

Local circumstances may still sometimes justify the choice of any of these types, but nearly all the later machines are made to revolve through a complete circle. This has proved to be of great practical advantage. In many cases, the breakwater to be constructed being a detached work without any connexion with the land, it is necessary to bring the blocks up to the work in barges. From these barges the revolving Titan, working simply as a huge crane, is able to lift the blocks and stack them on the pier at the back of the machine until wanted—an operation quite impossible with a non-revolving machine. Even when the blocks are brought forward on trucks the revolving Titan can pick them off the truck when placed in its rear, and is thus, as previously indicated, enabled to stand nearer the end. In this way the available overhang is increased, and with the completely revolving machine the blocks can be set as far out at each side as in front. In addition, certain structural advantages are gained by the adoption of the revolving type; *e.g.*, considerably greater overhang with a given weight of machine. This question of overhang is one of paramount importance to the designer both of the breakwater and of the Titan. In a regularly built breakwater in course of construction, the lowest layer of blocks is always the longest, and the last cross row in this layer forms the bottom step of a great flight which rises step by step until it reaches the surface, where the top step consists of the cross row of blocks forming for the time being the end of the surface layer. Now, the deeper the water, the greater the number of steps and the greater the distance of the bottom step in advance of the top one; and it is this distance which practically settles the required overhang, though it is also to a considerable extent affected by the way in which the blocks break joint or are bonded together, and by the size of the blocks. In a pier built with a sloping bond the tiers of blocks break joint on lines placed more nearly upright than horizontal (about 60° is a usual angle), and this gives for obvious reasons a much shorter scar end, and one well suited for setting by the older type of Titan with short overhang. Taking all these points into consideration, it has been found necessary gradually to increase the overhang beyond that which was practicable with the older type. In the revolving machines the dimension which determines the overhang is the "radius," or the horizontal distance from the centre pivot to the load when travelled outwards as far as it will go. A very usual radius for an average size of Titan is now about 75 feet, but radii are found in the largest machines ranging up to as much as 100 feet. Even those not conversant with engineering matters will appreciate the enormous size and power of a machine that will pick up a block weighing 50 or 60 tons and swing it round in a circle 200 feet in diameter.

The modern Titan therefore consists of a high truck running on a wide railway and carrying on its upper side a great circular turn-table and a centre pin around which revolves a massive superstructure. The essential features of the revolving upper part are the long horizontal arm on which the load is run out, and the platform carrying the lifting machinery, engines and boiler, and also at the rear end the concrete ballast. There are two methods of supporting the horizontal arm: one is to construct it in the form of two stiff cantilever girders, either built up of solid plates of steel or of openwork lattice bracing; and the other to erect on the superstructure a so-called "king-post," and to support the arm or "jib" by tension rods in a somewhat similar manner to the rods of a suspension bridge. The former are known as "cantilever" machines and the latter as "overhead trussed" machines. Which of these two types should be adopted in any given case is, in the writer's opinion, very much a matter of fashion or individual preference; but, speaking generally, it may be said that for loads over 40 tons combined with a radius of over 75 feet the cantilever type would now be the one more generally adopted. Fig. 1 illustrates the method of working with a Titan setting blocks with inclined bond as described above, and Fig. 2 (see Plate) shows a similar machine setting apron blocks at right angles to the line of the breakwater at South Shields. Fig. 3 (see Plate) shows one of the two large cantilever machines built by Messrs Stothert and Pitt of Bath, used for the Admiralty harbour works at Gibraltar. As will be seen, they are of the cantilever type, with open lattice-work jib; they can set blocks weighing 36 tons at a maximum radius of 75 feet. The concrete block is suspended by wire ropes from a trolley which can be moved in or out along the horizontal jib; the ends of the lifting rope are attached to a large revolving barrel which can be set in motion by the engines, lowering out being effected by the weight of the block itself and the descent controlled by Matthew's hydraulic brakes, which absorb the work given out in lowering by forcing water through a narrow orifice. The illustration also shows the large circular rings with the rollers between them on which the whole upper part revolves, the turning motion being given by a steel pinion which gears into a circular fixed toothed ring attached to the lower roller path. For the travelling movement along the breakwater there is a shaft which passes down through the centre pin and communicates motion to the wheels on which the Titan runs. The large box or tank under the boiler contains the necessary concrete ballast, and it will be seen that the engines, boiler, and machinery are placed as far back as they conveniently can be, in order to assist the balance and to get a long straight pull for the wire ropes. The lower wheels are fitted with springs, to allow for inequalities of the railway. The breakwater at Gibraltar is a detached work, which was commenced by floating out a large steel caisson and sinking it until it rested on a rubble mound. It was then filled with concrete so as to form an enormous monolith of artificial stone, on which the first Titan was erected and employed to lay blocks until a sufficient length of wall was built for it to be moved forward to make room for the erection of the second machine. The two were then set back to back, the distance between them being gradually increased as the work proceeded. For a further description of the breakwaters and other naval works at Gibraltar the reader is referred to the article on DOCKYARDS.

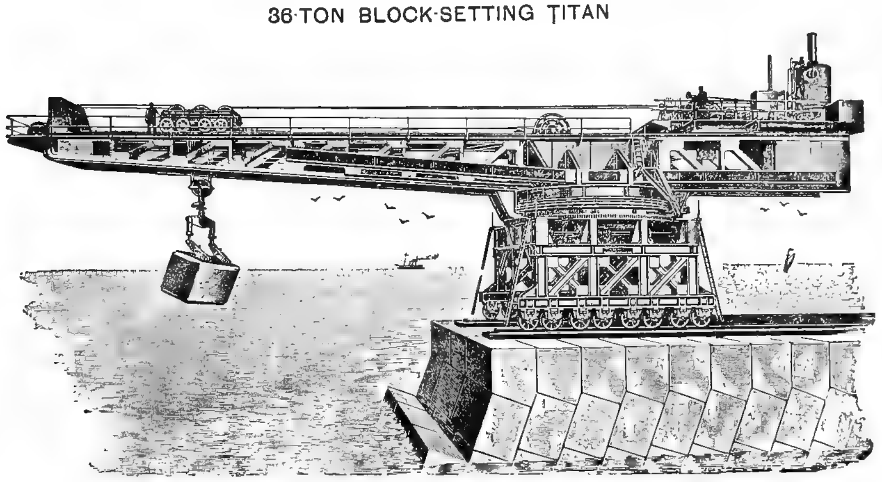


Fig. 1.—36-ton Block-setting Titan Crane.

The introduction of these Titans has been of enormous service to the harbour engineer. They have enabled harbours to be built in difficult situations at much less cost than by previous methods and in much less time, while a special advantage is the facility with which they can be brought up to the work and removed again, since in this way short spells of fine weather can be utilized and the risk of loss is reduced to a minimum. In many works it is a regular rule to run the setting plant back to a safe place and anchor it fast every evening after the day's work is done; and that this is not an unnecessary precaution will be seen when it is remarked that in several instances Titans have been carried along the rails by the force of the wind and the waves and lost over the end or washed bodily into the sea.

The huge blocks which are placed in position in the sea by the Titan require elaborate machinery for their preparation. The concrete has to be mixed out of sand, shingle, and cement, then placed in the moulds and allowed to set; when sufficiently firm to permit of being removed, the blocks have to be stacked in the blockyard until seasoned for use, and finally they have to be lifted on to the heavy railway trucks which convey them to the Titan. All these operations involve the use of specially designed plant, among which may be mentioned particularly the great Goliath cranes which span the blockyard and handle the blocks.

Little has been written on the special subject of the Titan, but a few descriptions of single machines may be found in the files of the *Engineer* and *Engineering*, and a general *résumé* in Pitt's paper "On Plant for Harbour and Sea-Works," *Proc. Inst. C.E.*, vol. cxiii. (W. P*.)

Tithes (ENGLAND AND WALES).—The payment of tithes, or the tenth part of the produce of lands, and in some cases of the profits of labour, towards the maintenance of the beneficed clergy, has been known to English law since the 8th century, and was certainly established before the Norman Conquest. A full discussion of their origin and history is to be found in Lord Selborne's *Ancient Facts and Fictions concerning Churches and Tithes*, and the *History of the Law of Tithes in England*, by G. Edwardes Jones.

In present circumstances, the subject is perhaps best dealt with in two chronological divisions—tithes under the system existing previously to the Commutation Acts, and tithes under the system then introduced.

Before the Commutation Acts.

I. Whether or not, as it is said, before the Council of Lateran in 1180, a man could have given his tithes to any church or monastery that he pleased, at any rate since that time, with the division of dioceses into parishes, they now of common right belong to the church within whose parish they arise, although by prescription they may belong elsewhere. The general rule was said to be that all lands within a parish are subject to tithes, and a layman was not allowed to prescribe generally that his lands were exempt; but he had to show a special exemption, and no length of possession was regarded in law in view of the maxim *nullum tempus occurrit ecclesiæ*, although equity did take account of it. The tithes in places extra-parochial, *e.g.*, forest lands, belong to the Crown, although by canon law they were to be disposed of by the bishop; but by custom a parson or vicar might be entitled to them. The tithes of tithable cattle pasturing in any waste or common ground whereof the parish is not certainly known, were made

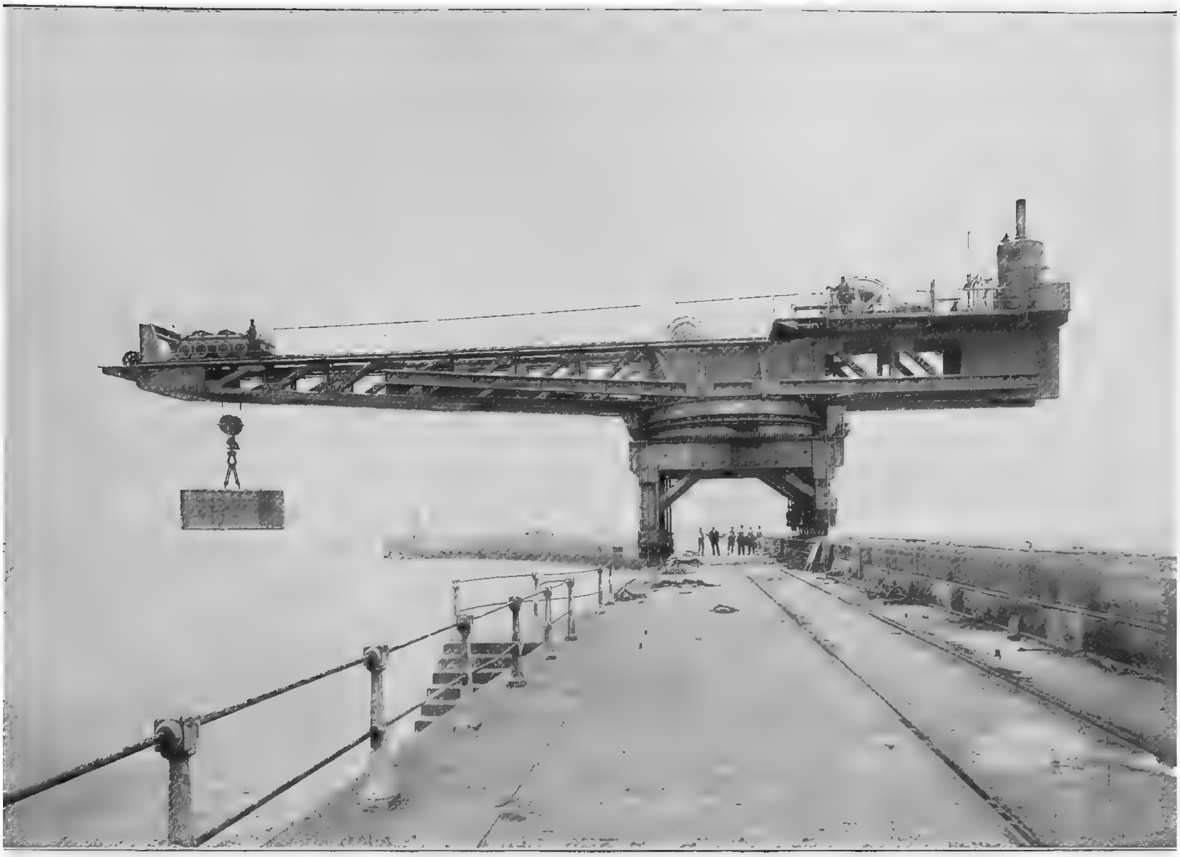


FIG. 2.—Titan Crane setting Apron Blocks at the Breakwater at South Shields.

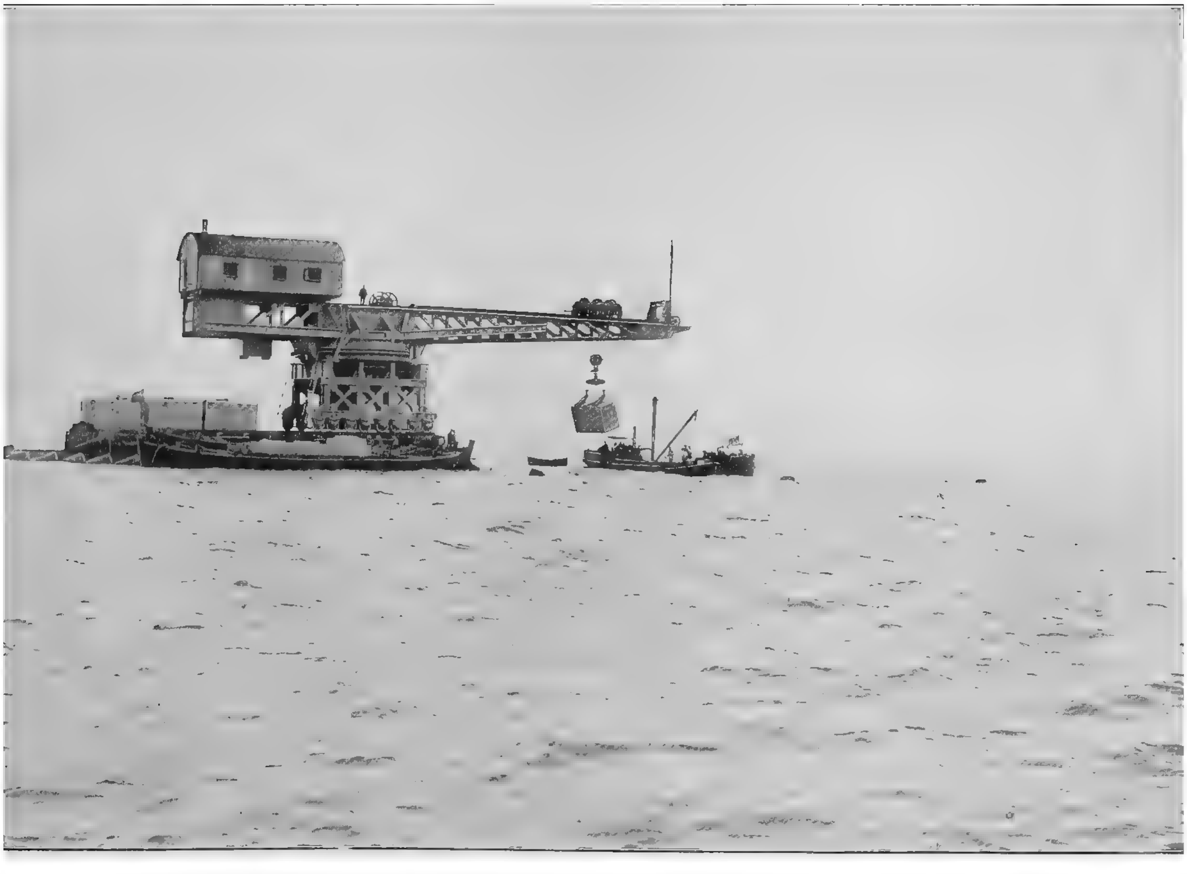


FIG. 3.—Cantilever Type of Titan Crane used for the British Admiralty Harbour Works at Gibraltar.

payable to the parson of the parish where the cattle dwell, by a statute of Edward VI.

Tithes were classified according to their nature as prædial, or arising immediately from the ground, *e.g.*, grain of all sorts, hay, wood, and the like; mixed, or arising from things immediately nourished by the ground, *e.g.*, colts, lambs, eggs, and the like; or personal, namely, of profits arising from the honest labour and industry of man, and being the tenth part of the clear gain, *e.g.*, fishing, mills, and the like; or according to value, as great, *e.g.*, corn, hay, and wood; or little, which embraced all others. Of common right tithes were only payable of such things as yield a yearly increase by the act of God, and generally only once a year. They were not payable of the following, except by custom: things of the substance of the earth, such as coals, minerals, turf, and the like; things *feræ naturæ*, such as fish, deer, and the like; things tame, such as fowls, hounds, or fish kept for pleasure or curiosity; barren land, until it is converted into arable or meadow land, and has been so for seven years; forest land, if in the hands of the king or his lessee, unless disafforested; a park which is disparked; or glebe land in the hands of the parson or vicar, which was mutually exempted from payment by the one to the other, but not if in the hands of the vicar's lessee. Another exception to the incidence of tithes were abbey lands. These were exempted generally by Pope Pascal II. while in the hands of their owners, but the privilege was restricted by Pope Adrian IV. in the time of Henry II. to the three religious orders of Cistercians, Templars, and Hospitallers (to whom the Templars' lands were given on their dissolution in 17 Edw. II.), to which Pope Innocent III. added the Præmonstratenses. The Council of the Lateran in 1215 further restricted this exemption to lands of which these orders were in possession before that Council. A custom by the religious to obtain exemption for lands let to their tenants by means of bulls from the Pope was put an end to by a statute of Henry IV. making the acquisition or use of such bulls henceforward a *præmunire*. When the religious houses were dissolved by Henry VIII., in the case of the greater abbeys and priories the exemptions from payment of tithes enjoyed by them passed to the Crown or the persons to whom the Crown assigned them, and thus any lands which might have been thus exempted, whether they had been actually so or not, were presumed to be exempt; and a further exemption was created by parsonages coming into the same hands as tithable lands, which lasted so long as such union continued.

A further exemption from tithes was given by an Act of 1832 (2 & 3 Will. IV. 100), which fixed a period of prescription against claims of tithe by laymen or corporations aggregate, of thirty years during which there had been no payment of tithes or a *modus* or composition had existed, in the absence of contrary evidence, and in any case of sixty years; and against corporations sole, of sixty years or the tenures of two successive incumbents and three years after the entry of a third. The tithes which came into lay hands by the dissolution of the religious houses and the previous suppression of alien priories by Henry V. became in all respects incorporeal freehold property. Under the Limitation Act of 1833 twenty years of adverse possession of an estate in tithes gave a good title, except as against spiritual or eleemosynary corporations sole whose right to recover tithes was limited if at all to a period of two incumbencies and six years afterwards, or sixty years (§ 29).

Tithes were generally recovered by a writ against the owner of the tithable property usually brought in the ecclesiastical courts (questions of title to tithes being reserved to the temporal courts), the jurisdiction of which in this respect was confirmed by the statutes *Circumspecte agatis* (13 Edw. I.), *Articuli Cleri* (9 Edw. II.), and others of Henry VIII. and Edward VI., and was enforced by ecclesiastical censures and the writ *de excommunicato capiendo;* and an Act 2 & 3 Edw. VI. made any person refusing to set out tithes liable to pay double the value in the ecclesiastical court or treble in a common law court. Tithes of small amount or due from Quakers could be recovered by summary proceedings before justices under statutes ranging from William III. to Victoria. Tithes could also be sued for in equity, especially the equity side of the Exchequer. A custom also sprang up, and was common at the time of the Commutation Acts, for a tithe-owner to accept a fixed sum of money or fixed quantity of the goods tithable in place of the actual tithes, known as a *modus decimandi*, whether in respect of a whole parish or only of particular lands within it; and this could be sued for in the ecclesiastical courts. Tithe-payers could also file bills in equity to establish a *modus* against a tithe-owner. In the City of London there were customary tithes; in other towns and places there were compositions for tithes which were confirmed by local Acts of Parliament; and according to a return presented to the House of Commons in 1831, there were passed between 1757 and 1830 no less than 2000 local Acts containing clauses for the commutation of tithes. Enclosure Acts often gave a portion of the lands enclosed to the spiritual or lay rector, and exempted the rest from tithes; and in other local Acts a corn rent or yearly money payment was substituted for tithes. Except, however, where made under parliamentary authority, no composition for tithes, although made between the landowner and the parson or vicar with the consent of the patron and ordinary, bound a succeeding incumbent, the statute 13 Eliz. 10 prohibiting any parson or vicar from making any conveyance of (*inter alia*) tithes, being parcel of the possessions of their churches, to any persons, except leases for twenty-one years or three lives.

II. The principle of the Tithe Commutation Acts (1836–1860) is to make permanent and general the system which had been only partial or temporary (in most cases), and to "substitute a corn rent (known as a tithe rent charge), permanent in quantity and payable in money, but fluctuating in value, for all tithes, whether payable under a *modus* or composition or not, which may have heretofore belonged either to ecclesiastical or lay persons" (Phillimore, *Eccles. Law*, ii. 1161).

After the Commutation Acts.

Commissioners (now the Board of Agriculture) are appointed to execute the Acts; a rent charge on all lands liable to tithes at the time of the passing of the first Act is substituted for those tithes, of which the gross amount is ascertained either by voluntary parochial agreement, or, failing that, by compulsory award confirmed by the Commissioners; and the value of the tithes is fixed in the latter case by their average value in the particular parish during the seven years preceding Christmas 1835, without deduction for parochial or county and other rates, charges, and assessments falling on tithes, the rent charge being liable to all the charges to which tithes were liable. The rent charge is apportioned on all the lands liable in the parish, and such apportionment may be altered or a new one made: and the value of the rent charge is fixed at the value (at the time of confirmation of the apportionment) of the number of imperial bushels and decimal parts of bushels of wheat, barley, and oats as the same would have purchased at the prices so ascertained by the advertisement (of prices of corn) to be published immediately after the passing of the Act 6 & 7 Will. IV. 71, in case one-third part of such rent charge had been invested in the purchase of wheat, one-third part in the purchase of barley, and the remaining third part in the purchase of oats; and the respective quantities of wheat, barley, and oats so ascertained shall be stated in the draft of every apportionment. The price at which the conversion from money into corn is to be made at the time of confirmation of such apportionment, according to the provisions of the said Act, are 7s. 0¼d. for a bushel of wheat, 3s. 11½d. for a bushel of barley, and 2s. 9d. for a bushel of oats (7 Will. IV.

and 1 Vict. 69); the average price of the bushel of each grain is now computed by substituting for the "advertisement" above the statement of the septennial average price of the imperial bushel of British corn made under the Corn Returns Act, 1882; and thus the value of the statutory amount of corn is now fixed for each year at the beginning thereof at the average price of the three components of corn for the previous seven years. The extent of the depreciation in value of tithe may be gathered from the fact that for 1902 the price of the wheat bushel is thus fixed at 3s. 5¼d., that of the barley bushel at 3s. 0½d., and that of the oats bushel at 2s. 1d.

As already indicated above, certain lands are exempt from payment of tithes while in the occupation of their owners, either by reason of their having been parcel of the possessions of any privileged order, or by reason of their being of the tenure of ancient demesne and exempt whilst in the tenure, occupation, or manurance of the Crown, its tenants, farmers, and lessees, or under-tenants although they are subject to tithes when aliened or occupied by subjects not being such; and in these and in all such cases, with the consent of such owners, a fixed rent charge may be substituted for any contingent rent charge imposed on them (2 & 3 Vict. 62; 3 & 4 Vict. 15, now repealed except as to tithes not commuted). In certain cases where commutation of tithes for rent charge in the ordinary way was impracticable, *e.g.*, in the case of Lammas lands or in the case of common lands, power was given to charge a fixed sum or rate per head of the cattle there pasturing, with an exception in the case of Lammas lands which for seven years before Christmas 1835 had paid no tithe; and also to fix a rent charge in respect of tithes of common appurtenant on the allotment made in respect of the lands to which such right of common attached (2 & 3 Vict. 62; 3 & 4 Vict. 15; 9 & 10 Vict. 73). By an Act of 1860 (23 & 24 Vict. 93) a gross rent charge can be substituted for a commutation of tithes on common rights at a fixed sum per head; a gross rent charge made payable in respect of the tithes of a gated or stinted pasture rated to the relief of the poor may be apportioned thereupon and enforced in the method prescribed by the other Tithe Acts; a rent charge on commons may be commuted for part of the land or redeemed, if the landowners and persons liable for tithe so agree; and upon enclosure, a rate per head may be converted into a rent charge on the lands allotted. These rent charges are not subject to the Tithe Act of 1891. This Act of 1860 also gave power to convert the corn rents established under local Acts into rent charges.

In the case of hop-grounds, orchards, fruit-plantations, and gardens, power was given to the Commissioners to value them separately, according to the average rate of composition for the seven years preceding Christmas 1835, and to fix an ordinary and an extraordinary charge for tithes thereof, the former for such lands going out of cultivation, the latter for such as were thereafter newly cultivated: lands subject to the latter were exempted during their first years of cultivation; and such lands were only subject to it if situated in a parish in which an extraordinary charge had been distinguished at the time of commutation (6 & 7 Will. IV. 71; 2 & 3 Vict. 62; 3 & 4 Vict. 15; 23 & 24 Vict. 93; 36 & 37 Vict. 42). In 1886, however, it was enacted that no such extraordinary charge shall be levied on any such grounds so newly cultivated in future; the capital value of the existing charges was assessed, and the payment of interest thereon was made a rent charge on the land payable in priority to all other charges until its redemption, and recoverable in the same way as ordinary rent charge and exempt from all rates, charges, and assessments: the charge was redeemable at the capital value, and saving existing contracts it was as between landlord and tenant payable by the landlord, any agreement to the contrary notwithstanding; and it is not subject to the Tithe Act of 1891. Under the Act of 1840 (3 & 4 Vict. 15) gardens and lawns and the like, of small size, could be exempted from tithes.

Besides the tithes dealt with by local Acts as already mentioned, certain other kinds of tithes are outside the scope of the Commutation Acts, namely, tithes of fish and fishing, personal tithes other than tithes of mills, and mineral tithes, unless the landowners and tithe-owners consent to make a parochial agreement for commutation before the confirmation of an apportionment after a compulsory award in such parish. As already seen, fish being *feræ naturæ* are only tithable by custom; but fish taken in the sea by the custom of the realm are tithable as a personal tithe, *i.e.*, in some small sum for the net profits of the fishing, and customs for payment in kind have been upheld by the courts. Personal tithes, if not commuted or otherwise still payable, are regulated by a statute of Edward VI., which (except in the case of fishing and tithes for houses in cities and towns, which may be due by custom) restricted them to such persons exercising merchandises, bargaining and selling clothing, handicraft or other art or faculty in such places as had for forty years previously so used to do. Personal tithes are now rare, except of fish caught at sea, when they are payable to the church where the taker hears divine service and receives the sacraments. Tithes on houses or customary payments in lieu of tithes have, by local Acts, in some cases been turned into church rates. Statutory provision is also made for allowing tithes and tithe rent charge to be exchanged for land, and for the redemption of rent charges made under the Acts, and also of corn rents under the local Acts. Tithe rent charge may also be merged in the land tithable, with the consent of the Tithe Commissioners and the landowner, by the legal and equitable owners of tithes in fee simple or fee tail, or persons having power to appoint the fee simple in tithes, or owners of glebes, or owners of lands and tithes settled to the same uses.

Tithe rent charge under these Acts is subject to the same liabilities and incidents as tithes, such as parliamentary, parochial, county, and other rates, especially the poor rate and highway rate; but the owner of tithe rent charge attached to a benefice has been exempted by an Act of 1899 from payment of half the amount of any rate which he would be liable to pay under the Agricultural Rates Act, 1896, the other half being borne by the Inland Revenue Commissioners. The limitation of time for recovery of tithes or estates in tithes, whether between rival claimants to tithes or tithe-owners or tithe-payers, if belonging to lay individuals or lay or spiritual corporations aggregate, is a period of twelve years, as in the case of other real property (37 & 38 Vict. 57); and in the case of spiritual corporations sole the period of limitation of actions, if any, is governed by the Limitation Act, 1833, § 29, already quoted, the Act 2 & 3 Will. IV. 100 being held only to apply to demands of tithe in kind.

The method of recovering rent charge under the Commutation Acts was distraint where the rent charge is in arrear for twenty-one days after the half-yearly days of payment, and entry and possession with power of letting if it is in arrear for forty days, and arrears for two years are so recoverable: this power of distress and entry extends to all lands occupied by the occupier of the land whose tithe is in arrear as owner or under the same landlord; but no action lies against the owner or occupier of the land personally. If a tenant quits leaving tithe unpaid, the landlord may pay it and recover it from him. The tithe-owner cannot recover damages from the tithe-payer for not cultivating the land. Special provision is made for the recovery of the rent charge in railway lands.

The Act of 1891 has, however, altered this method of recovering tithes, and substituted another intended to shift the burden of responsibility from the occupier to the landowner, by making the latter directly and solely responsible, but giving the remedy against the land. The landowner is made liable to pay the rent charge in spite of any contract to the contrary between him and the occupier; the rent charge if in arrear for three months is recoverable by an order of the county court, whatever its amount may be: if the land is occupied by the owner, the order is executed by the same means as those prescribed in the Tithe Acts; but if it is not, then by a receiver being appointed for the rents and profits of the land: neither landlord nor occupier is personally liable for payment; an appeal lies to the High Court on points of law; and a remission of rent charge may be claimed when its amount exceeds two-thirds of the annual value of the land. The Act does not apply to the particular kinds of rent charges mentioned above.

The Tithe Acts do not apply to the City of London, which has always had its own peculiar customary payment regulated by episcopal constitutions of 13 Hen. III. and 13 Ric. II. and statutes of Henry VIII., confirming a decree of the Privy Council, under which the rate of tithes was fixed at 16½d. for every 10s. rent, and at 2s. 9d. for every 20s. rent of houses, shops, and the like by the year. Provision was made by statute after the Fire of London for certain annual tithes to be paid in parishes whose churches had been destroyed, and there have been local Acts from time to time since with regard to particular parishes therein.

Authorities.—Phillimore. *Ecclesiastical Law.* 2nd edition. London, 1895.—Cripps. *Law of Church and Clergy.* 6th edition. London, 1886.—Eagle. *Tithes.* London, 1836. (g. g. p*.)

Title Guarantee Companies apply the principle of corporate indemnity to the protection of those interested in real estate titles, either as owners or lenders. They are of the class of indemnity companies in which technical skill and experience in investigation of risks are relied upon to protect the guarantor from loss. They are peculiar to countries where the title to real estate is a matter of public record, and where the complexity of the record and the variety of possible liens and encumbrances have made it difficult and expensive to determine whether the title is good. The only country where they have reached large proportions or achieved success as independent business enterprises is the United States. In Australia no investigation of a title to real estate is necessary, because before the land passed into individual ownership the Government adopted a system of State registration and guarantee of title, so that its certificate of registered title was universally accepted. In certain other countries there is neither registration of title nor recording of deeds; the title-deeds are preserved and passed from owner to owner, and are accepted on the authority of the records and opinions of family solicitors. In the United States, however, there have been from the beginning Acts providing that all deeds and mortgages be recorded, and the records, when properly made, constitute legal notice to all the world of their contents and claims. At the same time, there are other records of wills, suits, judgments, taxes, and mechanics' claims which may encumber the title. In the great cities these various records became in course of time so voluminous that the proper investigation of them, and the determination of the validity of the title in view of them, required the best skill of an experienced lawyer and involved very heavy expenses. On a re-sale of the property the new buyer did not rely upon the lawyer who had made the examination for the seller, but felt called upon to employ and pay his own lawyer, who had to go over the same work again, and more, for with each new transaction the history was getting longer. The delay and expense involved were great, and yet the owner had little or no protection, for a lawyer is not held to guarantee the correctness of his opinion.

The first legislative grant of corporate authority to guarantee titles to real estate was included in the charter of the New York Guaranty and Indemnity Company, a trust company incorporated in New York by Act of the Legislature in 1864; but the power to guarantee titles was never exercised. In 1869 the Real Estate Assurance Company of the City of New York was chartered with the sole object of insuring the validity of titles, but was never organized. In 1871 a pamphlet was issued by a member of the New York bar, calling attention to the business carried on by the Prussian Mortgage Insurance Company of Berlin, and outlining plans very similar to those now followed by the principal title guarantee companies of the United States; but the pamphlet seems to have been forgotten. The first company actually to undertake the guarantee of real estate titles was formed in Philadelphia, Pa., in 1876. It differed from the Prussian Mortgage Insurance Company (which guaranteed titles merely as an incident in its business as a dealer in, and custodian and guarantor of, mortgages) in that its main business was the issue of a policy of guarantee on a transfer of title to land. The advantages of its method were immediately recognized. Corporations to carry on the business were organized in Washington, Baltimore, Boston, and New York in the order named, and subsequently in nearly every considerable city in the United States.

In order to be independent of the inaccurate and clumsy methods of the public record offices, title guarantee companies generally compile in their own office a copy or digest of all the real estate records of the locality in which they are established, maintaining for this purpose a staff of skilled clerks. To make the necessary examination of a title prior to the issuing of a guarantee, they require continually a body of experienced real estate lawyers. By these means a title can be examined and guaranteed in a week, whereas thirty or forty days was formerly required. This has done much to make real estate available capital, for individual and corporate lenders on mortgage accept the guarantee of the companies as the best evidence of title, and loans can be had without the delay that once prevailed.

The expense of maintaining the staff of clerks and lawyers is great, amounting to half of the gross charges on titles guaranteed. Strictly speaking, the risks outstanding are also large, running up to $100,000,000 a year for a single company in New York City; but in well-managed companies the losses are very small, not exceeding 2 per cent. of the gross charges on titles guaranteed, so that the outstanding obligations should scarcely be called risks. In spite of the office expenses, the charges for first bringing a piece of land under the guarantee are no more than owners were in the habit of paying each time for examination and opinion by counsel, amounting to about one-half of 1 per cent. on the value of the property or on the amount of the mortgage; and when once the guarantee has been issued, it is re-issued on a subsequent sale or mortgage on short notice and for a small fee. The largest capital employed is that of the leading company of New York City, which amounts to $2,500,000. From that it runs down to $100,000 in some of the smaller cities. (c. h. k.)

Titusville, a city of Crawford county, Pennsylvania, U.S.A., on Oil Creek, and on the Dunkirk, Allegheny Valley and Pittsburg, and the Western New York and Pennsylvania railways, in the north-western part of the state, at an altitude of 1181 feet. It is in the heart of the Pennsylvania oil region, and is regularly laid out on a level terrace, divided into four wards, has a good water-supply, pumped from wells, and is well sewered. The industries are chiefly connected with the refining, pumping, and transporting of petroleum. It has oil-wells, refineries, tanks, and pipe lines. Population (1890), 8073; (1900), 8244, of whom 1573 were foreign-born and 106 negroes.

Tiverton, a municipal borough, market town, and railway station in the Tiverton parliamentary division of Devonshire, England, at the confluence of the Exe and the Lowman, 14 miles north of Exeter. A canal 11 miles long connects Tiverton with the limestone quarries of Burlescombe. The system of waterworks has been improved, a public park provided, and "homes" for twenty-four inmates erected. Area, 17,680 acres. Population (1891), 10,892; (1901), 10,382.

Tivoli, a town and episcopal see of the province of Rome, Italy, 17 miles east-north-east of Rome. Five miles west are the sulphur baths of Acque Albule, which were known to the ancients, and are now again frequented by over 40,000 persons annually. The temperature of the water is 75·2° Fahr. The falls in the river afford electric power for lighting Rome, as well as for driving several factories in Tivoli itself. Population (1881), 9730; (1900), about 11,500.

Tlaxcala, a state of Mexico, bounded on the N., E., and S. by Puebla, and on the W. by Mexico. Area, 1595 square miles—the smallest state in the republic. Population (1879), 138,988; (1900), 172,217. It forms a part of the central plateau, and is consequently in the cold region, its mean altitude being between 6000 and 10,000 feet. Three railways cross the state. It is essentially an agricultural state, cereals and pulque being the chief products. The annual value of the commerce is about $8,000,000 (silver). The capital Tlaxcala, with a population of 2847, the most important town in the state, has fine buildings, and is connected with the city of Mexico by the Santa Ana and Tlaxcala railway. The principal towns are Chiautempan (5000 inhabitants), Calpulalpan San Antonio, Tlaxco San Augustin, Huamantla, Barron-Escandon (or Apizaco).

Tlemçen, a town of Algeria and seat of a sub-prefecture in the department of Oran, near the frontier of Morocco, 80 miles south-west of Oran, 2500 feet above the sea, on the north slope of mountains 4800 feet high. Its seaport is Rashgun, and it has been placed in railway communication with Oran by way of Sidi-bel-Abbès. It is the chief town of a wide district exporting olive oil, corn and flour, wools, and onyx. Population (1900), 34,672, of whom 3812 were French.

Tobago, the most southerly of the Windward group of the British West India Islands. The products are sugar, rum, and molasses (all on the decline), and coffee, cacao, and nutmegs. But in the last year or two of the 19th century many thousands of rubber trees were planted in the island. Population (1885), 19,363 (principally negroes, there being but few whites); (1901), 18,750. Scarborough, the capital, on the south side, had in 1891 a population of 919. The mean annual temperature at sea-level is about 81°. The average annual rainfall is 66 inches on the windward side, the wettest months being June to December. Imports (1898) £11,657, exports £19,401. Revenue (1898) £8107, expenditure £8386. The religious denominations of Anglicans, Roman Catholics, Moravians, and Wesleyans maintain 25 schools, with about 2874 scholars, assisted by a Government grant of £1000. Till 1889 the island formed part of the colony of the Windward Islands, but in that year it was made part of the colony of Trinidad and Tobago, administered by a commissioner, the fiscal arrangements of the two islands being kept distinct. In 1899 it became a ward (under a warden and magistrate) of the colony, and its revenue, expenditure, and debt were merged in those of the united colony, the laws of Trinidad becoming, with some exceptions, the laws of Tobago.

Tobolsk, a Russian government in western Siberia, extending from the steppe provinces of Akmolinsk and Semipalatinsk in the S. to the Arctic Ocean in the N., and having the provinces of Orenburg, Perm, Vologda, and Archangel on the W., and Tomsk and Yeniseisk on the E. It has an area of 539,660 square miles, and its population, which was 1,283,000 in 1882, numbered 1,438,482 (domiciled only) in 1897, of whom 726,502 were women, and 86,398 urban. In 1899 it rose to 1,474,804 (87,148 urban), of whom about 118,000 were exiles and their families. Small as this increase was, it was largely due to immigration, there having been 47,000 immigrants from 1891 to 1895, and 41,800 in 1896. At the present time it is considered that no more immigrants can be taken into the southern districts of Yalutorovsk and Kurgan; immigration is consequently directed into the district of Ishim, and even into the woody and marshy tracts (*urmans*) of the districts of Tara, where some 12,600 persons settled in 1899. The population is practically all Russian, except for some 42,000 Tatars in the south, 22,500 Ostyaks, 6000 Samoyedes, and from 4500 to 6000 Voguls. There are, moreover, about 5000 Germans and Finns, some Jews in the towns, and about 1000 Tziganes. The government is divided into ten districts, the chief towns of which are: Tobolsk, Berezoff (1073), a small town standing alone in the dreary tundras, Ishim (7160), Kurgan (10,579), Surgut (1120), Tara (7230), Turinsk (2940), Tyukalinsk (1180), Tyumen (29,588), and Yalutorovsk (3450). The standard of education is still very low; in 1897 there were only 701 schools, attended by 1400 boys and girls in the middle schools (7 gymnasia), 6000 in the schools in towns, and 17,340 in the village schools.

Agriculture is the chief occupation, and Tobolsk is fast becoming a vast granary from which corn is exported to the northern provinces of European Russia. In 1896 the total cereal crop amounted to 6,548,090 quarters, but 2015 tons of hemp seed and 3100 tons of linseed were also grown. The total area under cereal crops in 1900 was 3,334,600 acres, and the average yield in 1895–99 was: rye 10,250,000 poods, wheat 22,709,000 poods, oats 22,103,000 poods, and barley 2,790,000 poods; also potatoes 8,500,000 poods. The lack of improved agricultural implements places many obstacles in the way of the farmers, but efforts are being made by the local authorities to bring such implements into more general use. Cattle-breeding is carried on on a large scale, nearly 110,000 horned cattle and more than 150,000 sheep being killed every year within the province. There are no exact figures, owing to the difficulty of ascertaining the number of cattle brought for grazing from the steppe provinces. Dairy-farming has made remarkable progress since the trans-Siberian railway has been built, numbers of agents coming from European Russia and from western Europe to purchase butter, eggs, and fowls in the villages. More than 200 dairies, of which some 12 are on co-operative principles, have grown up, the aggregate production being estimated in 1900 at about 90,000 cwt., or 3,000,000 roubles' worth. Apiculture and fishing retain their importance. Manufacturing industries, as carried on in factories, are still insignificant; in 1897 they employed only 7400 workers, and showed a return of only 6,287,000 roubles. Domestic industries, on the contrary, are widely spread, especially carpet-weaving and the making of cheap rifles and all sorts of wooden ware. Navigation on the rivers of Tobolsk has developed considerably (see SIBERIA). The yearly returns of the many fairs which are held in the province are valued at 15,000,000 roubles' worth sold; the most important is that held at Ishim. (P. A. K.)

Tobolsk, the capital of the above province, on the right bank of the Irtysh, nearly opposite its junction with the Tobol river, 172 miles north of the Tyumen railway station on the North Siberian railway. It is an out-of-the-way town, visited only by steamers during the summer. It has, however, a good archæological and natural science museum, which issues a valuable annual report, gymnasia for boys and for girls, a theological seminary, and 17 other schools, and various educational and philanthropic institutions. Fishing is the chief occupation of the inhabitants and of its merchants, who keep their own steamers and send out fishing crews down the Ob. The merchants also carry on a considerable trade with the natives farther north, receiving fish and furs in exchange for grain, flour, salt, &c. Population (1899), 22,752.

Tocantins. See AMAZON.

Todmorden, a municipal borough (since 1896) and market town, Yorkshire, England, partly in the Sowerby parliamentary division of the West Riding and partly in the Middleton parliamentary division of Lancashire, 13 miles west of Halifax, on the Calder, with a station on the Lancashire and Yorkshire railway. A new chancel was added to the church of St Mary's in 1896. Population (1891), 24,478; (1901), 25,419.

Togoland, a German colony in West Africa, on the Gulf of Guinea. It is a mountainous country, being situated chiefly on the southern escarpment of the Sudan plateau. Two ranges, of which one is a line of hills parallel to the plateau margin, traverse the country from south-west to north-east. The coast is a low, sandy foreland, formed of the detritus deposited by the sea current called Calema. Large coast lagoons receive the numerous rivers, the Mono, Haho, Sio Tapjie, and Volta. The last is the largest, and receives a number of affluents which rise on the plateau. In its middle part it forms the boundary of the country; it becomes navigable at Krachi.

Boundaries and Population.—The southern boundary is the sea. In the east the boundary between Togo and French Dahomey, by Franco-German agreement of 1897, is the middle of the river Mono as far as 7° N. and in a generally northerly direction to 11° N. The western boundary, between Togo and the British Gold Coast, was settled by Anglo-German agreement of 1890;

it leaves the coast near Lome and proceeds in a zigzag line to where the Deine river joins the Volta; it follows this river to its junction with the Daka, and continues from here in a manner agreed upon in 1899, so as to secure the neutral zone of Salago; this remains to be settled definitively. The area is estimated at 33,000 square miles, with 3,000,000 inhabitants.

Meteorology.—There are two wet seasons, the first lasting from March till June, the second and shorter one from September to November. The greatest heat falls in the winter months. A dry wind, called harmattan, which carries great quantities of red sand, is specially remarkable.

Flora and Fauna.—The lagoons on the coast are surrounded by dense belts of reeds, and the coast-land is covered with low, impenetrable bush. Large groves of oil-palms are planted. On the hills the baobab and hyphæna palm are characteristic, and on the plateau are grass and the shea butter-tree. Animal life is much the same as in the other parts of tropical Africa; it is poor on the coast, and in the interior the influence of the Sudan steppe is noticeable.

Ethnology.—The inhabitants are Sudan negroes. In the north they are Hausas, in the west they speak the Tchi dialect, while on the coast the Ewé language is spoken. The Adeli and Aprosso have a dialect of their own. In the north they form small though well-organized states. The whole country is well populated; on the coast the inhabitants are agriculturists, in the interior they raise cattle, and the Hausas are successful traders, who traverse the country in large caravans.

Government and Forces.—There are three Government stations in the interior and on the coast. Lome is the residence of the Commissioner, who is also chief justice. There is a force of 250 coloured soldiers, under one white commissioned and ten non-commissioned officers.

Religion.—The inhabitants are partly Mahommedans, partly believers in fetish. There are four mission societies, one Roman Catholic; they have several schools, which, however good, are not equal to the Government school in Little Popo.

Revenue, Taxation.—There is an import tax of 4 per cent. of the value on all mercantile goods. Certain exceptions are admitted. Liquors, powder, tobacco, and firearms are subject to a special tax. Trading firms have to pay a licence of £50 a year, and of £25 for each branch establishment near the coast, or of £5 in the interior. Firms which only import pay £30 per annum. The budget revenue for 1899 was 550,000 marks, the expenditure 789,000 marks; the imperial subvention for 1900–1901 was 270,000 marks.

Shipping.—There is direct steamship communication between Togo and Hamburg; the Woermann line sends regularly three steamers a month, and the steamers of three French lines and two English call at Togo ports. In 1898–99, 95 vessels of 110,241 tons entered the ports.

Roads, Post, and Telegraph.—Roads are gradually being pushed towards the interior. A short line of railway is in course of construction, and a jetty which ships can approach for loading purposes has been built. The colony belongs to the Universal Postal Union, and there are two post offices on the coast. Twice a week mails are sent by runners overland to the French and British post offices in the neighbouring colonies. The stations in the interior receive mails twice a month. There is a telegraph between Lome and Little Popo, and both places are joined on to Accra and Dahomey, and thus to the international cable system. There is a Government telephone line between Little Popo and Lome.

Productions and Industry.—The country is rich in natural products—palm oil and kernels, copra, rubber, ground nuts (*arachis*), shea butter of the *Bassia Parkii Sapotacea*, fibres of the *Raphia vinifera*, the *Sansevieria Guineensis*, indigo, and cola nuts, ebony and other valuable wood. Minerals have not been found yet. In the interior cattle and sheep are plentiful, on the plateau horses and donkeys. The natives are good weavers. They collect and spin the indigenous cotton, and dye it with indigo or other pigments; the country produces and manufactures very handsome shawls. Pottery and smith's-work are largely practised, and iron is being imported. Carving in wood is common, and the examples are sometimes very handsome. In 1898–99 the imports were valued at 3,029,598 marks, the exports (mainly palm kernels and palm oil) at 2,016,708 marks.

Progress since Annexation.—Since its annexation to Germany the country has been most prosperous. Trade has grown considerably. Plantations have been started, and only cocoa and tobacco have proved a failure, there being too little rain for the one and not the right quality of soil for the other. Coffee and cocoa palms thrive well, and the produce increases from year to year. Cotton has not been cultivated with equal assiduity; rubber promises good results. Peace and order have been established, and the good-will of the natives has been gained throughout the country.

See N. Seidel. *Die Küste und das Vorland der Togocolonie.* Berlin, 1897.—R. Büttner. *Die Forschungsstation Bismarckburg und Adeli.* 1894; *Das Deutsche Schutzgebiet Togo.* Bremen, 1891. (J. von P.)

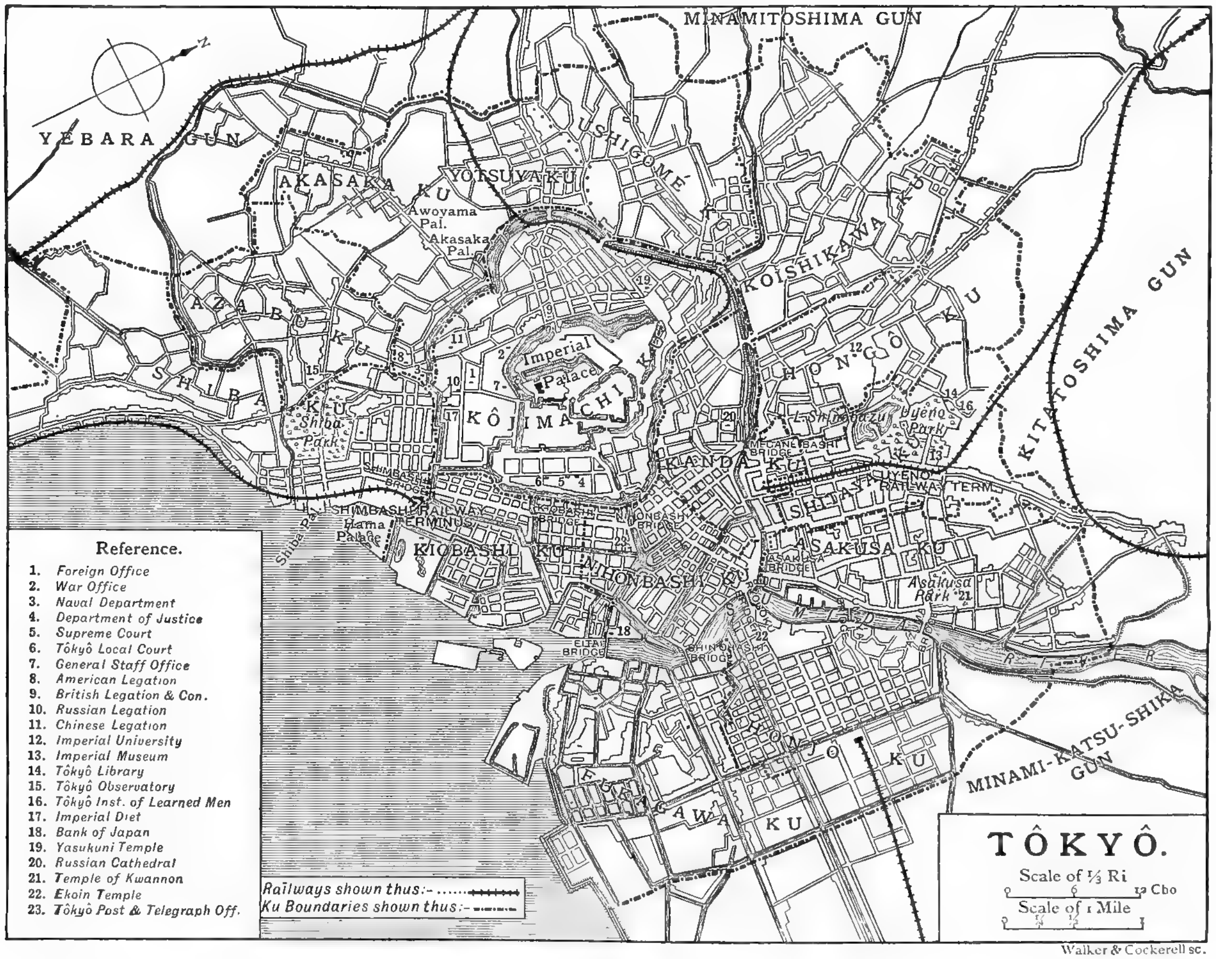
Tokat (Armenian, *Evtoghia*), the ancient *Dazimon*, altitude 2280 feet, chief town of a sanjak of the same name in the Sivas viláyet of Asia Minor, situated on the Sivas–Samsún *chaussée*, at the mouth of a rocky glen which opens out to the broad valley of the Toranli Su, a tributary of the Yeshil Irmak. The industries are the manufacture of copper utensils and yellow leather, and stamping colours on white Manchester cotton. Near Tokat copper pyrites, with iron and manganese, kaolin, and coal are found. In November 1895 there was a massacre of Armenians. Population, 30,000 (Moslems 19,000, Armenians 10,000, Greeks 1000).

Tokay (Hungarian, *Tokaj*), a market town of Hungary, in the county of Zemplén. The phylloxera made enormous ravages in the famous vineyards, but by means of new plantations the wine industry is again reviving. Population (1891), 4815; (1901), 5110.

Tokelau. See Polynesia.

Tôkôy, formerly called Yedo, the capital of the empire of Japan, situated in 35° 41′ N. and 139° 45′ E., at the head of the bay of the same name on the south-east coast of the main island. The city stands on the banks of the river Sumida, which, although wide, is unnavigable by vessels of large tonnage owing to the shallowness of its mouth, due to the silt brought down by the current. A scheme was on foot in 1902 to overcome this difficulty and thereby open the port to shipping in general. Meanwhile Yokohama, with which Tôkyô is connected by 18 miles of railway, is practically the port of the capital.

Tôkyô covers an area of about 100 square miles. Geographically, it may be divided into two parts, upland and lowland (Yama-no-té and Shitamachi), which for administrative purposes are split up into fifteen districts or *Ku*, of which Kôjimachi, Hongô, Koishikawa, Ushigomé, Yotsuya, Akasaka, Azabu, and Shiba are situated in the upland portion, while Kanda, Kiobashi, Nihonbashi, Shitaya, Asakusa, Honjô, and Fukawaga are in the lowland. Suburban Tôkyô is divided into eight districts or *Gun*, which, with the city proper, collectively form the Tôkyô-Fu (prefecture), under the general control of one governor called Fu-Chiji. Questions affecting the interests of the whole Fu come before the *Fukwai*, or prefectural assembly, made up of representatives from both *Ku* and *Gun*, and a prefectural council, of which the governor is president; while matters concerning the city alone are discussed by a *Shikwai*, or municipal assembly, and administered by a municipal council, of which the Shichô or mayor is the president. The population in 1898 was 1,440,121, as compared with 1,242,224 in 1894. For many years past it has shown a steady and substantial increase. The streets are still in many quarters narrow and irregular, and do not permit of heavy traffic. In this direction much has been achieved, however, under the Tôkyô Streets Improvement Act of 1888. The chief thoroughfares have been widened, and the excessive crowding in them no longer exists. All along the best streets, at regular intervals on each side, the willow, the flowering cherry, and other ornamental trees have been planted between the footpath and the carriage-way. The Ô-dori (main street) is the most important thoroughfare. It runs from the Shimbashi station to Mégané-bashi or Spectacles-bridge (so called from its circular arches), and traverses the business quarters of Nihonbashi, Kiobashi, and Kanda. In the section of it called Ginza most of the best shops and bazaars are to be found. The pavement is generally composed of pebbles held together by clay, and these, in fine weather, afford a sufficiently smooth surface. With much rain, however, the clay turns to mud. The principal streets, especially those in the business part, are lighted by electricity and gas, or by good oil lamps; but, generally speaking, the illumination is poor, there being in some quarters no light whatever, and in these it is still necessary to carry a lantern. The jinrikisha, drawn by one or sometimes two men, forms the chief means of passenger conveyance. Horse and electric trams are used in certain parts of the town, and street railways and trams are being introduced. Lowland Tôkyô, that part of the city covering the flats on both sides of the river Sumida, is intersected by a system of canals along which merchandise and tradesmen's wares are conveyed by barges. The many bridges which span these canals have always been distinctive and picturesque features of Tôkyô. The Nihonbashi (Bridge of Japan), in the district of the same name, is by far the most famous. It is the central point from which all distances in Japan are calculated. The largest bridges are those named Azuma, Umaya, Ryôgoku, Shin-ô, and Eitai, and these all serve to connect the districts of Fukagawa and Honjô on the eastern bank of the Sumida with the other portions of the city on the western. Shin-ô remains wooden, but the other four have been reconstructed of iron. Ochanomizu-bashi, a suspension bridge connecting Hongô with the Surugadai Hill of Kanda, is also a famous structure. On this hill stands the Russian cathedral, an imposing edifice dominating the view in the lowland district. The climate is mild and healthy, and for the greater part of the year very pleasant, the seasons of spring and autumn being more especially delightful. There is a regular water supply, the new water-works, commenced in 1892, having reached completion, and water is laid on to the dwelling-houses. The reservoir at Yodobashi is capable of supplying water to all parts at a pressure varying from 80 to 100 feet, and is of such dimensions as will enable it to meet the requirements of a population twice the size. The water is brought from the river Tama by the old aqueduct, 27 miles in length. Hydrants are fixed in all the streets for the use of the fire brigade, whose operations have been rendered much more effective by reason of the enormous pressure and ample supply afforded by the new



Walker & Cockerell sc.

Plan of Tôkyô.

system. The fire brigade has a well-disciplined and very efficient personnel, and it does not lack opportunities for the exhibition of its skill in a town built almost entirely of wood. In 1899 there were 358 conflagrations in the Tôkyô-Fu, destroying altogether 1441 buildings. The fire brigade is not yet adequately equipped with engines of European type, but the firemen, though they rely upon antiquated methods, are nevertheless highly trained, and display at all times invincible courage. On the second day of the year a public display of the fire brigade is given at the Kaji-bashi ground, where the greatest excitement and interest are evinced by crowds of people who come from all quarters of the town to witness it. The police force is another well-trained and successful service. In 1899 its numbers were 3519 in Tôkyô-Fu, or one policeman to every 543 inhabitants. Both police and fire brigade are under the command of a single *Keishi-sokan* (inspector-general). The postal arrangements are very satisfactory, frequent deliveries being made with the utmost despatch. Telegrams can be despatched to and from any part of the city. The telephone, too, has been adopted. There are long-distance wires to Yokohama, Osaka, and other large towns, through which messages may be spoken. In 1901 there were 29 post and telegraph offices, 23 offices for post only, and 5 offices for the despatch of telegrams only. A very complete and successful system of education exists. In 1899 there were 715 public and private elementary schools, giving employment to 3053 teachers. In that year children of school age numbered 294,864, and of these 195,371 went through the course of instruction prescribed by the Ministry of Education. There are also many schools for advanced students devoted to the various branches of science, mechanics, and art, the principal of which are under direct Government supervision. Under the same control there is the Imperial University of Tôkyô, which consists of the colleges of law, medicine, literature, science, engineering, and agriculture. There are several very good daily newspapers, as well as weekly and monthly publications of all kinds. In the suburbs there are many factories, but Tôkyô as a whole cannot be described as a manufacturing city. It has often experienced earthquakes, and more than once has suffered from severe shocks. For this reason the number of tall substantial houses of brick and stone is limited, lest earthquakes may occasion loss of life and property through the fall of such heavy buildings. It has been suggested, however, that iron framework constructed according to scientific methods would reduce the enormous destruction of houses from which the people suffered in past days, and it was decided to build the palace of the Crown Prince at Aoyama of that material. The Imperial Palace, which is half European and half Japanese in its style of architecture, stands on the site of the old Yedo Castle, almost in the centre of the Kojimachi-Ku. It is surrounded by moats. The Nijûbashi is the main entrance. To the east and south of the palace the neighbourhood has undergone great changes in recent years. It was here, at the Sakurada Gate, that Ii Kamon-no-Kami, Prime Minister of the Shogun's Government, and the first Japanese Progressive, was assassinated by the anti-foreign party in 1860. On the site of his residence a little higher up to the right of the gate now stands the War Office and the offices of the general staff. In another street, immediately facing the gate, are the Foreign Office, the Supreme Court, the Local Court, and the Departments of Justice and the Navy. The temporary buildings of the Imperial Diet, which first met in 1890, are also in this part of the capital. Adjoining the above-named buildings the new Hibiya Park has been laid out. It is modelled attractively on public gardens of the European style. The parks have always afforded to the people their chief means of recreation. The largest and most beautiful are those in Shiba and Uyeno, the latter encircling Lake Shinobazu, so famous for its lotus flowers. In Uyeno, too, are the Imperial Museum, the Imperial Library, the Zoological Gardens, and the temples of the Shoguns. The famous temple of Kwannon, the goddess of mercy, is in the Asakusa Park, in which a permanent fair is held; it is a great holiday resort of the middle and lower classes. Kudanzaka Park is approached by a long steep road. In its grounds is the Yasukuni Temple, consecrated to the spirits of departed heroes who gave their lives for the state. To the right of the temple is a museum of arms, where the old Japanese swords and scabbards, as well as trophies from China and Korea, are exhibited. The pastimes of the people for the most part take the form of out-of-door sight-seeing, regulated by the season of the year. In the spring or cherry-blossom season many picnic excursions are made into the country. One of the greatest sights is the shell-fish gathering in April, when the tide runs out, leaving the bed of the bay accessible to thousands of gay young people, who wade out in search of bivalves. Athletic sports, once altogether ignored, have become very popular. Twice in the year, in May and January, wrestling contests take place in the enclosure of the Ekoin Temple near Ryôgoku Bridge, and these evoke the greatest interest and enthusiasm. Rowing is popular with schoolboys and students. Cycling, too, is a favourite pastime, even with Japanese ladies, who are usually very conservative in their habits.

Tôkyô is the centre from which several railways radiate. The trains of the Tokai-do line, starting from the Shimbashi station, run westwards to Kôbé, thence to Shimonoseki, the western end of the main island, a distance of 700 miles. The Uyeno station is the starting-point for trains to Aomori, a town 460 miles away, at the northern extremity of the island. (G. U.)

Toledo, a province of Spain; area, 5620 square miles; population, 359,562 in 1887, 370,012 in 1897. The birth-rate is 4·08 per cent., the death-rate 3·36 per cent., and the proportion of illegitimate children 2·05 per cent. of the births. The province is divided into twelve districts and 206 parishes. There are 250 miles of railways. The mountainous districts were until lately the abode of brigands, who found shelter in the forest-clad sierras that were so extensively denuded of timber in the last decade of the 19th century. From the woods in the lower sierras much charcoal and firewood is yet drawn, and the commons produce £70,000 yearly in this way.

The northern part of the province is richest in agricultural products, and the southern in wines. About three millions of acres are cultivated, 503,500 acres in 1897 being devoted to wheat crops, 263,822 to rye, oats, barley, maize; 70,437 to pod fruit; 109,880 to vines; and 60,472 to olives. There are extensive pasture grounds, where much live-stock is reared and excellent breeds of bulls for their popular sport. The live-stock in 1897 included 3971 horses, 24,248 mules, 22,059 asses, 14,810 cattle, 346,228 sheep, 39,349 goats, and 21,410 pigs. There is an active trade in the products of agriculture.

Toledo, capital of the above province; population, 20,837 in 1887, and 23,465 in 1897. It is on a branch of the Southern Railway. The aspect of this ancient city has not changed, and it is still the silent old-world place that attracts natives and foreigners who desire to form an idea of a town preserving so many traits of the past in its noble churches and public buildings, its narrow streets and massive houses, its Gothic, Moorish, and old Castilian ruins and monuments intermingled. The Alcazar, so often restored after fires that caused much damage, was again much injured on the 9th January

1887. The Government spent a considerable sum in once more restoring it, and it is now the military academy for infantry. A masterpiece of Covarrubia was fortunately saved from all the successive fires. Toledo has some modern buildings worthy of notice—the institute for higher education and the primary schools, the school for training teachers, courts of justice, hospitals. The arms manufactory, a mile outside the town walls, is conducted by the Government. There are many private manufactories in Toledo that rival the royal works.

Toledo, a city of Ohio, U.S.A., capital of Lucas county, on the Maumee river at its mouth, in the northern part of the state, at an altitude of 587 feet. The city is regularly laid out on a level site, covering an area of 28½ square miles, extending 8 miles along the Maumee, is divided into fifteen wards, has a good water-supply by pumping into stand-pipes, is well sewered and well paved with granite blocks, brick, wood, and asphalt. Among its fine buildings is its public library, containing 35,000 volumes. The city has a large share of the lake commerce, consisting of grain (mainly wheat), clover seed, lumber, iron ore, and coal. It is one of the most important railway centres of the country, being entered by no less than thirteen railway companies. It is also the terminus of the Miami and Erie Canal. Its manufactures are large and rapidly increasing. In 1900 there were 1050 establishments, with a total capital of $25,591,916. They employed 15,383 hands, and the product was valued at $37,372,355. The principal products, with their values, were flouring and grist mill products, $4,458,749; foundry and machine-shop products, $2,715,613; bicycles, $1,583,450; liquors, $1,458,593; tin and sheet-iron working, $1,435,089; petroleum refining, $1,392,745; and lumber, $1,376,149. The assessed valuation in 1900 of real and personal property was $53,445,760, the net debt was $6,526,204, and the rate of taxation $32.60 per $1000. The total income was $2,158,872, and the total expenditure for maintenance and operation $1,484,588. Population (1890), 81,434; (1900), 131,822, showing an increase in the decade of nearly 62 per cent. Of the population in 1900, 27,822 were foreign-born and 1710 negroes.

Tolstoy, Leo (1828- ——), Russian novelist and social reformer, was born on the 9th September (28th August) 1828, in the home of his fathers—Yasnaya Polyana, near Toula—a large country house (not the present one) built in a severely formal style, with Doric pillars and architraves, standing solitary in a typical Russian landscape. The Tolstoy family, to whom it had belonged for several generations, was originally of German extraction, and had settled in Russia in the days of Peter the Great. The first ancestor of distinction was Peter Tolstoy, at one time Russian ambassador to the Sublime Porte, and ennobled in 1724. Subsequently becoming involved in a court intrigue, he forfeited his title and estates, which were not restored to him until the year 1760, in the reign of the Empress Elizabeth. Neither his son nor his grandson were men of mark, but the latter, at the conclusion of the Napoleonic wars, was made governor of Kazan. Unfortunately, his incapacity for administration soon brought the affairs of the province into confusion, and a commission was appointed to inquire into the case, with the result that the count was dismissed from office. The disgrace told upon his health, and he died soon afterwards. His son Nicholas (the father of the great author) was born in 1797. After serving for a short time in the army he retired in 1824, and led the life of a Russian boyar. By his marriage with the Princess Maria Volkonsky, Count Nicholas in a great measure rebuilt the family fortunes, which had fallen into decay during the two previous decades. Count Leo Tolstoy was the youngest but one of the five children of this marriage, and lost his mother when he was barely three years old. Some six years later his father died also, at the early age of forty-one. Tolstoy has described his parents as Rostov and Maria Volkonskaya in *War and Peace*, but his childish recollections of them were necessarily dim and fragmentary. They are said to have been kind and good, cultured and God-fearing persons, his mother possessing the superior mind, together with a remarkable gift of story-telling. It is related of her that her girlish companions would often desert the dancers in the ballroom to sit listening to her fascinating tales. As a child, Tolstoy, though observant and thoughtful, showed no marked talent. In common with his elder brothers, he was fond of play and mischief, impatient of discipline, and disliking the routine of lessons. He was plain and very sensitive on the point, suffering keenly for want of notice and affection. This sensitiveness led him as he grew older to hide himself away from his playmates and spend hours in lonely brooding. He describes in *Childhood* how, one day, it dawned suddenly upon his mind that Death was ever lying in wait, and that to be happy one must enjoy the present, unconcerned with the future. Whereupon the youthful Epicurean flung aside his books and pencils, and, stretched on his bed, fell to munching sweetmeats and reading romances. But Tolstoy's childhood was not without its share of wholesome pleasure. Hunting and shooting, the delight of the Russian noble, occupied much of his father's leisure, and from his earliest years the boy was wont to accompany his parent. At other times he was quite happy sitting beside his father's coachman on an expedition to one of the neighbouring towns, or with his brothers running in and out of the stables and coach-houses. The tedium of the schoolroom, the reproofs of his tutor, made a reverse side to the picture, but did not prevent this fund of early memories from being, as he writes, "ever to be treasured, and fondled again and again, serving as a well-spring from which to draw my choicest treasures." After his father's death at Moscow in 1837, Tolstoy and his brothers were placed under the guardianship of his aunt, the Countess Osten-Sacken, and in the care of Madame Ergolskaya, a distant relative. The former died, however, in 1840, and the charge devolved on another aunt, Madame Jushkov, who lived in Kazan. Madame Jushkov was a typical Russian lady of her class. Keeping open house, fond of gaiety and society, her ideas on moral questions were liberal in the extreme, though not more so than those of most women of her rank and day. Religion was indeed a factor in her life, but acted rather as a stimulant to her emotions than as a guide in her daily conduct. Tolstoy was eleven years old when he became subject to her influence—an influence which he subsequently regarded as having been the reverse of beneficial. A French tutor was engaged for him and his brothers, prior to their entrance into the University of Kazan. Outside the hours of study Tolstoy spent his days either in solitary rambles, during which he reflected on the problems of life, or in violent exercise at the gymnasium (the only form of athletics enjoyed by boys of his position in Russia). Thus the physical and philosophical impulses of his nature were developed in equal measure, and these two conflicting forces began their lifelong duel. Only in later years did the philosopher outweigh the man of action in Tolstoy's vigorous personality.

Childhood.

In 1843, at the age of fifteen, he entered the University of Kazan, and gained with his college cap and uniform what he prized most, his independence. The lax rule of the university—which was of no high scholastic repute, *At college.*

giving ready admittance to the sons of the rich and noble—enabled him at the same time to enter the world of society and study its complex problems at leisure. Kazan was in those days a real paradise for such as sought happiness in social excitement, dining, and dancing. No city in Russia was so given up to the pursuit of pleasure. Among these scenes of luxury and licence the students of the university played a prominent part. Granted an unusual degree of liberty, together with an indifferent system of education, even those who were desirous of serious study made little progress, while the greater number spent their time in parading the town and letting off their exuberant spirits in all sorts of horse-play. Belonging mostly to the families of rich landed proprietors who wintered in Kazan, they held themselves a privileged community, and the inspectors of the college were practically powerless over them. Amid such influences the boy soon ripened into the man. The constant succession of balls, picnics, and parties finally wearied and disgusted him. Over-strung nerves and irritability showed how the poison distilled from excess of pleasure had entered his system. The pages of *Youth* are eloquent of deadly ennui. He is for ever seeking "Her," engaged in an undefined "pursuit of the Well-beloved," with a half spiritual, half physical longing. At intervals in this quest of the unknown he devoured the novelists of his day, chiefly Dumas and Eugène Sue. He already thought deeply on the object and aim of existence; forming new ideals, aspiring to noble deeds, seeing himself in imagination by turns now a passionate lover, now a leader of men. His forceful nature led him constantly to extremes. A story which, even if not true, illustrates the common opinion of Tolstoy, is told of how in his youthful pursuit of novelty he felt a longing to fly. The attempt, however, brought him to the ground with an injured leg. He says of himself that he was always endeavouring to be original, and to tread unbeaten tracks. Partly in consequence of this feeling, he determined to enter the school of Eastern languages. His first attempt was unsuccessful, but finally passing in through the medium of a supplemental examination, he took up Arabic and Turkish. These studies, however, proved uncongenial to his versatile nature, and failing to distinguish himself in them, he turned his attention in 1845 to the school of law. Here he met with equal discouragement. The professors—all Germans, and many of them not knowing enough Russian to make themselves understood— were favourite butts for the students' wit. There was practically no serious teaching, nor any personal interest shown in the pupils. Tolstoy's evil genius had once more cast him in stony places and left him to work out his own salvation. History, religion, and law now claimed his attention in his final effort to gain the university diploma. In religion his opinions had undergone a great change. From the child's unthinking acquiescence in a hereditary faith had sprung absolute unbelief. History he held a useless form of knowledge. "Of what avail," he said, "to know what happened a thousand years ago?" Hence he neglected the lectures on these subjects, absented himself from the examinations, was confined in the university gaol for irregular attendance, and ended by coming out but moderately well in the yearly examination. The conviction that he was wasting his time forced itself upon him. An idle, dissipated life had told upon his health, and early in 1847 Tolstoy asked permission to go down, "on account of ill-health and private reasons." Thus ended his college life, which from an educational point of view he had treated as a jest. Somewhat of an enigma as he was to his companions, with his alternate fits of feverish gaiety and melancholy abstraction, aristocratic hauteur and liberal views, there was yet found a little band of students to accompany him on the first stage of his journey homewards. While probably admiring the original bent of his mind, they little dreamed their late comrade would one day be acclaimed as Russia's greatest thinker and novelist.

The youthful reformer.

Tolstoy went back to his estates with fresh hope and energy, determined to ameliorate the condition of his peasantry and fulfil the duties of a landlord. Rumours had reached him at Kazan from time to time of the recurring famines, revolts, miseries of the serfs. In 1847, as often before, the crops failed to suffice for the needs of the starving people, and whole districts set forth to petition the Tsar for food. Here was a vital problem requiring prompt solution. In the course of desultory reading at the university he had studied the writings of Jean Jacques Rousseau, and the Frenchman's plea for Nature, honest work, and simplicity of life had impressed him greatly. Fired with enthusiasm, he now entered heart and soul on the task of realizing this ideal. Unfortunately, he was as yet without sufficient moral stamina to withstand recurring disappointments and to combat the suspicions of the serfs. The youthful reformer lacked the patience necessary to deal with the deep-rooted mistrust engendered by years of oppression and neglect. After six months of struggle with this discouraging state of things he temporarily gave up the attempt, and we find him in St Petersburg taking up for a time the broken threads of his education. But with the restlessness of transition strong upon him he soon returned to country life, and in company with his brother Sergius gave himself up to hunting, gambling, carousing with Zigani dancers, and throwing all serious thoughts to the winds. *The Landlord's Morning* may be taken as a picture of this stage of Tolstoy's life. The inevitable reaction soon came. Oppressed by debts and difficulties, in the spring of 1851 he betook himself to Caucasus, where his eldest brother Nicholas was stationed with his regiment. At Pyatigorsk, a small town at the foot of the mountains, he rented a cottage for about twelve shillings a month, and lived there with the utmost frugality.

Enters the army.

Finally his brother's persuasions, aided by the influence of relations in high places, led him to enter the army. He passed the necessary examination at Tiflis, and joined the artillery in the autumn of the year. At that time Russia was much disturbed by the lawlessness of the Caucasian races. Bands of Circassians were constantly on the move, plundering and looting. The punitive expeditions in which Tolstoy took part were his first taste of warfare. Neither his military duties nor his love of sport entirely absorbed him, however. The great power which had hitherto lain dormant now awoke. He began to write, and within the next few years produced some of his finest works. Nekrassoff, the editor of the Russian *Contemporary*, accepted *Childhood*, the young author's maiden effort. In accordance with the common practice, he received nothing for the MSS. Publication of a first attempt was considered ample payment in those days. Tolstoy was now twenty-four years of age. *Childhood* was followed by *The Landlord's Morning*, *Boyhood*, and *Youth*, in quick succession. His early aspirations were revived in these pages, which reflect the doctrines of Rousseau. "You neither know what happiness is nor what life is," he writes to expostulating friends. "Once taste life in all its natural beauty, happiness will consist in being with Nature, seeing her, communing with her." His philosophy notwithstanding, Tolstoy felt a pardonable desire for promotion, which was slow in coming to him. Some verses ascribed to him (an authorship never denied) making fun of the general during the siege of Sebastopol, which appeared in print, may possibly have had something to answer for. Be that as it may, the spirit of unrest and dissatisfaction was moving Tolstoy to return home, when rumours of hostilities arose, and the Crimean war burst into flame. He promptly volunteered for active service, and asked to be allowed to join the army on the Danube, under the command of Prince Gortschakoff.

The Crimea.

In the early part of 1854 we find him encamped before the walls of Silistria, a town of Bulgaria, which Gortschakoff had invested. At the very height of the bombardment, however, Austrian intervention prevailed, and the siege was raised. The din of battle was hushed, and revelry took its place. At the ball which promptly celebrated the event Tolstoy felt ill at ease. The joyous music and babel of tongues jarred on his sensitive ear, fresh from the moans of the wounded and dying. He went up to the prince and asked leave to start for Sebastopol. Permission being granted, he hastened from the ballroom, and left Silistria without delay. He now exchanged the offensive for the defensive. Shot and shell fell like hailstones on the bastions of Sebastopol. Courage, fortitude, presence of mind were at every moment demanded, while assault followed assault, until at last the overwhelming strength of the Allies compelled the Russians to retreat. Throughout that trying time Tolstoy cheered his companions, whiling away many a weary hour with jest and story. Amid this "wrackful siege of battering days" he wrote those *Tales from Sebastopol* which earned him instant literary celebrity, and caused the Emperor Nicholas to issue special orders that he should be removed from a post of danger. An official despatch recounting the events of the siege was next written by Tolstoy at the command of his superior officer, and with the charge of this document he was shortly afterwards sent to St Petersburg. He was never again on the field of battle.

At St Petersburg.

Tolstoy returned home filled with new impressions. Sad at heart and sick of the horrors of war, he came back with a feeling of brotherly love for the common soldiers, whom he had seen day by day doing quiet deeds of courage and devotion, fighting for their country without hope of reward, without fear of death. He contrasted them with the more self-seeking nobles, and felt their superiority. The stirring scenes through which he had passed, the simple faith of his men, all had helped to renew his belief in God. Preceded by the fame of his descriptions of Sebastopol and the Caucasus, he arrived in St Petersburg to find himself the object of a general ovation. The *Sovremennik* (*Contemporary*), in which Tolstoy's first work, *Childhood*, had appeared, numbered among its contributors the foremost writers of the day. To be admitted to their ranks was considered by them an honour equivalent to the award of a *fauteuil* in the French Academy. They welcomed Tolstoy with open arms, the veteran novelist Tourguenieff in particular hastening to greet him on his arrival, and begging him to make his house his home. Society was equally eager to open its doors to the young soldier-author. His vivid and dramatic pictures of the war had been widely read, and had created a profound sensation. The great official world of St Petersburg proceeded to offer him a brilliant series of entertainments in which he found himself the central figure. It is not surprising that this combined adulation from literary men and society overcame for a time the growing asceticism of his character. Yet it also in a measure hastened its development. Even while borne swiftly on the current of pleasure, his strenuous nature gradually reasserted itself. In the pages of *My Confession* Tolstoy describes the phases of this mental unrest. The narrowness of a literary clique soon became irksome to his dominant character. His passionate desire for truth brought him into frequent conflict with those who paid more regard to convention. With Tourguenieff especially he found himself constantly at variance. A friendship between natures so diametrically opposite, between two men who might be described as leaders respectively of the old and the new school of thought, could not long subsist. Mutual admiration does not imply sympathy. Tourguenieff presently wrote to a friend, "I regret I cannot draw nearer to Tolstoy, our views are so opposed, the one to the other." And these differences of opinion gradually led to a complete estrangement. On the other hand, in Fet, the poet, he found a lifelong friend. Others of his intimates were Nekrassoff, the editor of the *Contemporary*, already mentioned; Katkoff, the celebrated journalist; Droushinine, Grigorovitch, Fet, and Ostrovski, the dramatist.

Russian popular movement.

While Tolstoy was thus waking to a sense of distaste for his environment, a great event was pending. With the accession of Alexander II. in 1855 a wave of progressive policy—set in motion by the Tsar himself—stirred the bureaucratic circles of Russia, and while fiercely resisted by some of the nobility, met generally with cordial encouragement. The emancipation of the serfs became the burning question. "The People!" and "Progress!" were the cries quickly caught up by the press of Russia and of Germany also. It was in Germany, indeed, that the novel of humble life sprang into being, Gotthelf leading the way with his tales *Uli the Serf* and *Uli the Tenant.* Auerbach followed with his village stories, which opened up a new world of thought; Stifter and a host of others brought up the rear. This new impulse in literature soon spread to Russia. Tourguenieff in his *Sportsman's Tales,* Grigorovitch in *The Village* and *Anton Goremika,* showed their sympathy with the moujik. But above all others, Tolstoy was most deeply and lastingly affected. Awakened by this echo from without of his own inmost yearnings, he realized at last the true bent of his mind. "The People" became his watchword. One increasing purpose henceforth ruled his life, and gradually brought into harmony the inequalities and contradictions of his character. Roused from the inertia which had been caused by nerves and hypochondria, he wrote *Polikoushka,* a painful story dealing with the ills of serfdom. His active brain then turned to considering the meaning and scope of the catchword "Progress," and fully to do this he determined to go abroad and study the educational and municipal systems of other countries. After some delay he finally started for Germany in January 1857.

Foreign travel.

Tolstoy has only three times crossed the Russian frontier, and these journeys were all undertaken between the years 1857 and 1861. Since then he has been rooted to the soil. On this first trip, Germany and Italy were hurriedly visited. He also made a short stay in Paris, which had attractions for him in the society of several Russian friends, among whom were Nekrassoff and Tourguenieff. With the latter he had not yet come to open rupture. From Paris he went to Lucerne. An incident which occurred there and is reproduced in his semi-autobiographical *Lucerne*, shows the workings of his spirit. He tells how a wandering musician stood one day in the hotel courtyard, and after his performance asked in vain for alms from the convivial crowd assembled. Tolstoy, in the person of the hero, then indignantly came to the rescue, brought the poor minstrel into the hotel, and, moved to wrath with the churlish waiters who were unwilling to serve him, ordered a private room where he himself supplied his guest's wants, and sent him away happy with a double lining to his pockets. Of his successive journeys westwards, the third alone was of long duration and of corresponding importance in its results. Prior to this last visit to foreign parts, his time was spent between Yasnaya Polyana and Moscow, often in the company of his friend Fet. On a bear-hunt together, Tolstoy narrowly escaped death, an incident which he graphically describes in his *Fourth Reading-book for Children* (20th ed., 1900, &c.). Fet also mentions it in his *Reminiscences.* His departure was finally hastened by the serious illness of his brother Nicholas, who had gone to France to recruit his failing health. Tolstoy, after halting in Berlin and Dresden, joined him, but only to endure the grief of witnessing his end. Nicholas died on the 20th of September 1860, and Tolstoy's letters of that period show how deeply he was affected by the death of his brother. It gave a yet more serious turn to his thoughts. In a letter to Fet he reverts to his old trouble, the enigma of life. "In truth," he writes, "the position in which we stand is terrible." This mental gloom probably still hung over him during his wanderings through Italy. There is no record of his impressions of Rome, Naples, Florence. Turning his footsteps northwards, however, he began to take renewed interest in social conditions, elementary and monastic education, and the general subject of his quest. From Paris (where his friend spoke of him as "singular indeed, but subdued and kindly") he went to London in 1861, no noteworthy incident marking his brief visit.

Educational experiments.

The spring of 1861 found him once more at Yasnaya Polyana, where some little time before he had forestalled the Emancipation Act by freeing all the serfs on that estate. He now began digesting the mass of information he had acquired abroad, eager to put his ideas into practice. The feelings with which he reviewed his experiences were largely those of disappointment. Of the educational systems of Italy, France, and Germany, that of the last-named country alone earned his partial approval. While there he visited the universities, prisons, and working men's clubs. He made the acquaintance of Auerbach, and was greatly influenced by his ideas on village schools. He was also much impressed by the novel institution of the kindergarten, to which Fröbel, the great educationist, was devoting all his energies. Determined to follow these lines, he sought and obtained permission to open a school. In his zeal he also started an educational journal called *Yasnaya Polyana.* This journal now only exists as a literary curiosity, but the essays published in it have all been reprinted in his collected works. The time for opening the school was well chosen. The liberal spirits of Russia had gained the day and won a great victory. Just two months previously the decree of emancipation (February 1861) had been sent forth. The air was rife with schemes for the betterment of the peasantry. A new era seemed to have begun. Tolstoy's school was essentially "free." "Everything that savours of compulsion is harmful," he said, "and proves either that the method is indifferent or the teaching bad." So that not only were no fees paid, but the children came and went as they pleased, learned what they pleased, and were subjected to no sort of punishment. It was the duty of the teacher to fix the pupils' attention, and his the blame if they failed to learn. "The student," said Tolstoy, "must have the right to refuse those forms of education which do not satisfy his instincts. Freedom is the only criterion. We of the older generation do not and cannot know what is necessary for the younger." On these principles the Yasnaya Polyana school was started in a house near that of Tolstoy. He himself taught drawing, singing, and Bible history. The Old Testament was his handbook; he held it as indispensable in any course of instruction, a model for all books. Doubts and fears sometimes assailed him, still for a year all went well. Other schools were opened on the same lines in the district, and success seemed assured. But the eyes of the Government inspectors had long been suspiciously fixed on them, and a correspondence on the subject presently ensued between the Ministry of Education and the Home Department. The verdict passed by the former was free from overt animus. "The activity of Count Tolstoy deserves respect, and should win co-operation from the Educational Department, although it cannot agree with all his ideas; ideas which he will in all probability abandon on due consideration" (October 1862). Yet there was a subtle threat conveyed in these last words which was probably not without effect. Signs of discouragement grew visible. We find the enthusiast complaining that his masters desert him, his pupils fall away. The plague of inquisitive visitors annoys him. This venture shared the fate of early blossoms, and fell victim to a frost—the frost of opposition, active and passive. At the end of the second year the schools were closed, the journal discontinued, and Tolstoy, disheartened and sick, "more," as he writes, "in mind than body," betook himself to the healthful quiet of the steppes, to breathe fresh air, to drink *koumiss*, and to vegetate. This was the end of his educational experiment, the aim of which was rather to develop the character than to educate in the ordinary sense of the term. When later he asked leave from the authorities to reopen the schools, it was peremptorily refused.

His socialistic theories were now fully unfolded. In his view the people were everything, the higher classes nothing. The latter had misinterpreted the meaning of "progress," imagining it to be synonymous with education; and hence compulsory teaching had been resorted to, with harmful results. Reading and writing played but a small part in forming a man's mind and fitting him for life. They merely rendered him more articulate. These questions should be left to the people themselves. Their demands were very clearly expressed. They knew what they wanted, and were thoroughly convinced that "in the great question of their spiritual development they would neither take a wrong step nor accept that which was false." Such was in substance Tolstoy's doctrine. "The people," he affirms, "are stronger, more independent, more just, more human, and above all more necessary than the upper class. It is not they who should come to our schools; we should learn of them." This desire to subvert society is akin to the philosophy of Rousseau, as expressed in *Émile* (livre iv.):—

> "C'est le peuple qui compose le genre humain ; ce qui n'est pas peuple est si peu de chose, que ce n'est pas la peine de le compter. L'homme est le même dans tous les états ; si cela est, les états les plus nombreux méritent le plus de respect. Devant celui qui pense, toutes les distinctions civiles disparaissent : il voit les mêmes passions, les mêmes sentiments dans le goujat et dans l'homme illustre ; il n'y discerne que leur langage, qu'un coloris plus ou moins apprêté. . . . Étudiez les gens de cet ordre, vous verrez que, sous un autre langage, ils ont autant d'esprit et plus de bon sens que vous. Respectez donc votre espèce ; songez qu'elle est composée essentiellement de la collection des peuples ; que quand tous les rois et tous les philosophes en seraient ôtés, il n'y paraîtrait guère, et que les choses n'en iraient pas plus mal."

While Tolstoy's theories were thus in course of practical solution, his literary powers suffered eclipse. Tourguenieff, who lived near him in the country, writes in disgust that he "has grown a long beard, leaves his hair to fall in curls over his ears, holds newspapers in detestation, and

Relations with the peasantry.

has no soul for anything but his property." Indeed, his time was fully taken up, for while still occupied in supporting the school, he had allowed himself to be nominated to the position of "Arbitrator," which he held for a year and some months (1861–62). This was an arduous post. The arbitrators were appointed under the Law of Emancipation to supervise the distribution of land, to adjust the taxes, define the conditions of purchase, and decide all matters in this connexion. These duties were after his own heart, and he went to work with a will. Every day he had difficult points to deal with, deputations of peasants coming to see him, the new law and the rights it bestowed on them having to be explained. The hardest of all Tolstoy's tasks was to remove the suspicion and mistrust felt by the serf towards the landlord. On the other hand, he had to contend with the nobility of the district, who were well aware of the side on which his sympathies placed him. For a year and a half he tried energetically to do his duty, but this experience led him eventually to regard the Emancipation Law as a not unmixed blessing. It had come too soon, and been granted unasked. The condition of the peasantry was worse than before. A noble impulse, inspired by love of the people, impelled Tolstoy to become their champion and interpreter. "Generations have sinned against them," he writes, "and no one deserves to live who is not ready to bear his part in undoing the wrong." This spirit of generous enthusiasm made itself felt throughout the country. The peasants respected him, and learned to look upon him as their friend.

A tragic incident occurring about this period (1866) forcibly illustrates Tolstoy's character as a defender of the helpless. A regiment had recently been stationed near Yasnaya Polyana, in consequence of some five hundred convicts being at work upon the railway. In this regiment was a certain Captain N., a strict disciplinarian, who led a solitary life and was much disliked by his brother officers and his men. For trifling faults he would condemn his soldiers to unheard-of punishments. One of his orderlies in particular, a young man of some education—who had voluntarily taken the place of a comrade to free him from military service—was constantly getting into trouble, until, for some slight clerical error in a report, Captain N. ordered him to be degraded and flogged. This was too much for the poor volunteer. He followed the officer as he was leaving the orderly-room, and struck him a blow on the face. He was immediately placed under arrest, and the details of the occurrence quickly spread through the neighbouring villages. Two officers of the regiment brought the story to Tolstoy, and begged him to undertake the soldier's defence. He consented readily, and no opposition being made by the military authorities, at once prepared for the court-martial. A few days afterwards the court assembled. Warned by the president of the severity of military law, Tolstoy made answer that he was come to defend not a criminal but a man compelled to crime by force of circumstances outside his will. The plea he set up was that the prisoner was not in full possession of his senses; but this defence was not allowed to stand. The soldier was condemned to be shot, in spite of the utmost intercession Tolstoy could make. The emotion of the crowded assembly stirred by his appeal, the mute quiescence of the soldier (persuaded that death was better than the living agony of exile), the closing tragedy—all this, added to the many scenes of war and bloodshed which he had previously witnessed, made a lasting impression, and caused him to raise his voice yet louder in the cause of universal love and peace. During the preceding period of ethical experiment he published only two books, but these stand high among his works. They were *Three Deaths* (1859) and *The Cossacks* (1863)—the latter written ten years before, its leading idea being that culture is the enemy of happiness. At the conclusion of his arbitratorship, seeing his efforts partially nullified, and feeling himself overstrained and overworked, he determined to exile himself for a time to Samara, a south-eastern province. He halted on his way in Moscow, and here one night's high play cost him the MSS. of *The Cossacks*, which he sold to the editor of the *Russian Messenger* for £100 to pay his debts of honour. A pleasanter feature of this visit to Moscow lay in the renewal of his intimacy with the Behrs family, Sophia, the younger daughter of the house, being his special attraction. He finally reached Samara in the spring of 1862, and went through a "*koumiss* cure," revelling in what he called "the life of a beast of the field."

Marriage.

By the month of July he felt completely restored to health, and returned to Yasnaya Polyana where his sister Maria and his aunt, Madame Ergolskaya, were looking after the property. The house in which he now lived was comparatively new. The one in which he was born was sold to pay some earlier gambling debts, and had been removed bodily to an estate (Dolgoe estate) some 30 miles distant. He now felt a sense of something wanting in his home—a feeling of incompleteness took possession of him. He wanted to see Sophia Behrs, and accordingly left almost immediately for Moscow. Sophia's father was a fashionable Russian doctor, born and bred in Moscow, and a graduate of that university. He had three daughters, of whom Sophia was the second. The friendship between the Behrs and the Tolstoy families was of old standing, Countess Maria Tolstoy having been a school companion of Mrs Behrs. It was now the height of summer, and every one of consequence was leaving the city for their country seats. The Behrs family were going on a visit to their grandfather, whose estate lay not more than 40 miles from Yasnaya Polyana. Here they accordingly broke their journey, and during the pleasant days that followed Tolstoy's attachment deepened. Not long after their departure his impulse took shape, and mounting his horse, he set out for Twicy, where they were staying. His errand was a definite one; and he lost no time in fulfilling it. At first Dr Behrs demurred, unwilling to allow his second daughter to marry before her elder sister, but his objections were presently overruled. On the 23rd of September 1862 the marriage took place, and Tolstoy installed his bride at Yasnaya Polyana with the conviction that calm and contentment were his at last. Two weeks later he wrote to his friend Fet, saying that he was now happy and felt quite a new man. In his *Confession* some years later he writes: "The new conditions of a happy family circle led me away from my researches into the meaning of life. My whole mind became concentrated on the family—on the mother, the children, and the anxiety to provide due means of subsistence. The effort after perfection resolved itself into the effort to ensure the happiness of my offspring." Tolstoy thereupon settled down to country life, and though to the young countess this exile from her town friends and relations must have been somewhat of a trial, they remained on their estates for the following eighteen years, with very short intervals of absence. They had thirteen children, of whom the eldest was born in June 1863. In the bringing up and instruction of his family, Tolstoy conformed in essentials to the requirements of his position. No experiments were attempted. English and German governesses were engaged, and their educational methods followed the usual routine. Both father and mother devoted a considerable amount of time to their children. Punishment was rare. It consisted in a strict "boycott" of the offender, which was not relaxed until a frank confession of fault was made—no light penalty to a sensitive child. The theory of free option in study was dropped by Tolstoy in the case of his children, but he was for ever joining in their games, taking them on his shooting expeditions, and sharing in their gymnastic exercises. Manual labour was always congenial to the great writer, and formed a natural concomitant to his pastoral existence. It was a common thing for him to mow the lawns, hoe and rake the garden beds, or when out walking to take the scythe from a labourer and wield it lustily. His overpowering vitality needed more than the ordinary man's quantum of exercise, and moreover, he upheld manual work as elevating in itself—an article of faith arising from his love of the people, and adhered to unanimously by his followers. He was devotedly attached to sport, and we find him constantly hunting and shooting. He was once (at the bear hunt before alluded to) in imminent danger of his life, and again on a more recent occasion, when out shooting hares, he severely dislocated his arm.

Literary work.

War and Peace and *Anna Karenina*, Tolstoy's two most widely known and finest novels, date their commencement from this period. These two novels were received with scant favour by both the Liberals and Conservatives in Russia. Katkoff, the editor who was publishing *Anna Karenina* in his periodical, introduced so many changes into the MSS. that the publication was not continued. It was due to N. Strachoff, the literary critic, that public opinion was brought to recognize the merits of these novels. Every day Tolstoy retired to his room for a certain number of hours, and whether in the humour or not, sat at his table and wrote. "Inspiration comes with writing," he used to say. Authorship he avowedly despised, yet confessed the temptation of public applause and heavy gains was too great to resist. The reading world has reason to be glad of this touch of inconsistency. The countess was at all times a helpmeet to her husband. At midday, when he stopped work, she took over his MSS. to copy neatly and place ready for him to read over on the following morning. In the evening he would confide the plots of his stories to her, and discuss the books he had been reading in preparation for them. Despite his genius for characterization, the task of novel-writing cost him a severe and determined effort. The technique of literary composition irked him exceedingly. "You cannot conceive," he writes in 1864 to his friend Fet, "how hard is this preliminary labour of ploughing the field in which I am compelled to sow. To consider and reconsider all that may happen to all the characters beforehand, and to think over the million of possible combinations, and to choose one out of a hundred thousand, is very difficult." In another letter he bemoans the shortness of life. "*Ars longa, vita brevis.* If one only had time to do a hundredth part of what one wishes, but alas! a bare ten-thousandth part is accomplished. Nevertheless, in the feeling that I am able to do it lies the happiness of your friend."

In the course of this correspondence interesting side-lights are thrown on Tolstoy as landowner and farmer. Not long after his marriage he wrote, "I have made an important discovery, of which I hasten to tell you. Agents, stewards, and overseers are only so many hindrances to farming! Dismiss them all and lie abed till 10 o'clock, and you will see things will certainly go none the worse. I have made the experiment, and am quite satisfied. Now to business. When you are in Orel buy me 20 poods of various kinds of string, &c., and send them to me if it does not cost more than two roubles thirty kopecks a pood with the carriage"; and in this vein he enters into manifold rural matters, the progress of crops, the illness of a favourite horse, or the calving of a valuable cow. Again the philosopher rises to the surface, and he questions Fet as to the workings of his mind.

> "I don't mean in the Zemstvo nor in agriculture; these are occupations for active men, with which we employ ourselves in a perfunctory fashion, much like ants engaged in hollowing out a clod of earth—work of which the result is neither good nor bad. But what are you doing with your thoughts; how is the inner mechanism working? Is the secret spring trying to show itself, making its presence felt? Has it forgotten how to work? that is the all-important question."

At another time he pays a well-earned tribute to his wife's helpful sympathy. "She is by no means a trifler," he writes, "but is an earnest helpmeet to me." In literary matters he valued above everything the opinions of Fet and of Tourguenieff (notwithstanding his saying of the latter, "the older I grow the less I love him"). Fet, on the other hand, was an intimate and devoted friend, constantly interchanging visits with the Tolstoy family. To him the scenes of *War and Peace* were first unfolded as Tolstoy read them aloud in the quiet evenings, when the children were hushed in sleep.

Quarrel with Tourguenieff.

It was at Fet's house (in 1864) that the violent quarrel took place between Tourguenieff and Tolstoy which nearly culminated in a duel. Many inaccurate accounts of it have been given, but the history of the rupture, as recorded by Fet, may be looked on as trustworthy. It seems that Tourguenieff in rather a boasting spirit was praising his daughter's English governess—how she had desired him to name the precise sum his daughter might spend in charity, and how, at her instigation, the young lady made a practice of mending the clothes of some of the poorest peasants. Tolstoy said brusquely that he thought it was artificial and theatrical, *poseuse*, for a daintily-dressed girl to sit sewing at filthy, evil-smelling garments in the name of charity. Tourguenieff thereupon rose, furious, from the table. "Stop saying such things!" he cried, "or I will force you to silence, with insults if need be." Peace was with difficulty restored by M. and Madame Fet, and this factious pair were despatched on their homeward way by separate conveyances. The letters which subsequently passed between them only served to fan the flame, so that even the amiable Fet was involved in the dispute and for a short time estranged from Tolstoy. Finally, after a lengthy and acrimonious correspondence, the threatened resort to arms was averted through the interposition of friends; but fourteen years were allowed to pass before a reconciliation took place. In 1878 Tolstoy, believing himself to be in a dying state, at length made overtures of peace to his brother author; overtures which Tourguenieff met cordially in the following terms:—

> "DEAR LEO NIKOLAEVITCH,—I received your letter to-day which you sent to me *poste restante*. I was delighted and much moved by it. With the greatest pleasure I am ready to renew our former friendship and to press your proffered hand. You are quite right in thinking I harbour no feelings of emnity towards you. If they ever did exist, they have long since disappeared, and no remembrance of you now remains save that of a man to whom I am sincerely devoted, and of a writer whose first step it was my great privilege to be one of the earliest to welcome; whose every new work has always aroused in me the greatest interest. I rejoice from my heart that our misunderstanding has come to an end. I hope to be in the province of Orel this summer, and then we shall meet. Till then I send you my best wishes, and once more grasp your hand in friendship."

Meanwhile Tolstoy had pursued literary labours with relentless ardour and with ever-increasing fame. Prince André (the hero of *War and Peace*) and *Anna Karenina* in turn occupied all his thoughts. Several years were given to the perfecting of these remarkable character-paintings. When the publication (1864–69) of *War and Peace* had been succeeded by that of *Anna Karenina*, he set himself to write yet another great novel, dealing with the times of Peter the Great, but after working at it for some months he suddenly abandoned the scheme. The public and private acts of the famous Tsar roused such indignation in Tolstoy's soul that he could not go on with the subject. One of the few excursions made during these years of tranquillity was undertaken in 1866 to the battlefield of Borodino, the scene of the famous fight in 1812. For two days Tolstoy wandered over the plain, investigating and taking notes, and there he drew a plan of the battle, which was afterwards published as a frontispiece to *War and Peace*. At this time, in the height of his powers and success, he confessed—with the unfaltering frankness that marks his utterances—that his creations were dearer to him than any living thing. But the continued pressure of severe nervous and mental strain was bound to affect a man of his calibre; health and spirits gradually sank, so that in 1870 Countess Tolstoy induced him once more to seek the healthful air of Samara, and subject himself to the "*koumiss* cure" in practice there.

At Samara.

A strange feature of this "treatment" lay in the avoidance of meal and vegetables, the diet being strictly confined to meat. Tolstoy pitched his tent in the village of Karalieck, where the primitive life among the Bashkir nomads exactly suited his habits and disposition. He had a faculty for making himself at home with peasant folk, and was a great favourite among them. In this district there was a large community of Molochans, a sect whose tenets differ considerably from those of the Orthodox religion of Russia. They acknowledge no guide save the Bible, and reject all the rites and ceremonies of the Greek Church. Their honesty, industry, and temperance made them an example to all the country round, and caused Tolstoy to study them with special interest. So delighted was the count with this visit to Samara, that he shortly afterwards purchased an estate of over 2000 acres in the district. But his pleasure was short-lived, for not long afterwards (1872–73) the crops failed and a serious famine broke out. He thereupon opened a subscription fund for the starving population, and went from village to village taking a quantity of grain with him, and making what provision was possible in the circumstances. He also endeavoured to arouse public sympathy by drawing a dark picture of the condition of things in an article which appeared in the leading newspaper of Moscow. In all that personal devotion could effect he left no stone unturned. His own immunity from the sufferings of the poor filled him with generous remorse. "Here we are," he writes, "seated at table. Crimson radishes, yellow butter, fresh loaves make a pleasant show on the clean cloth. The garden is green and shady, and our young maidens in their muslin frocks are rejoicing in the heat of summer. But outside the evil devil Famine is busy covering the fields with blight."

Tolstoy was now making up for lost time, learning what he had failed to learn at the university. Greek was his great attraction. "Without Greek," he exclaims, "there is no culture." He also became enamoured of the writings of Schopenhauer, and for the greater part of a year (1869) devoted himself to the study of that philosopher. "Never," he says, "have I experienced such spiritual joys." Enthusiastic in everything he takes up, he assures his friends that Schopenhauer is the greatest genius he has met with. He sets himself to translate his works, and tries to enrol Fet as a co-translator. Philosophy at this stage of his life went hand in hand with sport and agricultural interests. He contemplated buying an estate in the province of Penza, but on 21st October 1869 he writes:—

Studies in philosophy.

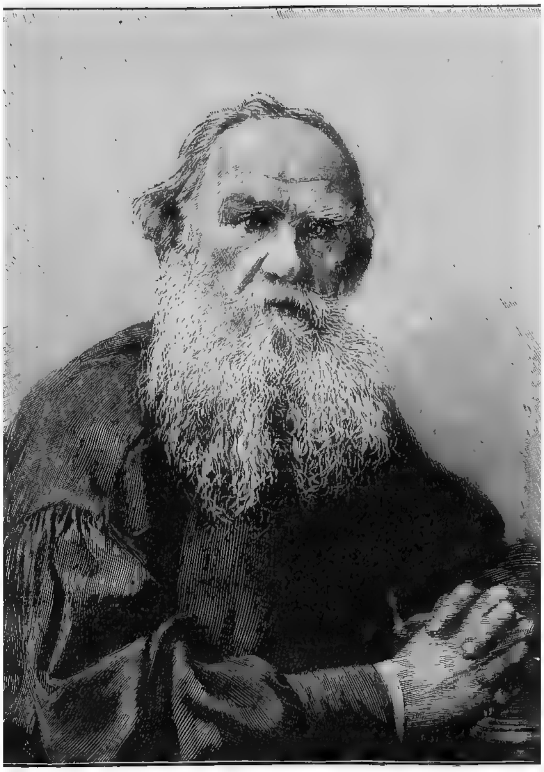
> "The purchase of the estate in Penza has not come to anything. I have now finished the sixth volume [*War and Peace*], and I hope it will be published on the 1st of November. There are a lot of snipe. I have shot four brace, and to-day found two brace and killed one bird."

After a period of comparative rest and ease, the shadows of war and death once more encompassed Tolstoy. Two of his children died in 1873, and their loss was followed by that of his much-loved aunt, Madame Ergolskaya. "In the death of a near and dear being," he writes, "there is always something novel and unique, something sudden and unlooked-for, however long expected"; and although he is able thus calmly to philosophize, and to say further that death comes easiest to the youngest-born, and they can best be spared, still these bereavements left an enduring sadness. A mental restlessness and uneasiness came over Tolstoy, and also a desire for the exercise of a wider philanthropy. The Russo-Turkish war put the crowning touch to these feelings. God and death, war and the intricacies of life were now the constant subjects of his letters. "You will not believe what joy your last letter has given me," he writes in 1877 to his dear friend Fet. "When you speak of the existence of the Deity, I agree with everything you say, and I would wish to write much, but time fails me and it is difficult in a letter. For the first time you write to me on the Divinity of God. I have been thinking about it for a long time. Don't say that we must not think about it. Not only we must, but we ought. In all ages the best people, the true people, have thought about it." Tolstoy now resumed the study of the Bible, and took special delight in the books of Ecclesiastes and Proverbs. He treats them as a new discovery, and recommends them to his friends as having much in common with the teaching of Schopenhauer! This revived interest in religious questions was accompanied and perhaps deepened by a state of extreme depression. He was not actually ill, but imagined himself to be a dying man. It was then he reconciled himself with Tourguenieff, and in December 1878 we find the latter staying with him on a visit of three days' duration. Tourguenieff writes that he finds him "very silent, but much developed." The count on his side feels the same want of mutual sympathy as of old, and confesses that no real friendship seems possible between them.

Tolstoy now entered on the third phase of his life. He himself thus describes the stages of his mental growth. In the first phase he lived only for his own lusts and pleasures. This came to an end at the age of thirty-four. Then came the interest in the welfare of humanity, which married life cooled and obscured for a while. The striving for the welfare of mankind was mingled with the striving for personal well-being. But the third and highest phase was reached when the service of God became the motive power of his existence. All other aims grew subservient to this, and interest in the merely personal life had begun to disappear. He had passed through every imaginable grade of religious thought. As a child he had gone to church and confession unquestioningly. As a student and young man he had scorned and ridiculed religion. Later in life he became a pious and devoutly Orthodox Greek Churchman, until one day during the Russo-Turkish war he was filled with a spirit of revolt at hearing the priests pray for the destruction of the enemy,

Religious development.

beseeching the Almighty to help them to kill their hundreds and thousands. His whole being recoiled from the un-Christianity of these prayers, and he then and there renounced the Orthodox faith. For three years he had exceeded the priests themselves in the regularity of his attendance. Now he felt there was something vitally amiss, and he flung it all to the winds. Though the final step was sudden, the change in his mind had been gradual, and may be traced throughout his works. The novelist was rapidly being hidden in the philosopher's cloak, to the dismay of literary Europe. So early as 1859 Tourguenieff had exclaimed, "If only Tolstoy would not philosophize, all might yet be well." As we see during the next fifteen years Tolstoy's increasing love of mysticism (taking mysticism to mean the emotional contemplation of the relations of man to the universe), we are constantly reminded of this characteristic. His brilliant contemporaries, Gogol, Dostoievski, and others, had all in different ways been seized in turn by what may be called the fever of religion. Tolstoy was to suffer from it too. Like the flickering of a dying lamp, his imagination again shone out in *The Death of Ivan Ilyitch* and *The Power of Darkness.* Since then, with rare exceptions, his writings have been marred by his ethical reasonings. He was now fifty. While leading a life outwardly calm and peaceful, he had passed through innumerable mental struggles and vicissitudes. Of these he speaks with simple candour in *My Confession*, an autobiographical sketch which appeared in print at intervals between the years 1879 and 1882. Many theories had appealed to him in turn. At one time it was his leading idea that "the object of life should be the happiness of one's family and oneself." This had failed to satisfy him. "I lived by this rule up to a few years ago," he writes. "Then a strange state of despair, a longing came over me. I had moments of doubt and despondency. Life as it were had come to a standstill; I neither knew how to live nor what to do. I wandered about aimlessly, a prey to low spirits. For a time this mood passed away, and I took up the daily duties of life. Then again these misgivings became more frequent and more acute. The same questions were always thrusting themselves on my mind—why and wherefore? and whither?" In the orthodoxy of the Greek Church, with fastings, prayers, and rigid observances of her rites, he vainly sought an answer to his doubts; finally he broke away from a ceremonial which had become empty and lifeless to him, and built up a religion of his own. His mind, so unhinged as to have been almost on the verge of suicide, was calmed by contemplating the dumb patience of the people, "who meekly accept illness and sorrow in the steadfast conviction that all is for the best." Weary of the routine of material prosperity, of the writing of books, of the cultivation of his estates still more drawn to the study of abstract questions, he exclaims, "How often have I not envied the unlettered peasant his lack of learning!" Impressed with the conviction that the peasant's mental ease was the result of his life of physical toil, Tolstoy tried to adopt the same habits, and for some ten years (dating from about 1880) he renounced the life of his own class as completely as it was possible for him to do. He rose early and went to work in the fields, ploughing, cutting the corn, working for the widow and orphan, and helping them to gather in the crops. He was often to be seen aiding a labourer, carrying his bundle, wheeling his barrow. He also learnt boot and shoe making, and enjoyed being praised for his skill. Thus he laboured late and early, and in these simple physical acts found the best cure for his attacks of despondency. "Simplicity! Simplicity! Simplicity!" Tolstoy seems to repeat the thought of Thoreau in the joy of his new-found peace—


Count Tolstoy.

> "I say, let your affairs be as two or three, and not a hundred or a thousand. Instead of a million count half-a-dozen, and keep your accounts on your thumb nail. In the midst of this chopping sea of civilized life, such are the clouds and storms and quicksands and thousand and one items to be allowed for, that a man has to live, if he would not founder and go to the bottom and not make his port at all, by dead reckoning, and he must be a great calculator, indeed, who succeeds. Simplify, simplify. Instead of three meals a day, if it be necessary eat but one; instead of a hundred dishes, five; and reduce other things in proportion."

On this principle his food and drink, his pleasures and personal indulgences, were curtailed. Meat was given up and replaced by a vegetarian diet. Field sports—equivalents for cruelty and lust of blood—were abandoned, and his gun hidden away to rot and rust. Even tobacco was renounced as luxurious and unhealthy.

But with all his straining towards simplicity, it was in the nature of things impossible for Tolstoy absolutely to lead the life of a peasant. Labour though he might throughout the day, there was his well-appointed house to return to. He could not cut himself off from his wife and children. Friends and acquaintances could not be wholly ignored by the would-be Diogenes. Circumstances in this respect were too strong for his views and wishes. The renunciation was still only a partial one. But as the strain of a great surrender is greatest while it is still incomplete, so Tolstoy felt more and more impelled to emancipate himself from worldly concerns. The break in the long spell of country life which presently occurred only served to deepen this desire. In 1881 his eldest son went to the university, and the two next in seniority soon followed him. It became necessary for the family to be in Moscow a great deal, for the sake of the children's education. The eldest daughter had come out into society, and friends were continually calling, obliging

Renunciation of property.

Tolstoy to sit and talk with them. All the elements of town life were distasteful to him. The artificiality of it; the competition of the merchants and the employers of labour; the curse of inequality—one and all weighed heavily on him. Money was an evil thing in his sight, and he gave up carrying it about with him, or even making use of it. "What makes a man good is having but few wants," he said, and he accordingly set himself to limit his wishes rigidly, and to detach his heart from all treasured objects. The year 1880 was the census year in Russia. The Government, as usual, called for volunteers to help to carry it out. Tolstoy became one of the enumerators, whose duties afforded an excellent opportunity for seeing the conditions under which the poor lived. The misery of it made him often wish to surrender all his property and have nothing more to do with lands and money, but the Government and family circumstances prevented him. In the pamphlet, *What are we to do?* he graphically narrates his census experiences. Again and again he attempted to carry his theories into effect. At last, calling his wife into his room, he explained to her that property and many possessions had become irksome to him. Wealth he now regarded as a sin. He wished to be rid of all personal ownership. In 1888 Tolstoy renounced all claim to his estates; everything was made over to his wife and children, the countess acting as trustee. True, this renunciation made little difference in his manner of life. He lived under the same roof as before, ate at the same table, wrote and read in the same study. The change was mental rather than material. He cared no longer for the growth or improvement of his estates, but gave himself up to ethical questions, and endeavoured day by day to bind himself more closely to the people. He now began to write specially for their benefit a number of simple tales which have been widely read, tales directed mostly against crying evils—the peasants' love of *vodka*, and like themes. He found willing fellow-workers in the firm of Russian publishers known under the name of Posrednik (V. Tchertkoff, and a group of friends). *John the Fool*, which was published in 1886 in the Posrednik series, is generally considered the best of these stories. *The Power of Darkness* (1885) also appeared in this series, and was written with the same object in view. Unfortunately, the popularity of these stories aroused the attention of the Government, and led to many of them being forbidden on account of their Socialistic tendencies.

The Doukhobors.

The terrible famine of 1891–92 added fresh lustre to Tolstoy's name. He and his family worked unceasingly in soup-kitchens and barns, distributing food and clothes. No true leader lacks a following. Every oppressed sect or individual turned instinctively to Tolstoy for sympathy and support, the most important case in point being that of the sect of the Doukhobors. Early in 1891 rumours began to reach headquarters of social and religious excitement fermenting among the inhabitants of the Caucasus, and especially among the Doukhobors (*q.v.*). This people, numbering from fifteen to sixteen thousand, shared their goods and property in common, and made laws of conduct for themselves, based on a simple form of religion unobscured by ceremonies or ritual. In these matters, and especially in refusing to serve as soldiers, they defied the governors of the Caucasian provinces, so that as their numbers and strength of opposition to authority grew formidable, severe measures were put in practice for their suppression. Several of their leaders were exiled, and in 1895 some hundred of them were condemned to be enrolled for three years in the so-called "disciplinary regiment." It was in that year that Tolstoy came in contact with them personally, and became deeply interested in them. He promptly identified himself with the agitation in their favour, and by his endeavours aroused sympathy for them in other countries, especially in England, where the Quakers, with whom they have much in common, espoused their cause. After many rebuffs from the Government, and many unavailing efforts to reach the kindly ear of the Tsar, the persecution of the Doukhobors at length ceased, and they were allowed to emigrate. With the aid of the Quakers and other sympathizers, sufficient funds were collected and a remarkable exodus began. No less than 7500 persons left Russia for Canada. It was in aid of these people that Tolstoy wrote and published *Resurrection.* The attack on the Orthodox Church in this novel was probably the chief cause which led to his formal excommunication by decree dated 22nd February 1901.

Tolstoy's religion.

His religious views are best given in his own words: "I believe in God, whom I understand to be a Spirit, to be Love itself and the Beginning of all things. I believe that the interpretation of the will of God is most clearly and most comprehensively given in the teachings of the man Christ. But I consider it the greatest blasphemy to think of Christ as God and to worship Him as such. I consider that the true happiness of man consists in fulfilling the will of God, which is that we should love each other, and act towards others as we would they should act towards us. I believe there is but one means by which to nourish the growth of love —Prayer, not public prayer in churches, which is expressly forbidden by Christ (Matt. vi. 5–13), but private prayer, an example of which is given by Christ Himself."

Tolstoy as a writer.

Before attempting to define the powers and position of an author, it is best to pass in review the works which have led to his present reputation. Tolstoy the writer is a guide of unusual faithfulness to Tolstoy the man. The gradual evolution of the reformer and preacher out of the brilliant novelist is described in no pages so clearly as in his own. *Childhood* (1852), *Boyhood* (1854), and *Youth* (1855–57)—Tolstoy's first literary efforts—may be regarded as semi-autobiographical studies; if not in detail, at least in the wider sense that all his books contain pictures, more or less accurate, of himself and his own experiences. No plot runs through them; they simply analyse and describe with extraordinary minuteness the feelings of a nervous and morbid boy, a male Marie Bashkirtseff. They are tales rather of the development of the thoughts than of the life of a child, with a pale background of men and events. The distinct charm lies in the sincerity with which this development is represented. We are introduced by the child, Nicholas Irtenyev, to a number of characters one after the other—father, mother, grandmother, tutor, servants, and serfs; and are led by him from the father's study to the morning-room, and so on to the kitchen and the housekeeper's closet; and we catch, as in a magic crystal, the lifelike scenes on his waking—in the schoolroom—at his mother's side. But the apparently unconscious change of the child's mind into that of the youth—his budding thoughts, hopes, fears—form the true drama of the story. To these essays in spiritual autobiography *My Confession* (1879–82) forms a continuation. It has passages of great power and vividness, but at times the morbid brooding over the meaning of life, so frequent in these works, becomes tedious and tiresome. Of the state of mind which Tolstoy calls "nihilism" for want of a better term he gives a faithful picture. This "nihilism" is a desperate, and yet at times merely dreamy, groping for something to satisfy the soul; a fatalistic inertia alternating with spasms of feverish activity.

The following quotation from the *Confession* shows the tangle into which these gropings occasionally led: "All that men sincerely believe in must be true: it may be differently expressed, but it cannot be a lie; and consequently, if it seems to me a lie, that must be because I do not understand it." We can but recall what Goethe said of the fate of the Romantics: "Am wiederkäuen sittlicher und religiöser Absurditäten zu ersticken." But in the interim between *Youth* and *My Confession*, a succession of brilliant performances had placed Tolstoy in the front rank of the novelists of the century. *The Cossacks* (1863), written round the theory that culture is an enemy to happiness, was followed by *War and Peace* (1864–69), which has been justly called a Russian epic. Within its pages Tolstoy has marshalled a panoramic array of kings, princes, and nobles, as they lived and moved during the times of the great Napoleonic wars. There are so many figures in

"War and Peace."

the picture, so much kaleidoscopic colour and movement, that the spectator often finds it difficult to follow the thread of the narrative. The leading characters all belong to the highest Russian society, whose circle—with its inflexible code of laws and customs, and a vitiated moral atmosphere affecting each member of it in a greater or less degree—links them together. The interest centres not so much in any single person as in the groups formed by four leading families of the "grand monde"—the Rostovs, Bezouchovs, Volkonskys, and the Kouragines—all bound together by common aims and interests. The men are eager to make a name and enjoy life; the women seek pleasure in gossip and romance. Peter Bezouchov and Prince André, with natures essentially different, but united by a love of truth, are the exceptions to this rule. Peter Bezouchov is one of Tolstoy's finest characterizations, drawn with a masterly hand. He is the embodiment of all that is good and bad in the Russian temperament. On the one side there is the striving after an ideal and a capacity for self-sacrifice, on the other an absence of firmness and balance. Like Tolstoy himself, he is always in doubt as to what is right and what is wrong, as to the meaning of life and death, and, like him, can find no answer to these riddles. While Peter Bezouchov is a typical Russian, a very Tolstoy, Prince André, if a less striking, is a more lovable personality. Upright and noble-minded, he yet is unable to cast off the chains of custom which have held him from childhood. He too is constantly seeking mental rest and finding none. The love-story of André and Natasha Rostov, which runs through the novel, is a poem in itself. Natasha is almost the only heroine Tolstoy has given us who wins our affections; but even she, after many transitions, sinks to the level of the *Hausfrau*, with no aim beyond the propagation and nurture of the race. There is something strained and abnormal in all the characters in *War and Peace;* but it must be borne in mind that Tolstoy winged his shafts not at men generally, but at that particular section of society to which he himself by birth and association belonged.

"Anna Karenina."

A long period of silence followed the publication of this novel, during which the world heard little of him. At length in 1873 he issued the first parts of *Anna Karenina.* It is without doubt his greatest production. The area of time and space in it, as in the preceding book, is large, but it has more continuity of action, and the principal characters are kept well in the foreground. It is a study of modern Russian life, in which the normal passivity of unsympathetic conjugal relations is sharply contrasted with the transient omnipotence of passion and deep love. The hero and heroine are Count Wronsky, a young soldier in a crack regiment, and Anna Karenina, the wife of an important official in the political world of St Petersburg. The parts of secondary heroine and hero are filled by Kitty Cherbatzky and her lover and ultimate husband, Levine. The central figure is of course Anna herself, an elegant and fascinating "mondaine." She is honest, frank, and well endowed by nature, and has an innate striving after truth and beauty in art and in life, but her early marriage with Karenina (who is double her age, reserved, and taciturn), while socially advantageous, has dulled and stunted her ideals. Ignorant of the meaning of love, she despises it, and it is not till she meets Wronsky that she realizes to the full the emptiness of her existence. Wronsky, young, handsome, impassioned, recognizing no principle but his own desires, offers her the rich wine of life at a draught. She tastes it, after scant hesitation; and then, flinging away her worldly position, deserting husband and child, she drains it to the dregs, only to find that poison lies in the cup. Anna and Wronsky have no true ideal to cling to. He, as their passion cools, finds the tie irksome and a hindrance to his career. She grieves for her lost and dearly-loved son, and frets as she sees that Wronsky's devotion is waning, recognizing too late that he loved her chiefly for vanity's sake, that they are slipping daily asunder, and growing displeasing to each other. Her past life is closed to her, the future opens like an abyss. The crisis has come, and swiftly obeying the impulse of her despair she seizes on death as her only weapon for wounding Wronsky and cutting the hopeless knot of her life. This pitiful end is led up to step by step with microscopic truth and insight into the springs of human action. In the married life of Kitty and Levine, on the other hand, Tolstoy describes a state of happiness of a material nature—disagreements easily bridged over, and mutual interest in their children and the pleasures of the country. Levine is the Tolstoy of fiction. The improvement and development of his estates, the life of a country squire, fail to satisfy him. The death of his brother, the birth of his child, awaken his mind to the problems of existence, and he is plunged in melancholy. Finally, relief comes to him with the words of a peasant who bids him "live for his soul and for his God." Thereupon Levine exclaims, "I have discovered nothing. I have simply opened my eyes to what I knew already; I have come to the recognition of that power which formerly gave me life and which renews life in me to-day. I am freed from error; I recognize my master." And the novel ends with the effacing of the intellect in a cloud of happy mysticism.

"Kreutzer Sonata."

The *Kreutzer Sonata*, published in 1890, created a profound impression. Many who were previously unacquainted with Tolstoy's work read this story of love, jealousy, and revenge, and were dumbfounded by its boldness. It is a startling advance upon *Family Happiness*, published thirty years earlier. Society generally, and Russian society in particular, is ruthlessly condemned for its views on marriage and its attitude towards the vexed question of the relations between man and woman. It is also a stern indictment of music as a debasing art. Marriage, Tolstoy says, can only be condoned if spiritual sympathy exists, and then only as the means to the continuance of the race; otherwise it is a breach of true morality. The "motive" of the *Sonata* is that the ideal we should strive after is a life where the spiritual penetrates and pervades everything and where all that is carnal is eliminated. Driven to its logical conclusion, the *Sonata* is the condemnation of marriage. But in the "Sequel" to the *Sonata* Tolstoy adds that great ideals are always unattainable, and affirms that no man can know, whilst yet striving, how nearly he approaches them. He is only conscious of his deviations.

"What is Art?"

The views of culture forming the basis of *The Cossacks* are yet further elaborated in *What is Art?* (1898), a sweeping criticism of the philosophy of æsthetics, to which he had devoted fifteen years of thought. The reformer's conclusions condemn the art to which those very conclusions owe their authority. He dismisses as inadequate the theories which define art as the pursuit of beauty, whether beauty be regarded with Shelley and Hegel as an approximation to archetypal perfection, and thus allied to God and goodness, or with Kant as that which gives disinterested pleasure. Tolstoy sets forth his own view that art is a human activity which aims at the transmission of emotion. He proceeds to narrow the definition by demanding that the emotion shall be actually felt, and shall belong to the highest feelings to which men can rise. True art must appeal to the religious perception of the brotherhood of man, and it must find universal response. He asserts that all exclusive art is bad art, and that such subjects as sexual love, patriotism, and religious devotion should be avoided. The theory postulates a universal art which shall ignore universal human nature. Tolstoy's doctrine is indeed a surprising medley of contradictions and arbitrary assumptions. As sincere iconoclasm the book is interesting, but can hardly be constructively helpful to the lover of art.

Toluca. See MEXICO (STATE).

Tomaszów Mazowiecki, or TOMASZÓW FABRYCZNY, an industrial town of Russian Poland, in the government and 41 miles N.E. of the town of Piotrków. It has large woollen mills, steam flour-mills and mechanical works, and is rapidly developing. Population (1897), 21,041.

Tompkinsville, formerly a village of Richmond county, New York, U.S.A., and since 1st January 1898 a part of Richmond borough, one of the five boroughs constituting New York City. It is on the eastern shore of Staten Island, just above the Narrows of New York harbour. The population is not separately returned by the census.

Tomsk, a Russian government in western Siberia, extending from the Chinese frontier to about 60° N., with Semipalatinsk on the S.W., Tobolsk on the N.W., and Yeniseisk on the N.E. It has an area of 331,159 square miles, including the Altai region; and its population, which was 1,134,750 in 1882, has rapidly increased, chiefly through immigration, until in 1897 it numbered 1,929,092 (domiciled only), of whom 958,312 were women, and 128,503 lived in towns. The bulk of the population (90 per cent.) is Russian, the remainder being Ostyaks, Mordves and Zyrianes, Tatars (mostly found in the Altai), Teleuts and Telenguts (belonging to the Mongolian stem, also chiefly found in the Altai), and nomad Samoyedes (representing a mixture between the Samoyedes and the Ostyaks, and found along the Ob river and its tributaries). The immigration during the years 1888 to 1896 varied from 13,000 to 34,000 per annum. Now that the Siberian railway has been built, it is on the increase.

Since the opening of a university at Tomsk education has made notable progress, and there were in 1897 1485 primary schools with 33,000 pupils, and 18 secondary or middle schools. Agriculture is the chief occupation of the people, and excellent crops are obtained in the southern portions of the province, especially in the Altai. No less than 4,033,500 acres were under cereal crops in 1900, and the average yield in 1895–99 was 4,702,000 cwt. of rye, 10,684,000 cwt. of wheat, 7,155,000 cwt. of oats, 1,040,000 cwt. of barley—all cereal crops, 24,302,000 cwt.; also 3,363,000 cwt. of potatoes. Kitchen gardening is well developed in the south, and some tobacco is also grown, but of inferior quality. There is an experimental farm, and the different agricultural societies are making considerable efforts to bring improved agricultural implements into more general use. Cattle-breeding is very important, and butter-making in model dairies, partly co-operative, has taken a great extension; butter is already exported from Tomsk to western Europe. There were in the province in 1896 1,747,000 horses, 1,628,000 horned cattle, 2,227,500 sheep, 100,600 goats, and 452,000 pigs. Apiculture is very general, and it is estimated that there are more than 660,000 beehives in the province; the export of honey and wax is considerable. An attempt to acclimatize the mulberry tree has been made at Tomsk University, and it has been found that though no fruit is obtained, the bushes are capable of being used for breeding silkworms. Hunting is common, especially in the Narym region, and the gathering of cedar-nuts is a trade of some importance (about £5000 worth a year). Fishing gives occupation to nearly 5000 persons, and mining to some 9000. The latter is especially developed in the Altai and in the Kuznetsk district, where gold and coal are obtained. Gold was extracted in 1897 to the amount of 2274 kilogrammes, silver 4563 kilogrammes, copper 213 tons, pig iron 1540 tons, iron 1097 tons, coal 22,440 tons, and salt 15,200 tons. Industries are beginning to develop, and there were in 1898 1390 factories, chiefly small, showing aggregate yearly returns of 8,442,000 roubles. The most important establishments are distilleries, breweries, tanneries, match factories, and iron-works. The Siberian railway has its own large carriage works on the Ob. A considerable trade is carried on, especially in grain and animal products, and the sixty-eight annual fairs show returns above 7,000,000 roubles. The inner navigation on the Ob is very active (about 250,000 tons are carried every year), and is maintained by 120 steamers (7750 horse-power) and 380 barges, representing an aggregate tonnage of 274,000 tons. The exterior trade with China is on the increase and Biysk has become an important centre. The government is divided into six districts, the chief towns of which are Tomsk, Barnaul (29,408), Biysk (17,206), Kainsk (5858), Kuznetsk (20,555), and Mariinsk (8300). The villages of Novo-Nikolaevsk (16,000) and Krivoschokovo, both near the spot where the railway crosses the Ob, have grown up with an American rapidity; so also have Tatarskaya, Karachi, Kainsk, Taiga, and Sudjenka, towns on the railway. (P. A. K.)

Tomsk, the capital of the above province, on the Tom river, 27 miles from its junction with the Ob. It is connected by a branch railway 54 miles long with Taiga, on the trans-Siberian railway, and is 1780 miles by rail from Samara. Its population, which was 31,380 in 1884, numbered 52,430 in 1897. It has now a university, a cathedral, a rich library, a number of lyceums for boys and girls, a theological seminary, various schools for the clergy, four professional schools, three public libraries, one of which is free, a society for popular education (established since the foundation of the university and displaying great activity), a number of philanthropic institutions, scientific societies (naturalist, geographical, medical, musical, &c.), and two newspapers. It was believed that when the trans-Siberian railway was built Tomsk would lose its importance as the great entrepôt for the storing of goods for distribution throughout Siberia. The contrary, however, has been the case. A great number of important firms have opened storehouses, and the quantity of goods shipped on the Siberian rivers is steadily increasing. The distilleries, tanneries, candle works, match factories, &c., are insignificant, and show a yearly return of only about one million roubles; nevertheless Tomsk remains a centre for the economical, industrial, and intellectual life of western Siberia. Its activity in this respect will be increased with the extension of the university and the opening of the technical institute, veterinary institute, mining school, and theological academy.

Tonawanda, a village of Erie county, New York, U.S.A., on the east bank of the Niagara river, at the western termination of the Erie Canal, in the western part of the state, at an altitude of 576 feet. Its site is level and its plan irregular. It has considerable manufactures, now in course of development owing to the introduction of power from Niagara Falls. Four railways enter the city—the Erie, the Lehigh Valley, the New York Central and Hudson River, and the Wabash. Population (1880), 3864; (1890), 7145; (1900), 7421, of whom 1834 were foreign-born.

Tonga, or Friendly Islands (so named by Captain Cook, but now universally known by their native name, Tonga), lying in the South Pacific, about 350 miles S.S.W. of Samoa and 250 miles E.S.E. of Fiji. The climate is healthy for Europeans, being dry and cool as compared with that of Samoa and Fiji. A cyclone which devastated Vavau in April 1900 was the most destructive ever recorded in the group, but hurricanes are rare. In 1886 there was a serious volcanic eruption in the outlying island of Niua fo'ou, and at the same time Falcon Reef, normally awash at high water, discharged sufficient scoriæ and pumice to form a new island 50 feet high. In 1898 the island had been washed away, but in 1900 H.M.S. *Porpoise* found that a solid core of black rock had been extruded 6 feet above high water. All the volcanoes in the group were then quiescent. The average rainfall for the year is about 80 inches, the greatest rainfall in one day being 4·56 in 1890. Earthquakes are not infrequent. The people, a branch of the Polynesian stock, are the most progressive and most intellectual in the Pacific Islands, except the Hawaiians. Their path towards political liberty has been thorny. In 1875 King George Tubou, acting on the advice of the Wesleyan missionaries, absolved the natives from the service tenures which were the equivalent for rent for their lands, and granted a "constitution," with a triennial parliament in which an equal number of hereditary chiefs and elected representatives have seats. A cabinet, a privy council, and an elaborate judicial system were established, and the cumbrous machinery was placed in the hands of a "prime minister," a retired Wesleyan missionary, who induced the king to break off his connexion with the Wesleyan body in Sydney, and to set up a state church. Persecution of members of the old church followed, and in 1889 the missionary-premier had to be removed from the group by the High Commissioner. He afterwards returned to initiate a new sect called the "Free Church of England," which for a time created further divisions among the people. There are now five churches in Tonga, the Free Wesleyans (14,000), Wesleyans (2000), Roman Catholics (2731), Seventh Day Adventists (50). A few natives belong nominally to the Anglican Church. King George Tubou died in 1893, at the age of 96, and was succeeded by his great-grandson under the same title. Since the change of rulers the central Government has become perceptibly weaker, but the fear of annexation by one of the Great Powers has hitherto prevented open resistance. The king has a bodyguard of thirty men. The abandonment of the old patriarchal form of government has not proved beneficial to the people, who, having lost respect for their chiefs, now respect no one. Unable to obtain the services of the community for building their houses, they live for the most part in wretched hovels. The population decreased slightly during the decade 1890–1900, though the returns furnished by the native Government show it now to be increasing. Natives in 1890 numbered 19,085; in 1899, 19,081, in addition to 80 Europeans and 260 "others." While under the control of Europeans the Tongans have shown some aptitude for administration; they fail when left to themselves. They pick up superficial and showy acquirements with astonishing ease, but they seem to be incapable of mastering any subject. They write shorthand, but speak no English; they have a smattering of higher mathematics, yet are ignorant of book-keeping. Their government, effective enough when dealing with natives, breaks down in all departments concerned with Europeans, and becomes the prey of designing traders. Their ambition is to rank as a civilized state, and the flattery lavished on them by their teachers has spoiled them. That they are a law-abiding and easily-governed people is shown by the fact that they pay a poll-tax of nine dollars, besides customs duties of 10 per cent. *ad valorem.*

Copra, bananas, and oranges are the principal exports; the export of copra might be quadrupled were the islands systematically planted with cocoanut trees, but since every tax-payer holds his land at the will of the Government, there is no fixity of tenure to encourage improvements. The imports and exports fluctuate considerably, as the following table shows:—

Year.	Imports.			Exports.		
	£	s.	d.	£	s.	d.
1888	50,186	7	5	68,337	3	8
1890	29,560	3	8	45,492	6	2
1895	87,240	15	4	113,279	6	4
1899	73,314	17	9	71,315	17	5

No returns of revenue and expenditure are furnished by the Government, but the estimates provide for an annual expenditure of about £24,000, and there are neither debts nor a balance in the treasury. English, German, and American coinage is current, accounts being kept in dollars reckoned at four shillings. The wisdom of the late king in refusing to alienate an acre of land except upon lease has resulted in Tonga having been the last native state in the Pacific to lose its independence. In May 1900 the group became a British Protectorate under the native flag, the appointment of the consul and agent being transferred to the Government of New Zealand. There is a good code of law, drafted upon the model of the Indian Penal Code.

AUTHORITIES.—*Cook's Voyages.*—MARTIN. *Mariner's Account of the Tonga Islands.* Edinburgh, 1827.—D'ENTRECASTEAUX. *La Recherche de la Pérouse.* Paris, 1797.—VASON. *Four Years at Tongatabu.* London, 1815. DUMONT D'URVILLE. *Voyage de l'Astrolabe.* Paris, 1837.—WILKES. *Narrative of the United States Exploring Expedition.* London, 1853.—WALDEGRAVE, in *R. G. S. Journal*, 1850.—WEST. *Ten Years in South Central Polynesia.* London, 1856.—PALMER. *Tonga and the Friendly Islands.* London, 1855.—ERSKINE. *The Islands of the Western Pacific.* London, 1853.—RUSSELL. *Polynesia.* Edinburgh, 1843.—THOMSON. *Diversions of a Prime Minister.* London, 1894.—REEVES. *Brown Men and Women.* London, 1898.—THOMSON. *Savage Island.* London, 1902. (B. H. T.)

Tongking (in French, *Tonquin* or *Tonkin*), the northern division of the kingdom of Annam, forming an integral part of French Indo-China, extending 250 miles from north to south between 20° and 23° 20′ N., and 400 miles east to west between 102° and 108° E. The combined territories of Tongking and Annam form the "kingdom or empire of Annam." Actually, however, the protectorate of Tongking approaches nearer to direct administration than that of Annam proper, where the conditions of the protectorate are more closely observed. It is the court of Hué which appoints and recalls, subject to the approval of the governor-general, native officials, whose salaries are paid by the court. Formerly the king of Annam was represented in Tongking by a viceroy (*kinh-luoc*). Since 1897 this post has been abolished, and the Annamese officials are directly under the control of the Resident-General, who until 1891 was the chief personage of Indo-China. Cochin-China, however, held first rank for wealth and prosperity; but Tongking, with its population of about 12,000,000 and its situation on the southern frontier of China, must acquire great importance in the future. France is putting forth here her strongest effort towards colonization. The railway line from Hanoi to the Chinese frontier, *viâ* Phu-Lang-Thuong and Langson, will terminate at the Canton river. The great bridge, about ½ mile long, across the Red River at Hanoi has been completed. The Red River railway, which is to run to Yunnan, has been laid as far as Viétry, passing through Sontai. The lines from Hanoi to Haiphong and from Hanoi to Ninh-binh (to be prolonged to Hué) are under construction, and other lines are projected, including one from Tourane to Kwang-tri and Hué, and another between Hué and Saigon. Roads have been opened, and are maintained by the provinces through which they run; for example, those between Annam and Laos, lower Laos more especially. Important public works have been carried out, the docks at Haiphong enlarged, and canals deepened and opened. The imports of Tongking in 1900 were valued at £2,552,000. The local budget for 1901 was estimated to balance at £4,197,950 (revenue and expenditure).

Local Administration.—Local administration on a communal basis exists. The institution of the mandarinate remains intact. The vacancies are filled on a most democratic system, by means of selection. The primary school, in which the pupils learn only Chinese writing and the precepts of Confucius, stands at the base of this system. Then succeeds a half-yearly examination, by means of which are selected those eligible for the course of higher education given at the capital of the province in a school under the direction of a *doc-hoi*, or inspector of studies. Finally a great triennial competition decides the elections. The candidate whose work is notified as *tres bien* is admitted to the examinations of the *dinh-thi*—which qualifies for the title of doctor and the holding of the highest offices. The note *bien* against a candidate gives him a second-class certificate entitling him to nomination as *phu*, prefect, or *huyen*, sub-prefect, as vacancies occur. The education of a mandarin includes local history, cognizance of the administrative rites, customs, laws, and prescriptions of the country, the ethics of Confucius, the rules of good breeding, the ceremonial of official and social life, and the practical acquirements necessary to the conduct of public or private business. Annamese learning goes no farther. It includes no scientific idea, no knowledge of the natural sciences, and is characterized by the most absolute ignorance of even the most rudimentary instruction conveyed in a European education. The complications of Chinese writing greatly hamper education. The Annamese mandarin must be acquainted with Chinese, since he writes in Chinese characters. But the character being ideographic, the words which express them are dissimilar in the two languages, and official text is read in Chinese by a Chinese, in Annamese by an Annamese. The very intricacy of these institutions conduces to their persistence. Chinese writing remains the only one in practical use. In other matters the mandarins have resigned themselves to the French régime. For several years, apart from the commercial and industrial movement which has so greatly developed in Tongking (and which includes the manufacture of matches, glass, and furniture, the spinning of cotton and silk, mother-of-pearl inlaying, &c.), a considerable agricultural movement has arisen. Plantations of coffee, cocoa, cotton, mulberry, &c., are making rapid progress. The chief towns, Hanoi, Haiphong, and Ninh-binh, have increased in population and extended their bounds. (See HANOI and HAIPHONG.)

The changes in Annam are in no sense as important, though Hué has increased. The total population is estimated at over 6,000,000, but there are very few Europeans. The port of Tourane, however, has become the centre of an important commercial movement and the town (a municipality) has a population of 100 French, 200 Chinese, and 4000 natives. Coal is worked in the district. The king of Annam, Prince Bua-Lan, was born in 1879 and proclaimed emperor under the title of Than-Thai on 31st January 1889, after the death of the emperor Ding-Khank three days before. Very active and open-minded, he has greatly modified the old Court customs and rendered himself accessible—whereas the king of former times was only to be seen from afar, in ceremonial ritual. He even visited the governor-general at Saigon in December 1897, and the Saigonese were privileged to behold the emperor of Annam riding on a bicycle. The local budget of Annam since the creation of a budget-general of Indo-China is somewhat straitened. It was estimated for 1901 at 2,081,416 piastres, receipts and expenditure. (See also COCHIN-CHINA and INDO-CHINA.) (J. M. A. DE L.)

Tonk, a native state of India, in the Rajputana Agency. It consists of six isolated tracts, some of which are under the Central India Agency. Area in Rajputana, 1415 square miles. Population (1881), 170,179; (1891), 198,934, showing an increase of 17 per cent.; average density, 141 persons per square mile. Population in Central India (1881), 167,850; (1891), 181,135. Population of both tracts (1901), 273,035. The gross revenue in 1896–97 amounted to Rs.17,01,237, of which Rs.3,10,000 was derived from loans. Of the expenditure, Rs.97,903 was directly devoted to famine relief, and Rs.39,000 to public works. No tribute is payable.

There were 13 schools, with 857 pupils. The chief, whose title is Nawab, is a Mahommedan of Afghan descent. The founder of the family was Amir Khan, the notorious Pindari leader at the beginning of the 19th century, who received the present territory on submitting to the British in 1817. The state is now well administered, the settlement of the land revenue and public works being each under a British official. The minister, Sahibzada Obeidullah Khan, C.S.I., was deputed on political duty to Peshawar during the Tirah campaign of 1897. A railway is now being constructed, with the help of a loan from Gwalior, in the outlying division of Chabra, on which 3740 persons obtained labour during the famine of 1896–97; and feeder roads are being made to railway stations in other parts of the state. Distress was again caused by drought in 1899–1900. The town of Tonk is situated 1462 feet above the sea, midway between Jaipur and Bundi, near the right bank of the river Banas. Population (1881), 40,726; (1891), 46,069; (1901), 38,641. It is surrounded by a wall, with a mud fort. It has a high school, the Walter female hospital, under a lady superintendent, and a hospital for males.

Tonnage.—The mode of ascertaining the tonnage of merchant ships is settled by the Merchant Shipping Acts. But before explaining the method by which this is computed, it is well to remark that there are several tonnages employed in different connexions. *Displacement tonnage* is that which is invariably used in respect of warships, and is the actual weight of water displaced by the vessel whose tonnage is being dealt with. Men-of-war are designed to carry all their weights, including coal, guns, ammunition, stores, and water in tanks and in boilers, at a certain draught, and the tonnage attributed to them is the weight of water which at that designed draught they actually displace. This displacement tonnage is therefore a total made up of the actual weight of the ship's fabric and that of everything that is on board of her. It can be found by ascertaining the exact cubic space occupied by the part of her body which is immersed (including her rudder, propellers, and external shafting) at the draught under consideration in cubic feet, and dividing this by 35, since 35 cubic feet of sea water weigh one ton. Of course there is nothing to prevent displacement tonnage from being used in describing the size of merchant ships, and indeed in regard to the performances of fast steamships on trial it is usual to give their draught on the occasion when they are tested, and to state what was their actual displacement under these trial conditions. But it is obvious, from what has been said as to the components which go to make up the displacement at load draught, that this tonnage must, in respect of any individual ship, be the greatest figure which can be quoted in regard to her size. It is usual for dues to be assessed against merchant vessels in respect of their *registered tonnage.* This must therefore be fixed by authority, and at present vessels are measured by the officer of customs according to the rules laid down in the second schedule to the Merchant Shipping Act, 1894. As will be seen from the explanation of the method adopted, this is a somewhat arbitrary process, and even the gross registered tonnage affords little indication of the actual size of the ship, whilst the under-deck and net tonnages are still less in accord with the extreme dimensions.

As to *length for tonnage,* the measurements start with the tonnage deck, which in vessels with less than three decks is the upper, and in vessels of three or more decks is the second from below. The length for tonnage is measured in a straight line along this deck from the inside of the inner plank at the bow to the inside of the inner plank at the stern, making allowance for the rake, if any, which the midship bow and stern timbers may have in the actual deck. When this is measured it is apparent into which of five classes the ship's tonnage-length places her. If she be under 50 feet in length she falls into the first class, while if she be over 225 feet in length she falls into the fifth class, the remaining three classes being intermediate to these. Vessels of the first class are measured as in four equal sections, and vessels of the larger class as in twelve equal sections, according to their length. Then at each of the points of division so marked off *transverse areas* are taken. This is done by measuring the depth in feet from a point at a distance of one-third of the round of the beam below the tonnage deck to the upper side of the floor timbers. Where the vessel has a ceiling and no water-ballast tanks at the point of measurement, 2½ inches is allowed for ceiling. But where there are such tanks the measurement is taken from the top of the tank and no allowance is made for ceiling, whether there in fact be any or not. If the midship depth so found exceeds 16 feet, each depth is divided into six equal parts, and the horizontal breadths are measured at each point of division and also at the upper and lower points of the depth, extending each measurement to the average thickness of that part of the ceiling which is between the points of measurement. They are then numbered from above, and the second, fourth, and sixth multiplied by four, whilst the third and fifth are multiplied by two. The products are then added together. To the sum are added the first and the seventh breadths. This total having been multiplied by one-third, the common interval between the breadths, the resultant is the transverse area. The transverse areas so obtained at each point of the vessel's length are numbered from the bow aft. Omitting the first and last, the second and every even area so obtained are multiplied by four, whilst the third and every odd area are multiplied by two. These products are added together, as are also those of the first and last areas if they yield anything, and the figure thus reached is multiplied by one-third of the common interval between the areas. This product is reckoned as the *cubical capacity of the ship* in feet. When divided by 100 the result is the *registered under-deck tonnage* of the ship—subject to the additions and deductions ordered by the Act. Directions of a kind similar to those already set out are given whereby the tonnage in the space enclosed between the tonnage and upper decks may be ascertained, and also for the measuring of any break, poop, or other permanent closed-in space on the upper deck available for stores, and the sum of the capacity of these must be added to the under-deck tonnage to arrive at the *gross registered tonnage.* But an express proviso is enacted that no addition shall be made in respect of any building erected for the shelter of deck passengers and approved by the Board of Trade. In the process of arriving at the *net tonnage* the main deduction allowed from the gross tonnage is that of machinery space in steamships. The method of measurement here is similar to that by which the under-deck tonnage is reached. Where the engines and boilers are fitted in separate compartments, each compartment is measured separately, as is the screw shaft tunnel in the case of steamships propelled by screws. The tonnage of these spaces is reckoned, not from the tonnage deck, but from the crown of the space, whilst if it has previously been reckoned in the gross tonnage, there may be an allowance for the space above the crown, if enclosed for the machinery or for the admission of light and air. Allowances are only made in respect of any machinery space if it be devoted solely to machinery or to light and air. It must not be used for cargo purposes or for cabins. Further, by the Act itself in the case of paddle steamships, where the machinery space is above 20 per cent. and under 30 per cent. of the gross tonnage, it is allowed to be reckoned as 37 per cent. of such gross tonnage; whilst similarly, in the case of screw steamships, where such machinery space is over 13 per cent. and under 20 per cent. of the gross tonnage, it is allowed to be reckoned as 32 per cent. Further deductions are also made in respect of space used solely for the accommodation of the master and the crew, and for the chart-room and signal-room, as well as for the wheel-house and chain cable locker and for the donkey-engine and boiler, if connected with the main pumps of the ship, and in sailing vessels for the sail locker. The space in the double bottom and in the water-ballast tanks, if these be not available for the carriage of fuel stores or cargo, is also deducted if it has been reckoned in the gross tonnage in the first instance.

From the rules above laid down it follows that it is possible for vessels, if built with a full midship section, to have a gross registered tonnage considerably below what the actual cubical capacity of the ship would give, whilst in the case of steam tugs of high power it is not unprecedented, owing to the large allowances for machinery and crew spaces, for a vessel to have a registered net tonnage of *nil*.

Suez Canal dues being charged on what is practically the registered tonnage (though all deductions permitted by the British Board of Trade are not accepted), it is usual, at all events in the British navy, for warships to be measured for what would be their registered tonnage if they were merchant ships, so that in case they may wish to pass through the Canal a scale of payment may be easily reached. But such tonnage is never spoken of in considering their size relative to other vessels.

Two other tonnages are also made use of in connexion with merchant ships, especially when specifications for vessels are being made. The first of these is *measurement capacity*. This is found by measuring out the true cubic capacity of the holds, whereby it is found what amount of light measurement goods can be carried. The second is *deadweight capacity*. This is generally given as excluding what is carried in the coal bunkers, and it is therefore the amount of deadweight which can be carried on the holds at load draught when the vessel is fully charged with coals and stores. (B. W. G.)

Tonnay-Charente. See ROCHEFORT.

Tönsberg, a fortified seaport town of Norway, county of Jarlsberg and Laurvik, situated on a bay on the south coast, near the entrance to Christiania Fjord, 72 miles by rail south by west of Christiania. It is one of the most ancient towns in Norway. It is now the headquarters of a sealing and whaling fleet (100 to 120 vessels of an aggregate of 10,000 tons), which employs approximately 2000 men. The principal industries are refineries for preparing whale and seal oil, and saw-mills. There is a trade of the yearly value of about £300,000. Tönsberg possesses a mercantile fleet of close upon 224,000 tons (over 150 vessels). Population (1885), 7034; (1891), 7215; (1900), 8620.

Toole, John Lawrence (1832-——), English actor, was born in London, 12th March 1832. His strong leanings towards the stage led him to abandon a commercial career when he was twenty, and to make his first public appearance at a benefit performance at the Haymarket in July 1852. In this he was so successful that he obtained an engagement at the Queen's Theatre, Dublin, where he became popular. After other engagements at Belfast, Edinburgh, and Glasgow, he appeared in London, in 1854, at the St James's Theatre, in "low comedy" characters. His reputation grew rapidly, and when Webster undertook the management of the Adelphi in 1858, Toole was engaged as his leading comedian. It was about this time that he first met Henry Irving, and began a lifelong friendship with him. Some five years at the Adelphi were followed by engagements at the Queen's Theatre (where the company included Charles Wyndham, John Clayton, Henrietta Hodson, and Henry Irving) and the Gaiety. In 1874 Toole undertook an American tour with considerable success, and reappeared at the Gaiety in 1875. In 1879 he became manager of the Folly Theatre, which he subsequently re-christened (in 1882) Toole's Theatre, and managed it until severe ill-health compelled him to retire from the stage in the autumn of 1895. In 1890 he made a most successful tour through the Australian colonies. Besides a remarkable fund of drollery, exploited to the full in such parts as Paul Pry, Spriggins in *Içi On Parle Français*, or "Chawles," Toole's powers of acting always included a considerable command of pathos, as he showed in characters such as Caleb Plummer, Michael Garner in *Dearer than Life*, or Uncle Dick in *Uncle Dick's Darling;* while those who saw him in *Paw Clawdian* and *Stagedora* will have a delightful recollection of his talent for travesty. His last public appearance was made on 28th September 1895, at his own theatre.

Toowoomba, a town of Queensland, Australia, in the county of Aubigny, 76 miles by rail west by north of Ipswich. It is the centre of population for the pastoral and agricultural district of Darling Downs, which is occupied by a desirable class of settlers. A town hall, school of arts, theatre, and library were erected in 1900 at a cost of £10,000, and waterworks have been constructed. Vineyards are cultivated in the suburbs by a German colony numbering about 1000, and large quantities of wine are made. Altitude, 1960 feet. Mean temperature, year, 61° F.; January, 71·6°; July, 48·2°; rainfall, 45·63 inches. Population (1891), 7007; (1900), 9137.

Topeka, a city of Kansas, U.S.A., capital of Shawnee county and of the state, on the Kansas river, in the eastern part of the state, at an altitude of 886 feet. The city is regularly laid out on a fairly level site, is divided into six wards, has water-supply and sewerage systems, and its business streets are paved, mainly with brick and asphalt. It contains many fine buildings, among them the United States Government building, the capitol, the court-house, and several fine business blocks. There are five railways—the Atchison, Topeka and Santa Fé (which has offices and workshops here); the Chicago, Rock Island, and Pacific; the Leavenworth and Topeka; the Missouri Pacific; and the Union Pacific —which give the city a large traffic. In 1900 there were 399 manufacturing establishments, with a capital of $3,891,531. They employed 3758 hands, and the product had a value of $9,977,605. The chief industry is flour-milling, the product of which was $2,188,034. The assessed valuation of real and personal property was in 1900 $11,728,525, indicating a very low rate of assessment. The net debt was $922,040, and the rate of taxation was $46.00 per $1000. Topeka is the seat of Washburn College, a Congregational institution opened in 1865, which in 1899 had a faculty numbering 18 and was attended by 228 students, 86 of whom were women. Population (1890), 31,007; (1900), 33,608, of whom 3201 were foreign-born and 4807 negroes.

Topelius, Zakris [or Zacharias] (1818–1898), after the death of Runeberg by far the most prominent writer of Finland, was born at Kuddnäs, near Nykarleby, on the 14th of January 1818. He was the son of a doctor of the same name, who was distinguished as the earliest collector of Finnish folk-songs. Topelius became a student at Helsingfors in 1833, and remained connected with that university for the rest of his life, being made professor in 1863 and receiving in succession all the academic distinctions open to him. Quite early in his career, by the side of his constant tutorial and professional work, he began to distinguish himself as a lyrical poet, with the three successive volumes of his *Heather Blossoms* (1845–54). The earliest of his historical romances was *The Duchess of Finland*, published in 1850. He was active in journalism also, and was editor-in-chief of the *Helsingfors Gazette* from 1841 to 1860. In 1878 Topelius was allowed to withdraw from his professorial duties, which he began to feel irksome, but this did not sever his connexion with the university; it gave him, however, more leisure for his abundant and various literary enterprises. Of all the multifarious writings of Topelius, in prose and verse, that which has enjoyed the greatest popularity is his *Tales of a Barber-Surgeon*, episodes of historical fiction from the days of Gustavus II. Adolphus to those of Gustavus III., treated in the manner of Sir Walter Scott; the five volumes of this work appeared at intervals between 1853 and 1867. Topelius attempted the drama also, with most success in his tragedy of *Regina von Emmeritz* (1854). Topelius was not an exquisite, but a fresh, cheerful, and wholesome writer. He aimed, with eminent but perhaps pathetic success, at the cultivation of a strong passion of patriotism in Finland, and he is to be thought happy in that he did not live to witness the oppression of the noble and long-suffering nation which he had roused by his writings. He died on the 13th of March 1898 at Helsingfors. Among his many claims on the attention of Finlanders it must be added that Topelius was an exceptionally happy writer for children. His abundant poetry is graceful and patriotic, but does not offer any features of great originality. (E. G.)

Topete, Juan Bauptista (1821–1885), Spanish naval commander and politician, was born in Mexico, 24th May 1821. His father and grandfather were also Spanish admirals. He entered the navy at the age of seventeen, cut out a Carlist vessel in 1839, became a midshipman at twenty-two, obtained the cross of naval merit for saving the life of a sailor in 1841, and became a lieutenant in 1845. He served on the West Indian station for three years, and was engaged in repressing the slave trade before he was promoted frigate captain in 1857. He was chief of staff to the fleet during the Morocco war, 1859, after which he got the crosses of San Fernando and San Hermenegildo. Having been appointed chief of the Carrara arsenal at Cadiz, he was elected deputy and joined the Union Liberal of O'Donnell and Serrano. He was sent out to the Pacific in command of the frigate *Blanca*, and was present at the bombardment of Valparaiso and Callao, where he was badly wounded, and in other engagements of the war between Chile and Peru. On his return to Spain, Topete was made port captain at Cadiz, which put him into a position to take the lead of the conspiracy in the fleet against the Bourbon monarchy. He sent the steamer *Buenaventura* to the Canary Isles for Serrano and the other exiles; and when Prim and Sagasta arrived from Gibraltar, the whole fleet under the influence of Topete took such an attitude that the people, garrison, and authorities of Cadiz followed suit. From that day Topete took part in all the acts of the Revolutionary Government, signed the proclamations, accepted the post of marine minister, was elected a member of the Cortes of 1869, supported the pretensions of Montpensier, opposed the election of Amadeus, sat in several cabinets of that king's reign, was prosecuted by the federal republic of 1873, and again took charge of the marine under Serrano in 1874. After the Restoration Topete for some years held aloof, but finally accepted the presidency of a naval board in 1877, and sat in the Senate as a life peer until his death on 29th October 1885 at Madrid. (A. E. H.)

Torda, a corporate town of Hungary, capital of the county of Torda-Aranyos, near the river Aranyos, 16 miles south-east of Kolozsvár. As a salt-producing district it was known to the Romans. It has still important salt mines and baths. It has a large public hospital, an old Unitarian church, an asylum supported by the Franciscans, and a large manufactory of cellulose. In its vicinity is the rocky formation known under the name of "Cleft of Torda," which crosses the calcareous mountain for 2 miles, presenting many romantic steep rocks and deep caves. Population (1891), 11,084; (1901), 12,117.

Toreno, Queipo de Llano y Cayoso de, Count (1840–1890), Spanish politician, was born in Madrid in 1840, and was the son of the Count de Toreno who distinguished himself in the independence war against Napoleon, and afterwards as a historian, orator, minister, and statesman during the reigns of Ferdinand VII. and Isabella II. Young Toreno was educated at the Madrid Institute and University, entered Parliament in 1864 as a Moderado, and sat in all the Cortes of Queen Isabella's reign as a deputy for his ancestral province, Asturias. Loyal to the Bourbons all through the revolution, he nevertheless became a deputy in the Cortes of 1871–73, and founded an Alphonsist paper, *El Tiempo*, in 1873. When the Restoration took place, its first cabinet made Count de Toreno mayor of the capital, and in 1875 minister of public works, in which capacity he improved the public libraries, museums, academies, and archives, and caused many important works to be published, including the *Cartas de Indias*. In 1879 he became minister for foreign affairs, in 1880 president of the House of Deputies, in 1884 again governor of Madrid, and in 1885 again president of the House of Deputies. During the reign of Alphonso XII. and the first years of the regency of Queen Christina, Count de Toreno was one of the most prominent Conservative leaders, and was often consulted by the Crown. He died on 31st January 1890. He was a patron of the Turf, and established a racecourse in Madrid, where the first races took place in the reign of Alphonso XII. (A. E. H.)

Torgau, a town of Prussia, province of Saxony, 48 miles by rail east by north of Halle, on the left bank of the Elbe, here crossed by two iron bridges (one a railway bridge). The fortifications were dismantled in 1889. The town hall contains a collection of Saxon antiquities. In the vicinity is the royal stud farm of Graditz. Population (1885), 10,988; (1900), 11,811.

Toro, a town of Spain, in the province and diocese of Zamora, on the right bank of the river Douro, 35 miles west by south of Valladolid. It has a station on the railway from Medina de Campo to Zamora. It has excellent and well-attended lay and ecclesiastical schools. There is a fine bridge of twenty-two arches across the Douro. The town is a picturesque assemblage of decaying palaces, convents, narrow streets, public buildings, in part repaired in the 18th and 19th centuries. The cathedral church or abbey of Santa Maria la Mayor is considered older than, and quite as remarkable as, that of Zamora. It dates from the reigns of Alphonso VII. and Fernando el Santo. Toro has several fine parish churches and convents, palatial residences of the dukes of Alcañices, Fonsecas, Albas, and especially of the marquis of Santa Cruz, the last famous because the Cortes of 1371, 1442, 1505, that made Toro and its code of laws celebrated, were held there. Toro is first mentioned in documents of the 10th century, and its chequered history is intimately associated with that of the mediæval monarchies of Spain. Population (1897), 8421.

Törökszentmiklós, a large market town, situated on the great Alföld (plain), in the county of Jász-Nagy-Kun-Szolnok, Hungary, 60 miles south-west of Debreczen. On the extensive communal territory—81,695 acres—are produced immense quantities of wheat and other cereals. There is a large brick factory, a manufactory of ploughs, a steam-mill, and a considerable nunnery. Population (1891), 18,772; (1901), 21,881.

Toronto, the capital of the province of Ontario, and the second largest city in Canada, situated on the bay of the same name on the north shore of Lake Ontario, in 43° 39′ 25″ N. and 79° 23′ 39″ W. It is, next to Montreal, the principal railway centre in the Dominion, and has direct communication with all points of importance in British North America and the northern United States by way of the main lines and the branches (seven in number) of the Grand Trunk and Canadian Pacific railways. An electric street railway, with a track of 87 miles within the city limits, affords rapid and easy communication with all parts of the city, and, by connecting lines and extensions, with the neighbouring towns. During the season of navigation several lines of steamers run between Toronto and the principal ports on the Great Lakes and the St Lawrence. It is the seat of the provincial government, and contains the official residence of the lieutenant-governor, the parliament and departmental building, courts of law, offices of the department of education, and Toronto University. The new parliament and departmental building is situated in the centre of a finely-wooded park of upwards of 30 acres. It is in the Neo-Greek style, with the central portion, containing the legislative chamber, standing forward, bold and massive. The city hall and court-house, completed in 1900 at a cost of upwards of $2,500,000, is one of the finest civic buildings in North America. It is in the Romanesque style, and has a total length of 290 feet and a depth of 275 feet. It accommodates all the civic, county, police court, high court, and school board officials. Toronto is the centre of the wholesale trade of Ontario, and the seat of many flourishing industries, including extensive iron foundries, rolling mills, breweries, distillery, agricultural implement works—the largest employing 1500 men—stove, shoe, carpet, bicycle, rubber, and musical instrument factories, shipbuilding, &c.

The city occupies an area of 16·2 square miles, exclusive of the harbour and the island of the same name. It has 260 miles of streets, 233 miles of sewers, and 260 miles of water-mains; the water-supply, drawn through a conduit from an intake in deep water in Lake Ontario, is pumped by engines with a capacity to treat 42,000,000 gallons per day to a large reservoir in the northern part of the city. In 1902 there were 207 places of worship, in addition to upwards of 50 buildings and rooms used as missions; there were 59 public schools with 682 teachers, including 126 on the kindergarten staff, attended by 34,863 pupils, and annual expenditure $539,910; also 21 separate Roman Catholic schools, with 103 teachers and 5227 pupils. For secondary education there were 3 collegiate institutes, with 1400 pupils. The city contains the head offices of 9 banks—the Toronto, Commerce, Imperial, Dominion, Nova Scotia, Ontario, Standard, Sovereign, and Traders—with an aggregate paid-up capital of more than $22,000,000; of 37 loan companies, with nearly $21,000,000 of paid-up capital; and of the principal trust and insurance companies doing business in the province. The exports for 1894 were $3,984,462; 1900, $9,506,911; imports for 1894, $17,731,843; 1900, $31,787,053; duty paid in 1900, $5,363,816; bank clearings, 1892, $326,564,322; 1901, $625,228,306; gross assessment, 1902, $157,915,397; exemptions, $23,949,850; net assessment, $133,965,547; taxation, $2,612,328. The population in 1881 was 86,415; in 1883 the suburb of Yorkville was annexed, and subsequently Leslieville, Seaton, Brockton, and Parkdale were brought within the city limits; in 1891 it had increased to 181,220, and in 1901 to 208,040. The city returns four members to the Dominion House of Commons, and four to the provincial legislature. It is the seat of an Anglican bishop and a Roman Catholic archbishop. (J. WH*.)

Torpedo.—In 1805 Robert Fulton demonstrated a new method of destroying ships by exploding a large charge of gunpowder against the hull under water. No doubt then remained as to the effectiveness of this form of attack when successfully applied; it was the difficulty of getting the torpedo, as it was called, to the required position which for many years retarded its progress as a practical weapon of naval warfare. Attempts were first made to bring the explosive in contact with the vessel by allowing it to drift down to her by the action of tide or current, and afterwards to fix it against her from some form of diving boat, but successive failures led to its restriction for a considerable period to the submarine mine, in which the explosive is stationary and takes effect only when the ship itself moves over or strikes the charge. Used in this way, it is an excellent deterrent to hostile warships forcing a harbour.

Spar or Outrigger Torpedo.—The limitations attached to the employment of submarine mines, except for coast defence, revived the idea of taking the torpedo to the ship instead of waiting for the latter to gain some exact point which she might very possibly avoid. This first took practical shape in the spar or outrigger torpedo. If the boat using it was not discovered and disabled while approaching, the chances were favourable to success and escape afterwards. Against a vigilant enemy it was doubtless a forlorn hope, but to brave men the venture offered considerable attractions.

Frequent use of this spar or outrigger torpedo was made during the American Civil War. A notable instance was the destruction of the Confederate ironclad *Albemarle* at the end of October 1864. On this mission Lieutenant Cushing took a steam launch equipped with an outrigger torpedo up the Roanoke river, in which lay the *Albemarle.* On arriving at the ship Cushing found her surrounded by logs, but pushing his boat over them, he immersed the spar and exploded his charge in contact with the *Albemarle* under a heavy fire. Ship and launch sank together, but the gallant officer jumped overboard, swam away, and escaped. Submerged boats were also used for similar service, but usually went to the bottom with their crews. During the war between France and China in 1884 the *Yang Woo* was attacked and destroyed by an outrigger torpedo.

Locomotive Torpedoes.—Though the spar torpedo had scored some successes, it was mainly because the means of defence against it at that time were inefficient. The ship trusted solely to her heavy gun and rifle fire to repel the attack. The noise, smoke, and difficulty of hitting a small object at night with a piece that could probably be discharged but once before the boat arrived, while rifle bullets would not stop its advance, favoured the attack. When a number of small guns and electric lights were added to a ship's equipment, success with an outrigger torpedo became nearly, if not entirely, impossible. Attention was then turned in the direction of giving motion to the torpedo, and steering it to the required point by electric wires worked from the shore or from another vessel; or, dispensing with any such connexion, of devising a torpedo which would travel under water in a given direction by means of self-contained motive power and machinery. Of the former type are the Lay, Sims-Edison, and Brennan torpedoes. The first two—electrically steered by a wire which trails behind the torpedo—have insufficient speed to be of much practical value, and hence are little used. The Brennan, since its adoption by the British Government for the defence of harbours and channels, has been developed and improved, especially in speed, which is now over twenty knots. Hence its superiority over other forms of controlled torpedo. It has the defect of all the species, that of possessing a very limited effective radius—much less than the range of modern guns—which consequently confines its use to narrow waters.

Uncontrolled Torpedoes (the Howell).—The objection of naval officers to have any form of torpedo connected by wire to their ship during an action, impeding her free movement, liable to get entangled in her propellers, and perhaps exploding where not desired—disadvantages which led them to discard the Harvey towing torpedo some years ago—has hitherto prevented any navy from adopting a controlled torpedo for its sea-going fleet. The last quarter of the 19th century saw, however, great advances in the equipment of ships with locomotive torpedoes of the uncontrolled type. The Howell may be briefly described as one of American origin, and has been placed in the armament of some of the warships of the United States: it has also a special feature of some interest. In this—as in all uncontrolled torpedoes—there is no attempt to steer it after entering the water, but the same direction is preserved throughout the run, allowance being made for the movement of the object at which it is directed. Motive power is provided in the Howell by causing a heavy steel fly-wheel inside the torpedo to revolve with great velocity previous to discharging the torpedo. This is effected by a small special engine outside operating on the axle. When sufficiently spun up, the axle of the fly-wheel is connected with the propeller shafts and screws which drive the torpedo, so that on entering the water it is driven ahead and continues its course until the power stored up in the fly-wheel is exhausted. The speed, therefore, is continually diminishing, but special mechanism has been devised to enable a uniform rate of progress to be maintained. A controlling apparatus keeps the torpedo from diving or coming to the surface, thus preserving a fixed depth throughout the run. Now when a torpedo is discharged into the sea from a ship in motion, it has a tendency to deflect owing to the action of the passing water. The angle of deflection will vary according to the speed of the ship, and is also affected by other causes, such as the position in the ship from which the torpedo is discharged, and its own angle with the line of keel. Hence arise inaccuracies of shooting; but these do not occur with this torpedo, for the motion of the fly-wheel, acting as a gyroscope—the principle of which applied to the Whitehead torpedo is described later—keeps this torpedo on a straight course. This advantage, combined with simplicity in construction, induced the American naval authorities at one time to contemplate equipping their fleet with this torpedo, for they had not, up to within a few years ago, adopted any locomotive torpedo. A great improvement in the torpedo devised by Mr Whitehead led them, however, definitely to prefer the latter, and to discontinue the further development of the Howell system.

Whitehead Torpedo.—Almost every year chronicles some advance in this wonderful piece of mechanism. The outward form is now somewhat different from that originally adopted. In place of a sharply-pointed head—believed at one time to be necessary for speed—the foremost compartment is now made much fuller, which not only adds to the speed, but allows of double the amount of explosive being carried with the same length and diameter of torpedo. All are now made with this bluff head or nose. This modification, with increased efficiency in the Brotherhood three-cylinder air engine, has enabled a speed of 30 knots for a short range to be attained. This is with a torpedo of 14 inches diameter. For a longer range a larger weapon must be employed capable of carrying a greater supply of air. To obtain this, torpedoes of 18 inches diameter, involving increased length and weight, have for some time been constructed, and have taken the place of the smaller torpedo in the equipment of warships. This advance in dimensions has not only given a faster and steadier torpedo, but enabled such a heavy charge of gun-cotton to be carried that its explosion against any portion of a ship would inevitably either sink or disable her. The dimensions, shape, &c., of the present 14 and 18 inch torpedoes are shown in Fig. 1. The defect of the Whitehead torpedo hitherto had been that a very limited range was imposed by the uncertainty of its course under water. The speed of the ship from which it was discharged, the angle with the keel at which it entered the water, and the varying velocity of impulse, tended to error of flight, such error being magnified the farther the path of the torpedo was prolonged. Hence 600 yards was considered the limit of distance within which the torpedo should be discharged at sea against an object from a ship in motion.

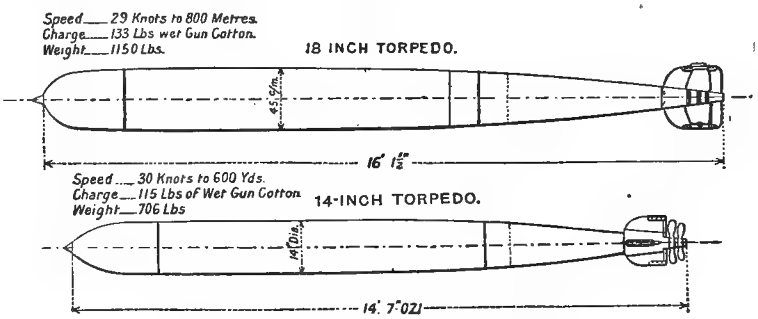

Speed—29 Knots to 800 Metres.
Charge—133 Lbs wet Gun Cotton.
Weight—1150 Lbs.
18 INCH TORPEDO.
45 c/m
16′ 1½″
Speed—30 Knots to 600 Yds.
Charge—115 Lbs of Wet Gun Cotton
Weight—706 Lbs
14-INCH TORPEDO.
14″ Dia.
14′ 7″·021

Fig. 1.—Diagrams of 14 and 18 inch Torpedoes.

In these circumstances, though improvements in the manufacture of steel and engines allowed of torpedoes of far longer range being made (the fastest torpedo up to 1898 having a speed of 29 knots for 800 yards), it was of no advantage to make them, as they could not be depended upon to run in a straight line from a stationary point for more than 800 yards, while from a ship in motion good practice could only be ensured at a reduced range. It was obvious, therefore, that to increase the effective range of the torpedo, these errors of direction must be overcome by some automatic steering arrangement. Several inventors have turned their attention to the subject since 1885, nearly all of whom proposed to utilize the principle of the gyroscope for the purpose. The first which gave any satisfactory results was an apparatus devised by Mr Ludwig Obry—an engineer in Austria—and tried by the Italian Government about 1896. These trials demonstrated the feasibility of accurately and automatically steering a torpedo in a direct line by this means. Messrs Whitehead and Co. of Fiume then acquired the invention, and after exhaustive experiments produced the apparatus which is now fitted to every torpedo made. It is based on the principle that a body revolving on a free axis tends to preserve its plane of rotation. A gyroscope with plane of rotation parallel to the vertical axis of the torpedo will have an angular motion if the torpedo is diverted from its original course. This angular motion is employed to actuate the steering mechanism by operating an air motor connected with the rudders, and keeping the torpedo in the line of discharge. The apparatus consists of a fly-wheel caused to rotate by a spring, the barrel on which the latter is wound having a segmental wheel which gears into a toothed pinion spindle of the fly-wheel. Owing to the diameter of the segment being much greater than the pinion, a rapid rotatory motion is imparted. The spring is wound up by a key from outside the torpedo, and kept in tension until the projectile is discharged, when the spring is released by the air lever being thrown back, which admits air to the engine; the gyroscope is then freed and set in motion with its plane in the plane of the vertical axis of the torpedo as it was in the launching tube.

Assuming now that the course of the torpedo is diverted by any cause, its axis will move or perform a certain angular motion with regard to the plane of the fly-wheel, which will have the same result as if we consider the conditions reversed, *i.e.*, as if the plane of rotation of the fly-wheel were altered and that of the axis of the torpedo remained the same. The axis of the fly-wheel performs a relative angular motion which it imparts to a crank actuating a servo-motor worked by compressed air, and connected with the rudders of the torpedo, moving them in the opposite direction to that in which the torpedo was diverted from its original course. Thus all inaccuracies of flight due to errors of adjustment, miscalculation of deflection, or even damage to some part, are eliminated. As long as the gyroscope is in good order the torpedo is bound to run in the line it was pointing when the fly-wheel was started. But the gyroscope can do more. By suitable adjustment the torpedo can be made to turn to any given angle from the direction of discharge, and then run in a straight line. For instance, when discharged from a tube fixed right ahead, the torpedo can be made, by means of the gyroscope, to travel in a new direction on either side; or supposing it be desired to fire ahead from a broadside tube which does not traverse sufficiently in that direction, the object can be attained by means of this apparatus. It is placed in the after body of the torpedo, as indicated in Fig. 2.

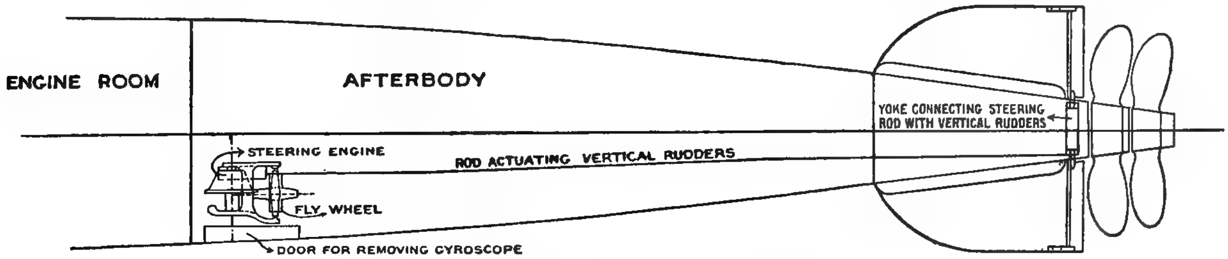

ENGINE ROOM
AFTERBODY
YOKE CONNECTING STEERING ROD WITH VERTICAL RUDDERS
STEERING ENGINE
ROD ACTUATING VERTICAL RUDDERS
FLY WHEEL
DOOR FOR REMOVING GYROSCOPE

Fig. 2.—Arrangement of Gyroscope in Torpedo.

The efficiency of the Whitehead torpedo has thus been enormously increased, and more accurate practice can now be made at 2000 yards than was formerly possible at 800 yards. This adds considerably to the chances of torpedo-boats attacking ships, even in daytime, at sea or at anchor, and will render further protection necessary against this weapon. Against a ship in motion there is still, however, the calculation as to her speed, and the distance she will travel before the torpedo reaches her. Should this be miscalculated, an increased range for torpedoes will magnify the error. For instance, a 30-knot torpedo will travel 1000 yards in a minute. If aimed at a ship on the beam assumed to be steaming 15 knots an hour, to reach her when 1000 yards distant the torpedo must be discharged at a point 500 yards ahead of her. But if the ship is actually steaming 12 knots, she will have travelled only 400 yards in the minute, and the torpedo will be 100 yards in advance of her. If discharged at a range of 500 yards, such a miscalculation causes an error of only 50 yards or 150 feet. But if the object is 300 feet long, and her centre was taken as the target, her bow would be just at the spot the torpedo would reach in thirty seconds. It would seem, therefore, that increased velocity of torpedo is necessary before the full advantages of the gyroscope can be realized. To attain this, higher pressures of air are sought, and experiments are being carried out with nickel-steel air-chambers, by which, without increasing their weight, they can safely stand a greater working pressure. Longer-range torpedoes are, however, being adopted by most nations. The following dimensions of torpedoes made by Messrs Whitehead for Japan will show what has been done in this direction:—

Length	21 feet 4 inches.
Diameter	17·7 inches.
Weight complete	1968 ℔.
Weight of explosive	198 ℔.
Pressure of air	2250 ℔ on square inch.
Speed for 2000 metres (2187 yards) .	28 knots.
Speed for 1000 metres (1094 yards) .	31 knots.

Torpedo Carriages and Discharge.—As no gun which is inefficiently mounted can give good results, so the best torpedo is valueless without a good carriage or system of discharge. In the early days of the Whitehead, discredit came upon it because the importance of this was not sufficiently realized; and an erratic course under water was in nine cases out of ten due to a crude method of discharge. A delicate piece of mechanism was dropped into the water from a height of several feet, and naturally suffered internal derangement. Gun-ports were then used for the purpose, but now a special orifice is made, to which the torpedo carriage is fitted with a ball-and-socket joint—forming a water-tight aperture—so that this carriage or tube may be only 2 or 3 feet above the water-line. The ball-and-socket joint enables it also to have a considerable angle of training. Originally the torpedo was pushed out by a rod acted upon by compressed air, in which case the carriage was a simple frame. The rod, pressing against the tail with some force, was apt to damage or disarrange the rudders, so the air-gun took the place of rod impulse. Here the torpedo fits closely in a tube or cylinder with an opening at the rear made air-tight when closed. At the desired moment compressed air is admitted to the rear part of the cylinder and blows the torpedo out. Gunpowder then superseded air for this operation; and now this has given place to a small charge of cordite, which does not leave any deposit on the inside of the cylinder. There is a double risk in the use of locomotive torpedoes from above water. (1) The charge may be exploded by hostile fire. Though mainly consisting of damp gun-cotton, which is not readily ignited, the dry primer and detonator may be struck, which would lead to a disastrous explosion. (2) The air-chamber is also a source of danger. As it contains air compressed to a high degree of tension, experiments have shown that if struck by a small shell it may burst with great violence; and as it offers a considerable mark, this is not an improbable event in an action. An instance of the danger of above-water torpedo tubes occurred in the Spanish–American war at the battle of Santiago. A shell entered the *Almirante Oquendo* and struck a 14-inch torpedo in the tube. The charge detonated, causing a fearful explosion and practically wrecking that part of the vessel. The development of moderate-sized quick-firing guns has increased this risk. Hence we find the use of above-water torpedo tubes diminishing, and in time this method of discharge will probably be employed only in special torpedo craft and such vessels as afford armour defence to positions where these weapons are located.

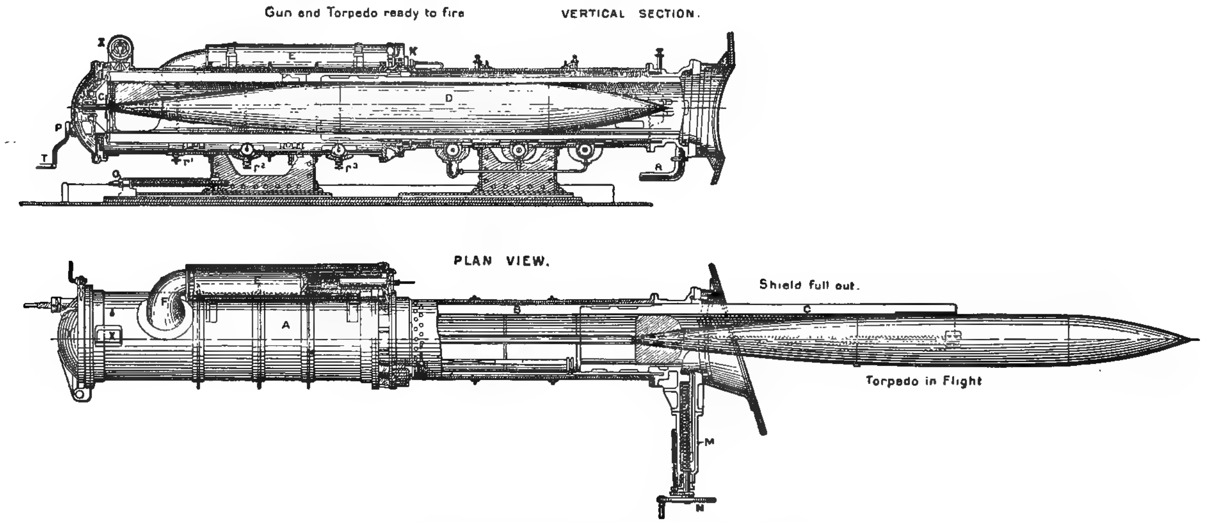


Fig. 3.—Broadside submerged 18-inch Torpedo Tube.

Submerged Discharge.—The risk attached to having loaded torpedoes above the water-line—independently of the fact that to get the best result they should start in the element to which they belong—has given great impetus to the system of submerged discharge. From the earliest days of the weapon this has been employed to some extent. But it was principally in the direction of right-ahead fire, by having an orifice in the stem of the ship under water, to which a torpedo tube was connected. The tactical idea was thus to supplement attack with the ram, so that if the vessel endeavouring to ram saw that the object would evade this attack, she could project a torpedo ahead, which, travelling faster than the vessel, might as effectually accomplish the required service. The stem orifice had a watertight cover, which was removed on the torpedo being placed in the tube and the inner door closed; then, sufficient impulse being imparted to eject the torpedo, and its machinery being set in motion at the same time, it darted forward towards the enemy. There is, however, some risk of the ship using a torpedo in this manner striking it before the missile has gathered the necessary impetus from its propellers to take it clear of the vessel. The system, moreover, has the disadvantage of weakening the ram, the construction of which should be of immense strength. There is the further liability of ramming with a torpedo in the bow tube, which would be as disastrous to friend as foe. This method of submerged discharge has therefore given place to ejecting the torpedo from the broadside. Considerable difficulty attached to getting the torpedo clear of the ship from this position without injury, especially when the vessel was proceeding at speed. The natural tendency of the passing water acting on the head of the torpedo as it emerged was to give a violent wrench and crush the rear end before that portion could clear the aperture. To prevent this the torpedo must be held rigid in the line of projection until the tail is clear of the ship. This is thus effected. Besides the tube with aperture in side of the ship under water, fitted with sluice-valve, all broadside submerged discharge apparatus possess the following features: A shield is pushed out from the ship's side. In this shield there are grooves of some form. Guides on the torpedoes fit and run in these grooves. When discharged the torpedo is thus supported against the streams of passing water, and guided so that its axis continues in the line of projection until the tail is clear of the side, the shield being of such length that this occurs at the same time that the guides on the torpedo leave the grooves in the shield. An apparatus on this principle has been fitted to a number of ships of the British navy, and gives good results at high rates of speed. It has the defect that the shield must be run out previous to the torpedo being discharged, and brought back afterwards, thus involving three separate operations, each performed by compressed air.

In the broadside submerged discharge, designed, constructed, and supplied to many foreign navies by Messrs Armstrong of the Elswick works, the three operations are combined in one. There is an outer tube as before, but it contains an inner tube carrying the torpedo. Fixed to this tube, and prolonging it, is the shield fitted with grooves. Both tubes have a door at the rear—made airtight when closed—by which the torpedo is entered. A charge of cordite is used for ejection instead of compressed air, the gas from which entering the outer cylinder first forces the inner tube out, and then by means of a valve in the door of the inner tube passes in and blows out water and torpedo together, the shield supporting the latter until the tail is clear of the ship. By this time the cordite gas has expanded and cooled so as to relieve the pressure in rear; this causes the pressure of the water outside to push the shield and tube into the ship again, so that practically the whole operation is one motion.

Fig. 3 will further explain this apparatus. A is the outer tube; B the inner tube; C the shield; D torpedo; E explosion chamber for cordite charge placed at K; F pipe for gas to pass into outer tube; G and Y doors of inner and outer tube; J the valve which opens automatically when inner tube arrives at position shown in Fig. 2; T and P appliance for running the tube in and out by hand when desired; O arrangement for bringing whole apparatus back for repair, &c.; M and N sluice-valve and handle; R, r^1, r^2, r^3, for draining tubes before torpedo is put in; X indicator showing position of inner tube.

Torpedoes have been discharged from this apparatus with successful result from a ship steaming at 17½ knots.

The advantage of cordite over compressed air for impulse is that it requires no attention: when a charge is placed in the explosion chamber, and a torpedo is in the tube, all is in readiness for firing when desired, without further attention in the torpedo-room. The cordite is fired by electricity from the conning-tower; the officer, therefore, having ascertained that all is ready below, has only to press a button when the object is in the required position. Automatic indications are given in the conning-tower when the sluice-valve is opened and when all is in readiness for firing.

This method of discharging torpedoes from the broadside under water eliminates the principal danger of the system, which required the shield to be put into position beforehand. It was then liable to be struck and distorted by passing wreckage without the fact being apparent to those in the ship. On the discharge of a torpedo its course might thus be arrested, or possibly the charge be prematurely exploded in dangerous proximity to its own ship. There was a risk of getting the shield out too soon, and thereby exposing it unduly to injury, or leaving the operation until too late. The tendency of naval equipment being towards complication, any readjustment which makes for simplicity cannot be otherwise than beneficial, and this feature is especially desirable in all matters connected with the use of torpedoes.

The compartment containing the broadside submerged apparatus usually extends across the ship, so as to contain a tube for each side. In the largest ships it is now customary to have two compartments—one forward and the other aft—for this part of the armament, with a pair of tubes in each; while above-water tubes are being given up where interior space will admit of a submerged discharge.

Use in War.—It is difficult to say what place the Whitehead torpedo will take in the next great naval war, and whether it is destined to fulfil those expectations which the expenditure allotted everywhere to this branch would seem to warrant. This generation believes it has found in the torpedo a most potent weapon with which the biggest vessels may be sunk, or rendered harmless, besides possessing the further great advantage that it can be taken into action on small and inexpensive constructions. Hence the great development of the torpedo-boat all over the world. Since the locomotive torpedo was adopted as a weapon of naval warfare, however, it has scored successes only when used in connexion with craft specially constructed for its use. Though the armament of all battleships and cruisers is not considered complete without an installation of Whitehead torpedoes, there is no instance of either suffering injury from one of their own class employing this weapon in recent wars. At the battle of Yalu, between the Chinese and Japanese fleets, torpedoes were discharged by the former, but none took effect. The Japanese trusted solely to gun-fire. In the war between Spain and the United States the inferiority of Admiral Cervera's squadron to that under Admiral Sampson might at the battle of Santiago have been to some extent counterbalanced by a skilful and vigorous use of torpedoes. If, instead of striving only to escape, a bold dash had been made for the American ships, the Spanish cruisers rapidly approaching end on to the foe, enveloped in the smoke of their own guns, should—some at least—have got within torpedo range without fatal injury. Closing each other at a speed of 10 knots only, they would cover an interval of 6000 yards in 9 minutes —a short time in which to disable a ship by gun-fire under such conditions. But Cervera elected to offer a passive resistance only, and while suffering destruction wrought no material injury upon his opponents. On the other hand, there have been several instances of large warships being sunk by locomotive torpedoes discharged from small craft. During the Chilian revolutionary war of 1891, a battleship, the *Blanco Encalada*, of 3500 tons, was attacked in Caldera Bay by two torpedo vessels—the *Lynch* and *Condell*—of 750 tons. They entered the bay at dawn, the *Condell* leading. This vessel fired three torpedoes which missed the ironclad; then the *Lynch*, after one ineffective shot, discharged a second torpedo, which struck the *Blanco* on the side nearly amidships. The latter had opened fire with little result, and sank soon afterwards. A similar incident occurred in 1894, when the Brazilian ironclad *Aquidaban* was sunk in Catherina Bay by the *Sampaio*—a torpedo vessel of 500 tons. She entered the bay at night, and first discharged her bow torpedo at the ironclad, which missed; she then fired a broadside torpedo, which struck and exploded against the bow of the *Aquidaban*. It caused a great shock on board, throwing an officer on the bridge into the water. The vessel sank soon afterwards, and the *Sampaio* escaped uninjured.

After the defeat of the Chinese at sea, their remaining ships took refuge in the harbour of Wei-hai-wei. Here they were blockaded by the Japanese fleet, which, having a number of torpedo-boats, made several determined attacks upon the ships inside. After one or two attempts, foiled by the obstructions placed by the Chinese to bar the passage, the Japanese boats succeeded in torpedoing several ships, and thus expedited the reduction of the place.

Effect upon Naval Tactics; Blockade.—It has often been assumed that steam and the torpedo-boat will in future render blockade impossible as it was carried out in the old wars; that, no longer dependent upon the wind to allow egress from the blockaded port, a vessel using steam can emerge when she chooses, while fear of torpedo attack will deter a blockading squadron from keeping such watch as to foil the attempt. As regards the power conferred by steam, it will be no less advantageous to a blockading squadron, enabling it to maintain its position, whereas sailing ships were often driven by gales to leave their station and seek a port. This gave opportunities for the blockaded vessels to escape. As regards torpedo-boats, they would no doubt be a danger to a blockading squadron unprovided with a means of defence against these craft. Such defence consists in an adequate number of small vessels interposing an in-shore squadron between the port and the main body outside. Thus they perform the two-fold service of watching the enemy's movements within and frustrating a torpedo attack.

The battleships of a squadron adequately provided in this respect would not require to remain close to a port; but, having a chain of communication with the advanced flotilla, its guard would be no less effective. As an instance of blockade under modern conditions, we have that of Admiral Sampson upon Santiago—a guard more rigidly maintained than any in the old wars. So little was he deterred by the knowledge that Admiral Cervera had two torpedo vessels in his force, that he drew his squadron closer in at night, when an attack might be expected, actually illuminating the entrance of the harbour with his electric search-lights, so that no craft could come out unperceived. No attempt was made to dislodge him from that position, and we may perhaps assume that blockade, if required in any scheme of naval strategy, will be carried out, whatever the weapons of warfare.

As regards the effect of torpedoes upon tactics at sea, and in general, as well as single ship, actions, they must operate against close range and employment of the ram. If it is recognized that a vessel within 800 yards—the effective radius of the torpedo—is liable to a fatal blow, she will endeavour in ordinary circumstances to keep outside that distance and rely upon gun-fire. The exception would be where she is overmatched in that respect, and hence might endeavour to restore the balance by the use of torpedoes. In a fleet action the danger of missing the foe and hitting a friend would restrict the discharge of torpedoes; and this risk increases as formations disappear. But the torpedo must be conceded a tactical superiority over the ram for the following reasons. A vessel to use the latter must come within torpedo range, while her adversary may successfully apply torpedoes without placing herself in any danger of being rammed. The ram can only be used in one direction, and a small miscalculation may cause disaster. If a vessel has more than one position from which torpedoes can be discharged, she is not confined as regards attack to a single bearing or direction.

In action we may consider the speed of the torpedo as double that of the ship, and since against a moving object allowance must be made for the space traversed while ram or torpedo is travelling towards it, the faster weapon is less affected in its chance of successful impact by change of direction and speed of the object at the last moment. Lastly, with machinery disabled a ship is powerless to use the ram, but can avert a ram attack with her torpedoes. The movements of squadrons or single ships on entering an action are not likely to be influenced by any contemplated immediate use of torpedoes, for the gun must remain the primary weapon, at any rate at the first onset. Commanders would hardly risk being crushed by gun-fire before getting within torpedo range. Having faith in the efficiency of their ordnance and the gunnery skill of their crew, they would first manœuvre to bring these into play. Tactics for torpedo attack in such circumstances have not therefore been laid down, and it is only necessary to consider the positions which are advantageous for the use of this weapon, and, conversely, what should be avoided when a vessel, finding herself overmatched in gunnery, seeks to redress the balance with torpedoes.

Size of Target.—This, with a ship, varies in length as the torpedo approaches end on to the vessel, or at angle to the line of keel; the greatest being when the path of both forms a right angle. Hence the object is to place your ship where it presents the former condition to the enemy, while he affords the larger target. It must be remembered that, owing to the comparatively slow velocity of the torpedo, it must be aimed not directly at a ship in motion—like a shot from a gun—but at a point ahead which the ship will reach after the torpedo has traversed the intervening distance. Thus speed of object has to be estimated, and hence the importance of adding to the velocity of the torpedo and getting a broadside shot so as to reduce as much as possible errors of calculation. The great increase of the dimensions of warships, especially in length, which now has reached and exceeded 400 feet, adds to the chances of a successful hit with torpedoes, and will doubtless tend to diminish a desire in future naval tactics to close inside torpedo range for the purpose of ramming.

Range.—Though the effective range of a torpedo is fixed at 800 yards, it does not follow that ships must be within that distance of each other before this weapon comes into play. At certain bearings the object will be considerably outside this distance at the moment of discharge; but if approaching, and her course remain unaltered, she will reach a point within 800 yards of the spot from which the torpedo started. In the interval her enemy will also have traversed a certain distance, so that the two may never come within 1000 yards of each other. It thus follows, as stated, that a ship cannot ram without liability to torpedo attack, whereas it is possible to disable or sink with torpedo without risk of being rammed.

Taking range and size of target together, the most advantageous position is to be on the bow of the enemy while he bears abaft your beam. Thus situated, he is exposed to your broadside and quarter discharges, while by working the helm so as to turn your stern to him you diminish his target and increase the distance his bow torpedo has to run before it can overtake you. Thus a high speed of ship enables her to attain the most advantageous position, and renders more difficult the counter attack with the same weapon.

Finally, by improvements in construction and methods of discharge the torpedo has recovered the place it was rapidly losing a few years ago. As armour receives increased resisting power to above-water projectiles, and gets on a level again with the gun, more attention will be given to under-water attack, against which no adequate protection has yet been devised. Thus we shall probably find the torpedo taking a very prominent place in any future war between the great maritime Powers.

(S. M. E.-W.)

Torquay, a municipal borough (1892) and watering-place in the Torquay parliamentary division of Devonshire, England, on the north side of Tor Bay, 215 miles west-south-west of London by rail. A commission of the peace was granted to the borough in 1893. The harbour has been extended by the corporation at a cost of £90,000. The drainage has been efficiently carried out at a cost of £70,000, the water-supply improved at a cost of upwards of £150,000, and electric light introduced (1898) by the corporation. Modern erections are a church and the Princess pier and groyne. The hospital has been enlarged. Area, 1465 acres. Population (1891), 25,534; (1901), 33,625.

Torre Annunziata, a town of the province of Naples, Campania, Italy, on the east side of the Bay of Naples, and at the south foot of Mount Vesuvius, 14 miles south-east of Naples by rail. It has a royal arms factory and other iron-works, considerable manufacture of macaroni, breeding of silkworms, and some fishing and shipping. The harbour is protected by moles, and in 1897 was cleared by 1585 vessels of 194,889 tons. Population (1881), 20,829; (1900), about 26,000.

Torre del Greco, a town of the province of Naples, Campania, Italy, on the east shore of the Gulf of Naples, and at the south-west foot of Mount Vesuvius, 8 miles south-east of Naples by rail. It has shipbuilding yards and lava quarries. The inhabitants play a prominent part in the coral fishing off the African and Sicilian coasts, and coral is worked in the town, the workers being partly trained in a technical school. There is also fishing for tunny, sardines, and oysters. Further, hemp is woven and wine made. Population (1881), 21,588; (1900), about 25,000.

Torredonjimeno, a town of Spain, province of Jaen, to the north of Martos, on the river Salado de Porcuna, on the railway from Puente Jenil to Linares. It has fine squares, broad streets, a large parish church, town hall, several convents, and modern schools. The neighbourhood produces good wine, oils, wheat, and fruit. Population (1887), 9399; (1897), 10,370.

Torrens, Sir Robert Richard (1814–1884), British colonial statesman, was born at Cork, Ireland, in 1814, and educated at Trinity College, Dublin. He went to South Australia in 1840, and was appointed collector of customs. He was in this capacity an official member of the first Legislative Council, and in 1852 filled the position of Treasurer and Registrar-General. When responsible government was established he was elected as a representative for Adelaide and became a member of the first Ministry. In 1857 he introduced his famous Real Property Act, which he contended would render the transfer of land as simple in method as the transfer of vessels. The principle of the Act consists of conveyance by registration and certificate instead of deeds. The system was rapidly adopted in the other colonies and elsewhere, and was expounded by the author during a visit to the United Kingdom in 1862–64. After finally leaving South Australia, Sir R. R. Torrens represented Cambridge in the House of Commons from 1868 to 1874. In 1872 he was knighted in recognition of the benefits attending the operation of his Real Property Act wherever it had been introduced. He was the author of works on the effect of the gold discoveries on the currency, and other subjects. He died 31st August 1884.

Torrens, William Torrens M'Cullagh (1813–1894), English politician and social reformer, son of James M'Cullagh (whose wife's maiden name, Torrens, he assumed in 1863), was born near Dublin, 13th October 1813. He went to the bar, and in 1835 became an active member of the special commission on Irish poor-relief, which resulted in the extension of the workhouse system in Ireland in 1838. His work, which involved travelling all over the country, started him on the path of useful social reform, which he followed up by doing much to encourage the establishment of mechanics' institutes and other modes of helping popular education. In the 'forties he joined the Anti-Corn-Law League, and in 1846 published his *Industrial History of Free Nations.* In 1847 he was elected to Parliament for Dundalk, and sat till 1852. In 1857 he was elected as a Liberal for Yarmouth, and from 1865 to 1885 he represented Finsbury. Torrens was a well-known man in political life, and devoted himself mainly to social questions in Parliament. It was an amendment of his to the Education Bill of 1870 which established the London School Board, and his Artisans' Dwellings Bill in 1868 was an important step in the direction of the clearing away of slums by local authorities: in many other ways, too, he acted as a true philanthropist. He published several books, and his *Twenty Years in Parliament* (1893) and *History of Cabinets* (1894) contain useful material. He died in London, 25th April 1894.

Torres Novas, a town of Portugal, district of Santarem, 19 miles N.N.E. of Santarem. It has manufactures of cottons, linens, jute, paper, leather, and spirits. It was founded probably by Greeks, and was successively in the power of the Romans, Goths, and Arabs, from whom it was conquered in 1148 by Affonso Henriquez. Population (1890), 9256; (1900), 10,738.

Torres Vedras, a town of Portugal, district of Lisbon, 36 miles N.N.W. of Lisbon. Here were the noted fortifications known as the "lines of Torres Vedras," constructed by Lord Wellington in 1810. Here in 1846 the troops of General Saldanha defeated those of the Count de Bomfim, and seized the castle and town. The town possesses hot sulphur baths. Population (1890), 6022; (1900), 6891.

Torrevieja, a town of Spain, province of Alicante, on the southern coast, with railway to Albatera Catral, on the Alicante–Murcia line. Population (1887), 7724; (1897), 7833. The district is famous for its salt beds, which constitute a Government monopoly. The industries are chiefly fisheries, and the making of everything connected with navigation. The roadstead affords safe anchorage for vessels of all sizes. There is an active trade in fruit and agricultural products. Great quantities of salt are produced from several lagoons and smaller pans, the Laguna Grande alone yielding more than one hundred thousand tons a year.

Torrington, a town and borough of Litchfield county, Connecticut, U.S.A., in the north-western part of the state, with a large rural population. The borough is on the Naugatuck river, and on a branch of the New York, New Haven, and Hartford railroad. The river furnishes good water-power, which has been utilized in varied manufactures. The town was incorporated in 1740, the borough in 1887. John Brown, the noted Abolitionist, was born in Torrington, 9th May 1800. Population of the town (1880), 3327; (1890), 6048; (1900), 12,453; of the borough (1890), 4283; (1900), 8360, of whom 2565 were foreign-born.

Torrington, Great, a municipal borough, railway station, and market town, Devonshire, England, in the South Molton parliamentary division of the county, 7 miles south-south-east of Bideford, on the Torridge. It is finely situated on a hill 300 feet high, and the river is here crossed by three bridges. A cattle market was erected in 1893, and a cottage hospital in 1897. The town received incorporation charters from Mary, James I., and James II., but all the borough records were destroyed by fire in 1724. There is a manufacture of silk gloves. Population (1891), 3436; (1901), 3241.

Tortosa, a town of Spain, province of Tarragona, on the Ebro, with a station on the coast railway from Valencia to Tarragona. The surrounding country produces oil, wheat, wine, fruit, and vegetables. No place in Spain for centuries has been so often seriously flooded. Many of the streets have been entirely rebuilt, and on the opposite bank of the Ebro a new suburb has sprung up, with modern buildings, squares, and better-paved streets. The fortifications are still standing, but are obsolete, the citadel being used as barracks and hospital. Population (1887), 25,192; (1897), 23,793.

Torts.—Tort is, in the law of England and the United States, the technical name of a civil wrong, *i.e.*, the breach of a duty imposed by law, by which breach some person becomes entitled to sue for damages. A tort must, on the one hand, be an act which violates a general duty. The rule which it breaks must be one made by the law, not, as in the case of a mere breach of contract, a rule which the law protects because the parties have made it for themselves. On the other hand, a tort is essentially the source of a private right of action. An offence which is punishable, but for which no one can bring a civil action, is not a tort. It is quite possible for one and the same act to be a tort and a breach of contract, or a tort and a crime; it is even possible in one class of cases for the plaintiff to have the option —for purposes of procedural advantage—of treating a real tort as a fictitious contract; but there is no necessary or general connexion. Again, it is not the case that pecuniary damages are always or necessarily the only remedy for a tort; but the right to bring an action in common law jurisdiction, as distinct from equity, matrimonial, or admiralty jurisdiction, with the consequent right to damages, is invariably present where a tort has been committed.

This technical use of the French word *tort* (which at one time was nearly becoming a synonym of *wrong* in literary English) is not very ancient, and anything like systematic treatment of the subject as a whole is very modern. Since about the middle of the 19th century there has been a current assumption that all civil causes of action must be founded on either contract or tort; but there is no historical foundation for this doctrine, though modified forms of the action of trespass did in practice largely supplant other more archaic forms of action by reason of their greater convenience.

The general scope of the law of torts has never been formulated by authority, the law having in fact been developed by a series of disconnected experiments with the various forms of action which seemed from time to time to promise the widest and most useful remedies. A short historical summary will be found in the article under this heading in the ninth edition of this work. But there is no doubt that the duties enforced by the English law of torts are broadly those which the Roman institutional writers summed up in the precept *Alterum non laedere*. Every member of a civilized commonwealth is entitled to require of others a certain amount of respect for his person, reputation, and property, and a certain amount of care and caution when they go about undertakings attended with risk to their neighbours. The precise amount of responsibility can be determined only by full consideration in each class of cases. It is important to observe, however, that a law of responsibility confined to a man's own personal acts and defaults would be of next to no practical use under the conditions of modern society. What makes the law of torts really effective, especially with regard to redress for harm suffered by negligence, is the universal rule of law that every one is answerable for the acts and defaults of his servants (that is, all persons acting under his direction and taking their orders from him or some one representing him) in the course of their employment. The person actually in fault is not the less answerable, but the remedy against him is very commonly not worth pursuing. But for this rule corporations could not be liable for any negligence of their servants, however disastrous to innocent persons, except so far as it might happen to constitute a breach of some express undertaking. We have spoken of the rule as universal, but, in the case of one servant of the same employer being injured by the default of another, an unfortunate aberration of the courts, which started about two generations ago from small beginnings, was pushed to extreme results, and led to great hardship. A partial remedy was applied in 1880 by the Employers' Liability Act; and in 1897 a much bolder step was taken by the Workmen's Compensation Act. But, as the common law and the two Acts (which proceed on entirely different principles) cover different fields, with a good deal of overlapping, and the Acts are full of complicated provisoes and exceptions, and contain very special provisions as to procedure, the improvement in substantial justice has been bought, so far, at the price of great confusion in the form of the law, and considerable difficulty in ascertaining what it is in any but the most obvious cases. The Workmen's Compensation Act includes cases of pure accident, where there is no fault at all, or none that can be proved, and therefore goes beyond the reasons of liability with which the law of torts has to do. In fact, it establishes a kind of compulsory insurance, which can be justified only on wider grounds of policy.

Employers' liability.

There are kinds of cases, on the other hand, in which the law, without aid from legislation, has imposed on occupiers and other persons in analogous positions a duty stricter than that of being answerable for themselves and their servants. Duties of this kind have been called "duties of insuring safety." Generally they extend to having the building, structure, or works in such order, having regard to the nature of the case, as not to create any danger to persons lawfully frequenting, using, or passing by them, which the exercise of reasonable care and skill could have avoided; but in some cases of "extra-hazardous" risk, even proof of all possible diligence—according to English authority, which is not unanimously accepted in America—will not suffice. There has lately been a notable tendency to extend these principles to the duties incurred towards the public by local authorities who undertake public works. Positive duties created by statute are on a similar footing, so far as the breach of them is capable of giving rise to any private right of action.

The classification of actionable wrongs is perplexing, not because it is difficult to find a scheme of division, but because it is easier to find many than to adhere to any one of them. We may start either from the character of the defendant's act or omission, with regard to his knowledge, intention, and otherwise; or from the character of the harm suffered by the plaintiff. Whichever of these we take as the primary line of distinction, the results can seldom be worked out without calling in the other. Taking first the defendant's position, the widest governing principle is that, apart from various recognized grounds of immunity, a man is answerable for the "natural and probable" consequences of his acts; *i.e.*, such consequences as a reasonable man in his place should have foreseen as probable. Still more is he answerable for what he did actually foresee and intend. Knowledge of particular facts may be necessary to make particular kinds of conduct wrongful. Such is the rule in the case of fraud and other allied wrongs, including what is rather unhappily called "slander of title," and what is coming to be known as "unfair competition" in the matter of trade names and descriptions, short of actual piracy of trade-marks. But where an absolute right to security for one's person, reputation, or goods is interfered with, neither knowledge nor specific intention need be proved. In these cases we trespass altogether at our peril. It is in general the habit of the law to judge acts by their apparent tendency, and not by the actor's feelings or desires. I cannot excuse myself by good motives for infringing another man's rights, whatever other grounds of excuse may be available; and it is now settled conversely, though after much doubt, and not without considerable dissent, that an act not otherwise unlawful is not, as a rule, made unlawful by being done from an evil motive. This rule was known some time ago to apply to the exercise of rights of property, and such speculative doubt as remained has lately been removed. Since the decision of the House of Lords in the leading case of *Allen* v. *Flood* (1898, A. C. 1), we know that it applies to the exercise of all common rights. The exceptions are very few, and must be explained by exceptional reasons. Indeed, only two are known to the present writer—malicious prosecution, and the misuse of a "privileged occasion" which would justify the communication of defamatory matter if made in good faith. In each case the wrong lies in the deliberate perversion of a right or privilege allowed for the public good, though the precise extent of the analogy is not certain at present.[1] It must be remembered, however, that the presence or absence of personal ill-will, and the behaviour of the parties generally, may have an important effect, when liability is proved or admitted, in mitigating or aggravating the amount of damages awarded by juries and allowed by the court to be reasonable. It may likewise be noted, by way of caution, that some problems of criminal law, with which we are not here concerned, require more subtle consideration. However, it is hardly ever safe to assume that the bounds of civil and criminal liability will be found coextensive. Perhaps we may go so far as to say that a man is neither civilly nor criminally liable for a mere omission (not being disobedience to a lawful command which he was bound to obey), unless he has in some way assumed a special duty of doing the act omitted.

We have already had to mention the existence of grounds of immunity for acts that would otherwise be wrongful. Such grounds there must be if the law is to be enforced and justice administered at all, and if the business of life is to be carried on with any freedom. Roughly speaking, we find in these cases one of the following conditions. Either the defendant was executing a lawful authority; or he was justified by extraordinary necessity; or he was doing something permitted by legislation for reasons of superior utility, though it may produce damage to others, and either with or without special provisions for compensating damage; or he was exercising a common right in matters open to free use and competition; or the plaintiff had, by consent or otherwise, disabled himself from having any grievance. Pure accident will hardly seem to any one who is not a lawyer to be a special ground of exemption, the question being rather how it could ever be supposed to be a ground of liability. But it was supposed so by many lawyers down to recent times; the reason lying in a history of archaic ideas too long to be traced here. Exercise of common rights is the category where most difficulty arises. Here, in fact, the point at which a man's freedom is limited by his neighbour's has to be fixed by a sense of policy not capable of formal demonstration. As Chief Justice Holmes of Massachusetts has said, we allow unlimited trade competition (so long as it is without fraud) though we know that many traders must suffer, and some may be ruined by it, because we hold that free competition is worth more to society than it costs. A state with different economic foundations might have a different law on this as on many other points. This freedom extends not only to the exercise of one's calling, but to choosing with whom and under what conditions one will exercise it. Also the law will not inquire with what motives a common right is exercised; and this applies to the ordinary rights of an owner in the use of his property as well as to the right of every man to carry on his business.[2] Owners and occupiers of immovable property are bound, indeed, to respect one another's convenience within certain limits. The maxim or precept *Sic utere tuo ut alienum non laedas* does not mean that I must not use my land in any way which can possibly diminish the profit or amenity of my neighbour's. That would be false. It is a warning that both his rights and mine extend beyond being free from actual unlawful entry, and that if either of us takes too literally the more popular but even less accurate maxim, "Every man may do as he will with his own," he will find that there is such a head of the law as Nuisance.

From the point of view of the plaintiff, as regards the kind of damage suffered by him, actionable wrongs may be divided into four groups. We have some of a strictly personal kind; some which affect ownership and rights analogous to ownership; some which extend to the safety, convenience, and profit of life generally—in short, to a man's estate in the widest sense; and some which may, according to circumstances, result in damage to person, property, or estate, any or all of them. Personal wrongs touching a man's body or honour are assault, false imprisonment, seduction or "enticing away" of members of his family. Wrongs to property are trespass to land or goods, "conversion" of goods (*i.e.*, wrongful assumption of dominion over them), disturbance of easements and other individual rights in property not amounting to exclusive possession. Trespass is essentially a wrong to possession; but with the aid of actions "on the case" the ground is practically covered. Then there are infringements of incorporeal rights which, though not the subject of trespass proper, are exclusive rights of enjoyment and have many incidents of ownership. Actions, in some cases expressly given by statute, lie for the piracy of copyright, patents, and trade marks. Wrongs to a man's estate in the larger sense above noted are defamation (not a strictly personal wrong, because according to English common law the temporal damage, not the insult, is, rightly or wrongly, made the ground of action); deceit, so-called "slander of title" and fraudulent trade competition, which are really varieties of deceit; malicious prosecution; and nuisance, which, though most important as affecting the enjoyment of property, is not considered in that relation only. Finally, we have the results of negligence and omission to perform special duties regarding the safety of one's neighbours or customers, or the public, which may affect person, property, or estate generally.

The law of wrongs is made to do a great deal of work which, in a system less dependent on historical conditions, we should expect to find done by the law of property. The law of negligence, with the refined discussions of the test and measure of liability which it has introduced, is wholly modern; and the same may be said of the present working law of nuisance, though the term is of respectable antiquity. Most recent of all is the rubric of "unfair competition," which is fast acquiring great importance.

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[1] It was until lately supposed that an action by a party to a contract against a third person for procuring the other party to break his contract was within the same class, *i.e.*, that malice must be proved. But since *Allen* v. *Flood*, and the latter decision of the House of Lords in *Quinn* v. *Leathem* (1901, A. C. 495), this view seems untenable. The ground of action is the intentional violation of an existing legal right.

[2] The rule that a man's motives for exercising his common rights are not examinable involves the consequence that advising or procuring another, who is a free agent, to do an act of this kind can, *à fortiori*, not be an actionable wrong at the suit of a third person who is damnified by the act, and that whatever the adviser's motives may be. This appears to be included in the decision of the House of Lords in *Allen* v. *Flood*. So far as we can learn, that decision, though not binding in any American court, is in fact likely to be approved and followed in most American jurisdictions. It is otherwise where a system of coercion is exercised on a man's workmen or customers in order to injure him in his business. The extension of immunity to such conduct would destroy the value of the common right which the law protects: *Quinn* v. *Leathem*. The coercion need not be physical, and the wrong as a whole may be made up of acts none of which taken alone would be a cause of action. In this point there is nothing novel, for it is so in almost every case of nuisance. Conspiracy is naturally a frequent element in such cases, but it does not appear to be necessary; if it were, millionnaires and corporations might exceed the bounds of lawful competition with impunity whenever they were strong enough. The reasons given in *Quinn* v. *Leathem* are many and various, but the decision is quite consistent with *Allen* v. *Flood*.

It will be observed that the English law of torts answers approximately in its purpose and contents to the Roman law of obligations *ex delicto* and *quasi ex delicto.* When we have allowed for the peculiar treatment of rights of property in the common law, and remembered that, according to one plausible theory, the Roman law of Possession itself is closely connected in its origin with the law of delicts, we shall find the correspondence at least as close as might be expected *à priori.* Nor is the correspondence to be explained by borrowing, for this branch of the common law seems to owe less to the classical Roman or mediæval Canon law than any other. Some few misunderstood Roman maxims have done considerable harm in detail, but the principles have been worked out in all but complete independence.

A list of modern books and monographs will be found at the end of the article on "Torts" by the present writer in the *Encyclopædia of the Laws of England*, vol. xii. p. 195. (Pollock's *Law of Torts* has reached a sixth edition, 1901.) He is not aware that anything new and important has been published on the subject since the date, September 1898, down to which that volume was revised. (F. PO.)

Toru. See UGANDA.

Totana, a town of Spain, province of Murcia, to the S.W. of Murcia, on the river Sangonera, with a station on the line from Murcia to Lorca. The surrounding country is mountainous to the north and level to the south, generally fertile, and producing wheat, almonds, olives, oranges, and other fruit. The town consists of two parts, styled Barrios de Sevilla and Triana, and has a fine square, large town hall, parish church with three naves (Santiago Apostle). Water is brought in for the fountains by an aqueduct 7 miles long from the Sierra de Espuña to a large reservoir in Jaspe, and a canal has been made from the Sangonera to the beach at Mazarron. Population (1887), 11,021; (1897), 11,634.

Totnes, a municipal borough, railway station, and market town, Devonshire, England, in the Totnes parliamentary division of the county, on the river Dart, 23 miles south by west of Exeter. It is connected with the suburb of Bridgetown by a stone bridge. From 1295 to 1867 (when it was disfranchised) the borough sent two members to parliament. The church of St Mary's (Early Perpendicular) is a fine one, with a peal of eight bells. It was reopened after restoration in 1889. A cottage hospital was built in 1901. The town was originally walled and entered by four gates; only the east and north remain. Bridgetown is now included in the municipal borough. Population (1891), 4113; (1901), 4034.

Totonicapan, chief town of a department of the same name, Guatemala, Central America. It is beautifully situated amidst luxuriant gardens on the same high plateau as Quezaltenango, from which it is some 12 miles distant to the north-east. It is inhabited mainly by Quiche Indians, employed chiefly in the making of cloth, furniture, pottery ware, and wooden musical instruments. There are hot mineral springs in the neighbourhood. Population, 25,000.

Tottenham, a suburb of London, in the Tottenham parliamentary division of Middlesex, 6 miles north of Liverpool Street by rail. A Roman Catholic church has been built, and Bruce Castle, an Elizabethan mansion, became public property in 1892, with its grounds of 20 acres. The Alexandra Palace is partly in this parish and partly in that of Muswell Hill. Population of the urban district (subdivided in 1888 into two districts, Tottenham and Wood Green) (1891), 71,343; (1901), 102,519.

Tottenville, formerly a village in Richmond county, New York, U.S.A., and since 1st January 1898 a part of Richmond borough, one of the five boroughs constituting New York City. It is near the south end of Staten Island, at the terminus of the Staten Island railway. The population is not separately returned by the census.

Touch. See PHYSIOLOGY: *Special Senses.*

Toul, chief town of arrondissement, department of Meurthe-et-Moselle, France, 14 miles west of Nancy, on the railway from Paris to Strasbourg. On the north side of the Marne and Rhine canal is the artillery park. In the garden behind the Hotel de Ville is a statue of "France recueillie" by Maindron (1874). At Bellevue, ½ mile north-west of the town, are large pottery works. The manufacture of embroidery is a local industry. Toul is now the centre of a vast entrenched camp. The hills surrounding the town are crowned with forts, constantly being strengthened, of which the highest is that of St Michel (1400 feet), whilst a series of forts, extending in echelon along the ridge bordering the Meuse, connects the fortifications with those of Verdun. Port traffic on the Canal de l'Est and Marne and Rhine amounted in 1900 to 251,561 tons. Population (1891), 8233; (1901), 9026.

Toulon, seaport and first-class fortress and torpedo station of France, department of Var, capital of the arrondissement of Toulon, on the Mediterranean, 42 miles east-south-east of Marseilles. It is the most important port in connexion with the French national military marine. It is frequently visited by foreign naval squadrons, and made the scene of friendly demonstrations not without political significance. The federation monument in commemoration of the centenary of the French Revolution was erected in 1890 in the Place de la Liberté, the finest in the new town. In 1883–87 a handsome Renaissance building was erected to accommodate the picture gallery and the town library. The principal industries, apart from the arsenal, are ship-building, fishing, lace-making, and wine-growing. Toulon possesses an observatory and a botanical garden. The Missiessy wet dock was added in 1889 to the naval arsenal. In 1899 379 vessels of 162,707 tons entered, and 376 of 160,708 tons cleared. Population (1886), 53,941; (1901), 101,172. (See DOCKYARDS: *French.*)

Toulouse, chief town of the department of Haute-Garonne, on the Garonne, 443 miles from Paris by rail. In respect of population it is the sixth town of France, and is the actual metropolis of this southern district, if judged by its historic and commercial importance. The Canal du Midi (between Bordeaux and Cette) has ceased to belong to the Southern Railways Company, and the shipping trade should receive a great impetus by reason of the consequent reduction in the tariffs. The monuments, in which the town is so rich, are restored and kept in repair. A colonnade and front were added to Notre Dame de la Daurade between 1890 and 1895, and at the back of the Capitole a façade has been built in place of the old, incongruous buildings, of which only the keep (now the depository of the archives) has been retained. The magnificent Hôtel d'Assézat has been bequeathed to the learned societies of Toulouse, which took possession of it in 1896; and the learned societies of all France, which for years had convened their annual sittings at Paris, held their congress in this building in 1899. The surplus treasures of the rich Museum of Antiquities have been bestowed on the Musée St Raymond, in which are various archæological, numismatic, and ethnological collections. The faculties of science, literature, law, and medicine, combined with pharmacy, were constituted a university in the year 1896. Population (1886), 123,040; (1901), 147,696.

Tourcoing, a town in the arrondissement of Lille, department of Nord, France, 2 miles north-west of Roubaix and 7½ miles north-east by north of Lille. A branch canal (1893) connects with the Roubaix canal. The town has extended in all directions, and many churches and public buildings have been erected, including an important school of industries and the Hôtel de Ville, an elegant structure in the Renaissance style, containing a museum of painting and sculpture. An abundant water-supply has been introduced. The industrial and commercial expansion has been very rapid, and Tourcoing now ranks as one of the foremost manufacturing centres of France. In 1897 there were 12 combing establishments employing 4800 persons; 58 spinning and twisting factories, with 580,000 spindles, employing 6460 persons, and producing 40,000,000 ℔ of yarn; 15 cotton spinning and twisting factories, with 540,000 spindles worked by 4200 persons, and producing 27,000,000 ℔ of yarn. In the weaving departments 4000 machine and 1000 hand looms turn out woollen and mixed woollen and cotton fabrics to the value of £1,400,000 every year, while the production of drapery, swan-skins, and jerseys is valued at £960,000 more. The making of velvet pile carpets has also greatly expanded, and the annual value of the output of that and allied industries now exceeds £500,000. Imports amounted in 1900 to £2,992,000, and exports to £5,164,000. The principal imports in 1898 were wool, forming 48 per cent., and flax, yarn, and hemp, together making up 20 per cent. of the total. Of the exports, combed wool, &c., accounted for nearly 70 per cent., while yarn, tissues, rags, and flax together made up nearly 16 per cent. of the total. Population (1891), 47,253; (1901), 78,233.

Tournai, a town of Belgium, in the province of Hainaut, 30 miles north-west of Mons, with a station at the junction of lines from Brussels to Lille (France) and from Mons to Courtrai. The Scheldt divides the town into two portions. Its manufacture of carpets is of ancient origin, but has declined in importance. Other industries include the manufacture of woollen and cotton goods, linen bleaching, and distilling. The public buildings are numerous and interesting. Population (1890), 34,442; (1900), 35,004.

Tours, chief town of the department of Indre-et-Loire, France, 145 miles south-west of Paris, on the railway from Paris to Bordeaux. The basilica erected over the tomb of St Martin was discovered as the result of excavations undertaken in 1860. Statues of Balzac (1889) and General Meusnier (1888) have been added to the public monuments. The printing works now give employment to only 800 persons, but have storage accommodation for 7 millions of books. Steel works, works for the manufacture of machinery and implements, iron foundries, and chemical works have become important industrial features. Population (1891), 54,283; (1901), 58,409.

Towanda, a borough of Pennsylvania, U.S.A., capital of Bradford county, on the North Branch of the Susquehanna river, and on the Lehigh Valley and the Barclay railways, in the north-eastern part of the state, at an altitude of 720 feet. It is in a lumber and farming region, and has planing-mills, furniture factories, and foundries. Population (1890), 4169; (1900), 4663, of whom 322 were foreign-born.

Townsville, a town, Queensland, Australia, on Cleveland Bay, about 870 miles north-west of Brisbane, in the county of Elphinstone. It has several handsome public buildings, including the Supreme Court and new custom-house. An excellent water-supply has been established. The tidal harbour is enclosed by stone breakwaters. Large vessels enter, and load frozen meat direct from the refrigerator cars. The port is an outlet for a wide area of pastoral country and for several goldfields, and has regular communication with all ports north and south by lines of steamers. The exports in 1899 were valued at over £3,000,000. The immigration barracks on Ross Island have accommodation for 500 persons. The railway station is the terminus of the Northern line, which extends 236 miles to Hughenden. Population (1891), 8564; (1901), 12,717.

Toxins and Antitoxins. See BACTERIOLOGY.

Trade, Balance of. See BALANCE OF TRADE.

Trade Marks.—This subject may conveniently be considered under the following heads: I. British Trade Marks before the Registration Acts, 1883–88; II. Trade Marks under the Registration Acts, 1883–88; III. "Passing off" and trade name; IV. Merchandise Marks; V. International and Imperial Arrangements; VI. Foreign and Colonial Trade Mark Laws.

I. *Before the Registration Acts.*—A trade mark may be defined as a symbol, consisting in general of a picture, a label, or a word or words, applied or attached to a trader's goods for the purpose of distinguishing them from the similar goods of other traders, and of identifying them as his goods, or those of his successors in the business in which they are produced or put forward for sale. A trade mark differs both from a patent and from a copyright in its legal character. In the case of a trade mark the property and the right to protection are in the device or symbol which is invented and adopted to designate the goods to be sold, and not in the article which is manufactured and sold. The article is open to the whole world to manufacture and sell, and all that the owner of the trade mark is entitled to prevent is such a use of his mark by other traders as will suggest that goods which are not his actually are so. On the other hand, patent-right and copyright protect the substance of the articles; and any unauthorized manufacture of it in the former case, or reproduction of it in the latter, while the protection lasts, is prohibited. The grounds, however, on which trade marks, patent-right, and copyright obtain legal recognition, though they are to a certain extent dissimilar, have a common element. Patent-right and copyright rest upon the view that the results of the original labour of the inventor and the author ought, as a matter alike of justice and of public policy, to be secured against piracy; while, as regards the proprietor of a trade mark, the question of originality, so long as the mark is sufficiently distinctive really to identify his goods (and, for purposes of registration, to satisfy the Trade Marks Acts) does not arise. But into the law of trade marks as well as into that of patents or copyright the element enters of a man's right to have the profit derivable from his own property guaranteed to him. "No man," said Lord Justice James in the case of the *Singer Manufacturing Co.* v. *Loog* (1880), defining in language that has become classic the foundation on which the law relating to trade marks rests, "is entitled to present his goods as being the goods of another man, and no man is permitted to use any mark, sign, or symbol, device or means, whereby, without making a direct false representation himself to a purchaser from him, he enables such purchaser to tell a lie or to make a false representation to somebody else who is the ultimate customer." The existing law in the United Kingdom cannot be properly appreciated unless the subject is approached in the first instance from the historical side. English trade mark law practically commences with the first years of the 19th century. The use of trade marks was indeed of far earlier date, for in 1742 we find Lord Hardwicke declaring that "every particular trader had some particular mark or stamp." But in the very case in which Lord Hardwicke made that statement (*Blanchard* v. *Hill*) he refused to protect the "Great Mogul" stamp on cards, being apparently under the influence of the notion that the legal recognition of trade marks would involve the creation of a new species of monopoly; and with regard to a case decided in the reign of James I. (*Southern* v. *How*), in which a clothier had applied the mark of another clothier to his own inferior goods, the reports leave it doubtful whether the action was brought by the owner of the mark, or by a defrauded customer, in which latter event it would be merely an ordinary action for deceit. But although the actual law of trade marks cannot be traced farther back than the beginning of the 19th century, Lord Eldon repeatedly granted injunctions to restrain one trader from fraudulently "passing off" his goods as those of another, and thus laid a foundation on which the present law has been built up. The stages through which its development passed possess considerable interest, and may be described quite briefly. The first reported case—apart from the doubtful one in the time of James I. above referred to—in which the infringement of a trade mark (a label on blacking) was restrained by the Court of Chancery was *Day* v. *Day* in 1816. In 1824 the common law courts, in the case of *Sykes* v. *Sykes*, established the right of the owner of an infringed trade mark to damages. In 1833 it was held by the Court of King's Bench that it was not necessary for the plaintiff in an infringement action to prove that the defendant's goods were inferior to his, or that he had suffered special damage by the infringement. Later this became a rule of equity as well as of law. On another point, however, the practice of the courts of common law and equity diverged for a time. It was decided by Lord Cottenham in 1838, in the leading case of *Millington* v. *Fox*, that an injunction to restrain the infringement of a trade mark could be obtained, even although the defendant had acted without fraudulent intent. On the common law side, on the other hand, fraud was an essential ingredient in the cause of action, and remained so till the fusion of law and equity by the Judicature Acts.

The effect of Lord Cottenham's decision in the case of *Millington* v. *Fox* clearly was to recognize a right of property in trade marks, and the action for infringement became a familiar species of litigation. Under the then existing law, however, the plaintiff in such actions generally found himself in a very disadvantageous and unsatisfactory position. The basis of his action was the reputed association between his trade mark and his goods. This association the defendant—often a person of no means—would deny, and it had to be proved as a fact by witnesses at a cost which there was little hope of his recovering. Moreover, even if the trade mark proprietor secured a judgment in his favour, it carried with it no immunity from the obligation of again establishing his right to the mark against any subsequent infringer who chose to dispute it. Thus—to take an interesting and pertinent illustration given in Kerly on *Trade Marks* (p. 6)—the case of *Rodgers* v. *Nowill* lasted five years and cost the plaintiff £2211, without giving him in the end any security that he might not have to incur equal delay and expense in proving his title to the exclusive use of the trade mark in proceeding against other defendants. To complete this statement of the shortcomings of the law before the Merchandise Marks Act, 1862, it should be noted that the infringement of trade marks—except in cases where the seller of spuriously marked goods cheated the buyer—was not a criminal offence. The remedies needed obviously were the establishment of a system of registration of trade marks, which would simplify the proof of a plaintiff's title, and the creation of a criminal law of false marking. The first step in the accomplishment of the latter object was taken by the Merchandise Marks Act, 1862, while provision was first made for the registration of trade marks by the Trade Marks Registration Act, 1875. That statute made registration in the register of trade marks which it established *primâ facie* evidence of the right of the registered proprietor to the exclusive use of the trade mark in connexion with goods of the class for which it was registered and used, and enacted that it should after the expiration of five years be conclusive proof of such right, provided that the proprietor of the mark remained the owner of the goodwill of the business in which it was used. The Act also provided that a person should not be entitled to institute any proceeding to prevent the infringement of trade mark until it was registered, or (a later statutory modification) until, in the case of a mark in use before the passing of the Act of 1875, registration of the mark as a trade mark had been refused. The Trade Marks Registration Act of 1875 was a considerable success, but no provision was made under it for the registration of words unless they either were old marks, or were registered in combination with one or more of the "essential particulars" prescribed by the Act, such as a distinctive device, heading, mark, label, or ticket. The Trade Marks Act, 1883, remedied this defect, besides altering the law in other important respects; and the law and practice in regard to trade marks are now embodied in that statute, in an amending Act passed in 1888, on the recommendation of a committee presided over by Lord Herschell, and in rules made by the Board of Trade in 1890, 1897, and 1898. Further reference may be made, in regard to the subject of Trade Marks before the Registration Acts, 1883–88, to an admirable introductory chapter in Kerly on *Trade Marks*, pp. 1–10, and also to the report of the Merchandise Marks Committee, 1862, and the annual reports of the Commissioners and the Comptroller-General of Patents from 1876 to 1884 (2nd Report.)

II. *Under the Acts.*—The Register of Trade Marks is kept at the Patent Office, Southampton Buildings, London, and is under the charge of the Comptroller-General of Patents, Designs, and Trade Marks, who is appointed by and acts under the superintendence of the Board of Trade, and has a deputy—the Registrar of Trade Marks. A copy of the entries relating to cotton goods is kept at Manchester; and there is a branch registry at Sheffield containing the marks for metal goods ("Sheffield marks") registered by residents in or within six miles of Hallamshire. The care of this register is vested in the Cutlers' Company, who are substituted for the Comptroller as to registration of "Sheffield marks," but subject to his veto, and subject also to an appeal from him to the courts.

Definition.

The Trade Marks Acts, 1883–88, do not affect the definition of a trade mark at common law, as it has been explained in the preceding portion of this article. A trade mark must still be a distinctive symbol, and it must also be so applied or attached to goods and "go to market" with them that the customer is led by the use of it to connect the goods with the proprietor of the mark. But re-enacting and enlarging the provisions of the Act of 1875, they lay down "essential particulars," of one at least of which a trade mark must consist, in order to entitle its owner to the benefits of registration. These "essential particulars" are as follows:—(*a*) A name of an individual or firm printed, impressed, or woven in some particular and distinctive manner. The name must be in the nominative case. Thus it has been held that the word "Pirie's" in "Pirie's Parchment Bank" did not come within this clause, and ordinary printing type is not printing in a "particular" or "distinctive" manner; (*b*) a written signature, or copy of a written signature of the individual or firm applying for registration—the signature must be the one *bonâ fide* used in business by the individual or firm, and not a fanciful or descriptive name; (*c*) a device, mark, brand, heading, label, or ticket, which is "distinctive" *i.e.*, capable both of identifying the goods as those of the trade mark proprietor, and also of distinguishing them from those of other traders (which are even new to the trade); (*d*) an invented word or invented words; and (*e*) a word or words having no reference to the character or quality of the goods, and not being a geographical name. The registration of "word marks" was first provided for by the Trade Marks Act, 1883. In that statute, however, clause (*d*) read "a fancy word or words not in common use." The expression "fancy word" gave rise to considerable difference of opinion. It was interpreted by the Court of Appeal as equivalent to "obviously meaningless as applied to the article in question," or "obviously non-descriptive." In accordance with this interpretation, the words "gem" for guns, "melrose" for a hair restorer, "electric" for velveteen, and "washerine" for a soap, were all held not to be registrable. On the recommendation, however, in 1887, of a committee appointed by the Board of Trade, and presided over by Lord Herschell, the expression "invented word" was substituted for "fancy word" by the Trade Marks Act, 1888. An invented word need not be wholly meaningless, nor is it disqualified because words may have suggested it. Thus "mazawattee" was held to be an "invented word," although the latter part of it was a Cingalese term meaning "estate," and there were estates in Ceylon having names ending with "wattee," from which tea came; and in a leading case on the construction of the clauses under consideration (*Eastman Co.'s Trade Mark*, 1898, 15 Rep. Pat. Cas. 476), the word "solio" was held to be registrable as a trade mark for photographic printing paper under both clauses, although it was objected that "solio" was equivalent to "sunio." Clauses (*d*) and (*e*), it should be noted, are independent: the former deals with newly-coined words, the latter with the existing words of the English language, or of other languages likely to be known to the public. A word which is really "invented" may be registered, whether it is descriptive or not.

Fancy words.

There may be added to any one or more of the "essential particulars" above enumerated any letters, words, or figures, or a combination of these. But the right to the exclusive use of the added matter must be disclaimed. A man is not required, however, to disclaim his own name, or trade name, or that of his place of business, if the name appears in the mark. In the case of what are called "old marks," viz., those used before the Trade Marks Registration Act, 1875, there may also be added to the mark any device, mark, brand, head, label, or ticket, which, although *primâ facie* distinctive, is really common to the trade.

Even if a trade mark satisfies the statutory conditions as to "essential particulars," it may still under certain circumstances be refused registration by the Comptroller-General. Two or more persons are not allowed, unless the court directs, to be registered as proprietors of the same trade mark with respect to the same description of goods; if it appears that three or more traders are entitled to an old mark for the same description, the mark is treated as common to the trade. Moreover, except by the direction of the court, the Comptroller must not register a mark having such resemblance to one already registered as to be calculated to deceive. The Trade Marks Acts contain elaborate divisions of goods into different classes. But the question whether particular goods are of the same description is not determined solely by reference to the statutory classification. "The true test," says Kerly (*Trade Marks*, p. 181), "would seem to be supplied by the question, Are the two sets of goods so commonly dealt in by the same trader that his customers, knowing his mark in connexion with one set, and seeing it upon the others, would be likely to suppose that it was used upon them also to indicate that they were his goods?" Wine and spirits, beer, and even an aperient drink and baking powder, have been held to be "goods of the same description." The expression "calculated to deceive" has been considered by the courts in very many cases. It is not merely nor chiefly the retailer or dealer that has to be kept in view when the question of the likelihood of deception is under consideration The courts have regard also, and mainly, to the ultimate purchaser whom the trade mark may reach, and careless or unwary persons are considered as well as those who are careful and intelligent. The judge's eye is the ultimate test as to the degree of resemblance that is calculated to deceive, although expert evidence on the point is admissible.

Registration of a trade mark is equivalent to public user of the mark. It is *primâ facie* evidence, and after five years is conclusive evidence, of the registered proprietor's right to the exclusive use of the mark for the goods for which it is registered, so long as the mark remains on the register (for the court has power, on the application of any person aggrieved by the entry of a mark on the register, to order its removal), provided that the proprietor is the owner of the goodwill of the business in the goods upon which the mark is used. Moreover, it is a condition precedent to an action for the infringement of a trade mark that the plaintiff should be the registered proprietor of the mark at the time when the action comes on for hearing. This last provision does not apply to an action for "passing-off" (see *infra*).

The right to a trade mark is determined if the mark ceases to be distinctive and becomes *publici juris;* if it is separated from the goodwill (a trade mark can only be assigned with the goodwill); if the mark is applied by the trader to spurious goods (as where boxes of cigarettes were so labelled, in conformity with an alleged custom of the trade, as to indicate that they were Russian manufacture, which was not the fact; or when the mark is abandoned (temporary disuse, however, is not abandonment unless the mark has in the meantime become associated with the goods of another trader); or where, as in the "linoleum" case, it has become the name of the goods, and so merely descriptive; or after fourteen years where the trade mark fees have not been paid.

Trade mark rights may be protected and enforced by an action for infringement, which may be brought in the Chancery or King's Bench Division; or, in the case of marks registered upon application at the Manchester office, in the Palatine Chancery Court of Lancashire; or, where not more than £50 damages is claimed, in the county court. As above mentioned, the court has power to rectify the Register of Trade Marks on the application of any person "aggrieved" by any entry in or omission from it; and a mark may be removed even after five years' registration. The court may, on the application of the registered proprietor of a trade mark, give him leave to alter or add to it (*e.g.*, a firm on becoming a limited company has been allowed to add the word "limited" to its name upon a registered mark), but no alteration will be permitted in regard to any "essential particular." An appeal lies from the refusal, or, where an application is unsuccessfully opposed, from the allowance of registration of a trade mark by the Comptroller-General, to the Board of Trade, which may and frequently does refer the question to the court. The work of the trade mark branch of the Patent Office has not increased at all in proportion to that of the patent branch, and indeed, as regards the number of registrations, shows a tendency to decrease (see article PATENTS). The number of applications for trade marks in 1884 was 7104, and the number of marks registered 4523. In 1899 the corresponding figures were 8918 and 3771.

III. *"Passing-off" and Trade Name.*—A trader has generally numerous other symbols, which he uses as *indicia* of his goods, besides his trade mark, *e.g.*, the name or title under which he himself trades, the name under which his goods are known and sold, badges of property which are termed "trade name," and the distinctive "get-up" of the goods as they appear in the market. These symbols enjoy the protection of the law, under certain conditions, equally with trade marks. No trader is entitled to "pass off" his goods as those of another, and if he infringes this rule he is liable to an action for an injunction and damages. Even if the "passing-off" is done innocently it will be restrained (*Millington* v. *Fox*, 1838, 3 Mylne and Craig, 338). Although the first purchaser is not deceived, still if the article delivered to him bears words or marks such that it is "calculated to deceive" a purchaser from him, the use of them is illegal. To this general rule there are several exceptions:—(1) No monopoly is allowed in names that are merely descriptive. But words which *primâ facie* are descriptive, such as "camel-hair belting," for belting made of camel-hair (*Reddaway* v. *Banham*, 1896, App. Cas. 199), or "Stone Ales" for ales brewed at Stone (*Montgomery* v. *Thompson*, 1891, App. Cas. 217), may be shown to have acquired by long use "a secondary distinctive meaning," and, in fact, to mean the goods of a particular trader. And where a defendant is not selling the genuine goods indicated by the name, as where the composition of the goods is a secret, even if the name might otherwise be taken as merely that of the goods, he cannot rely on the defence that the name is descriptive (*Birmingham Vinegar Co.* v. *Powell*, 1897, App. Cas. the "Yorkshire Relish Case"). (2) A trader cannot be prevented from trading under his own name, if he is using it honestly, even though from its similarity to the name of another trader it may injure the business of the latter (*Burgess* v. *Burgess*, 1853, 3 De Gex, M. and G. 896; *Turton* v. *Turton*, 1889, 42 Ch. D. 128). But if a trader's own name has, before he entered the trade, become the trade name of some other person's goods, he might probably not be allowed to use it without taking steps to prevent deception. It is provided by the Companies Act, 1862, that no company shall be registered under a name identical with that by which a subsisting company is already registered, or so nearly resembling it as to be calculated to deceive, unless the subsisting company is in process of being wound up and consents to such registration; and provision is also made for a change of the name of any company which, through inadvertence or otherwise, is registered under a name coming within the statutory prohibition. It is to be observed (cf. Buckley, *Companies Acts*, 7th ed. p. 28) that (*a*) the Companies Act applies only to the case of taking the name of a subsisting company already registered, and not to a case where a new company proposes to register in the name of, or in a name closely resembling, the name of an old-established company, which is not registered, or of a firm or individual trader; (*b*) that as soon as the new company is registered the Act ceases to apply; and (*c*) that the Act forbids registration irrespectively of the question whether the business proposed to be carried on by the new company is the same as that of the subsisting company or not. But the provisions of the Companies Act on this subject are merely supplemental to the common law, and, accordingly, an injunction will be granted to restrain a company from carrying on the same trade as that of another company under a name so nearly resembling the name of that company as to be calculated to deceive, whether it has been registered or not, and, in the latter event, to restrain the infringing company from applying for registration of the name. A new company will not be allowed to take the whole name of a subsisting company, even although that name is of a descriptive character (*Manchester Brewery Co. Ltd.* v. *North Cheshire and Manchester Brewery Co. Ltd.*, 1899, App. Cas. 83).

The purchaser of the goodwill of a business has the right to use the trade name under which the business is known, and to restrain others from using it, or using such imitations of it as may mislead the public. But he is not entitled by the use of the trade name to make the vendor liable, under the doctrine of "holding out," for debts of the business incurred after the sale. And if the vendor of the goodwill gave his name to the business, he cannot (in the absence of any restrictive condition in the agreement for sale) be prevented from beginning to trade in his own name again, unless it be shown that in so doing he is attempting to deceive the public into the belief that he is still the owner of the old business. It may be noted that the right to be protected against "passing-off" is restricted to goods of the same description as those upon which the trader uses the "get-up," &c., imitated.

IV. *Merchandise Marks.*—As has already been seen, the first attempt to make the falsification of trade marks a criminal offence was initiated by the Merchandise Marks Act, 1862. But that statute possessed numerous and serious defects. Although it provided that the forgery of a trade mark with intent to defraud, and the false application of a trade mark to goods with the like intent, should be misdemeanours, it left the burden of establishing the fraudulent intent upon the prosecutor. It contained no provision for summary prosecutions. And it did not provide for the seizure of falsely-marked goods on importation from abroad. It was to the existence of this last defect that the enactment of a more satisfactory measure was due. The International Convention for the Protection of Industrial Property, to which Great Britain acceded in 1884, contained a provision that all goods illegally bearing a trade mark or trade name may be seized on importation into those states of the union where the mark or name has a right to legal protection, and that the seizure shall be effected at the request of either the proper public department or of the interested party, pursuant to the internal legislation of each country. The law had to be amended in order to carry out this article in the Convention, and the Merchandise Marks Act, 1887, was passed to carry out this object and generally to make better provision for the protection of merchandise. It was subsequently amended in 1891. The effect of the provisions of these statutes may be briefly stated. Any person is guilty of an offence, punishable on indictment or summary conviction, by fine or imprisonment, who does any of the five following acts, unless he proves as regards the first four

Trade descriptions.

of them that he acted without intent to defraud (there is a special defence to No. v. which is noted below):—(i.) forges any trade mark, or makes, disposes of, or has in his possession for such purpose any die or instrument; (ii.) falsely applies any trade mark or a colourable imitation of any trade mark to goods; (iii.) applies any false trade description to goods: "trade description" is defined as any descriptive statement or other indication as to the measurement, quantity (not *quality*, it should be observed), or weight, place, or mode of production, or the material of the goods, or as to their being subject to an existing patent, privilege, or copyright; conventional or customary descriptions lawfully in use in August 1887 to indicate that the goods are of a particular class or method of manufacture are allowed to be continued; but if they contain the name of a place and are calculated to mislead as to the real place of production, the name of the latter must be added; (iv.) causes any of the above offences to be committed; (v.) sells or exposes for sale, or has in his possession for sale, trade, or manufacture, any goods or things to which any forged trade mark or false trade description is applied, or any trade mark or colourable imitation of a trade mark is falsely applied, unless *the defendant* proves that, having taken all reasonable precautions, he had no ground to suspect the genuineness of the mark, &c., and also that on demand he gave to the prosecutor all the information in his power as to the person from whom he obtained the goods, &c., or proves that he otherwise acted innocently.

There is power to forfeit the things found on a prosecution for any of these offences, although no one is convicted. If the offender is indicted (it is in his option to be tried in this way) the punishment is fine and imprisonment, the latter not to exceed two years. On summary conviction the punishment is not to exceed, for a first offence, four months' imprisonment, with or without hard labour, and a fine of £20; and for any subsequent offence six months' imprisonment and a fine of £50. The importation is forbidden of goods by means of or in relation to which an offence against the Acts has been committed, and also of all goods of foreign manufacture bearing any name or trade name being or purporting to be that of a manufacturer or trader within the country, unless it be accompanied by a definite indication of the country where the goods were made or produced. There are also special provisions with regard to the marking of watch-cases. The Commissioners of Customs have power to make general orders for carrying out the Merchandise Marks Acts, and a number of such regulations have been issued. Under the Sale of Food and Drugs Act, 1899, the importation, except in containers showing their character, of margarine, margarine cheese, adulterated or impoverished butter, or condensed, separated, or skimmed milk, is penalized, and it is provided that the Commissioners of Customs, in accordance with directions given by the Treasury after consultation with the Board of Agriculture, shall take such samples of consignments of imported articles of food as may be necessary for the enforcement of the law.

V. *International and Imperial.*—By the International Convention (see PATENTS) for the Protection of Industrial Property, which was signed at Paris in 1883, the signatory states, a list of which is given below, agreed that the subjects or citizens of each state should, in all the other states, enjoy as regards trade marks and trade names the advantages that their respective laws then granted, or should thereafter grant, to their own subjects or citizens. So far as Great Britain is concerned, the only provision that has been made for carrying out this convention is contained in § 103 of the Trade Marks Act, 1883. The effect of that section is to confer on an applicant for the protection of a trade mark in one of the other contracting states a priority over other applicants for registration in the United Kingdom during the space of four months. The section does not, however, exempt the applicant from the conditions and formalities incumbent on ordinary applicants for registration in Great Britain; nor does the fact that the foreign application has been successful of itself give the applicant a right to have his mark accepted for registration. Under the Convention of Madrid, 1891 (to which, however, Great Britain has not acceded), a trade mark may be registered as the result of a single application in the countries of all the signatory Powers.

The following is a list of the Orders in Council that have been issued applying the provisions of the Trade Marks Act, 1883, § 103, to foreign countries:—

Foreign State.	Date of Order in Council.
Belgium	June 26, 1884.
Brazil	June 26, 1884.
Denmark (including the Faroë Islands) . . .	November 20, 1894.
Dominican Republic . .	October 21, 1890.
Ecuador	May 16, 1893.
France	June 26, 1884.
Greece	October 15, 1894.
Italy	June 26, 1884.
Japan	October 7, 1899.
Mexico	May 28, 1889.
Netherlands	June 26, 1884.
,, (East Indian Colonies) . .	November 17, 1888.
,, (Curaçoa and Surinam) . .	May 17, 1890.
Paraguay	September 24, 1886.
Portugal	June 26, 1884.
Rumania	August 5, 1892.
Servia	June 26, 1884.
Spain	June 26, 1884.
Sweden and Norway . .	July 9, 1885.
Switzerland	June 26, 1884.
Tunis	June 26, 1884.
United States	July 12, 1887.
Uruguay	September 24, 1886.

In the following foreign countries penalties have been imposed under the Foreign Jurisdiction Act on British subjects committing offences against the Trade Marks Acts, 1883–88, and the Orders in Council thereunder—Africa, East Africa, Morocco, Persia, Persian Coast, Zanzibar.

By § 104 of the Trade Marks Act, 1883, the Sovereign is empowered by Order in Council to apply the provisions of § 103, above mentioned, with such variations or additions as may seem fit, to any British possession. The following is a list of the Orders in Council that have been issued:—

British Possessions.	Date of Order in Council.
New Zealand	February 8, 1890.
Queensland	September 17, 1885.
Tasmania	April 30, 1894.
West Australia . . .	May 11, 1895.

It should be added that the protection of the Merchandise Marks Act, 1887, extends to any trade mark which, either with or without registration, is protected by law in any British possession or foreign state to which the provisions of § 103 of the Act of 1883 are, under Order in Council, for the time being applicable.

A foreigner suing in the United Kingdom for infringement of a trade mark or for "passing-off" is in the same position as a subject.

VI. *Foreign and Colonial.*—It is impossible within the limits of this article to attempt a survey of the laws of foreign countries or of the colonies. Valuable information with regard to the former will be found in the *Transactions* of the International Association for the Protection of Industrial Property, London, vol. i., 1897, pp. 185 ("International Registration"), 245 ("Indications of Origin"), 259 ("Unfair Competition"); vol. ii., 1898, pp. 214 ("Unfair Competition"), 250 ("Industrial Property Department"), 445 ("Descriptive Marks"). The British colonies generally follow the model of the English Trade Marks Acts. The Hong-Kong Ordinance, No. 14 of 1898, is a typical instance of this. In the Isle of Man in 1898 a Merchandise Marks Act was passed which proceeds on the lines of the English Act of 1887, and contains an additional section imposing penalties on any person who falsely represents that any goods are made by a person holding a royal warrant, or for the service of the Sovereign or any of the royal family, or any Government department. There is a similar provision in § 105 of the Patents Act, 1883.

AUTHORITIES.—SEBASTIAN. *Trade Marks*, 4th ed. London, 1899 (in this work the American cases are fully dealt with).—KERLY. *Trade Marks.* London, 1894.—CARTMELL'S *Digest.* London, 1876–92.—SEBASTIAN. *Digest.* London (cases down to 1879).—GRAY. *Merchandise Marks Act.* London, 1888.—SAFFORD. *Merchandise Marks.* London, 1893.—The Reports of the Departmental Committee of 1887, and of the Select Committees of the House of Commons appointed in 1887 and 1890 to consider the law with regard to merchandise marks and false marks, and the annual Reports of the Comptroller-General, throw great light on both the history and the practical working of the law. (A. W. R.)

TRADE ORGANIZATION.

THE development of commercial organization which attended the growth of trade and industry during the 19th century has assumed two distinct phases. In the first, we see the creation of associations of persons engaged in trade and industry for the purpose of protecting their interests and of facilitating and fostering commercial relations. In the second, governments elaborate departmental organizations for the supervision of commercial matters, establish offices for the dissemination of commercial information, and utilize their consular services as means of commercial intelligence and influence.

The associations belonging to the first category may be divided into three classes:—

(*a*) Those which are themselves engaged in trade, like ordinary joint-stock companies, or which result from the combination of firms or individuals in the same or connected trades, for the purpose of facilitating or restricting production, limiting competition, regulating prices, &c.—in a word, of working to their common benefit by the union of their property, knowledge, and energies, such as co-operative societies and trusts.

(*b*) Those which, without engaging in trade, aim at providing facilities for the transaction of commercial or financial operations. They chiefly take the form of exchanges, bourses, public sale rooms, &c., such as the Baltic, Lloyd's, the Stock Exchange, the Corn and Coal Exchanges, the Commercial Sale Rooms, and impose upon their subscribers or members rules for the transaction of business which, in certain cases, apply not only to business transacted upon their premises, but also regulate the manner of transacting business generally.

(*c*) Non-trading bodies, in the nature of public institutions, whose objects are to protect the interests of trade; to advise, and if necessary to bring the weight of combined influence to bear upon governments and parliaments in commercial matters; to facilitate the obtaining of commercial information; to secure diplomatic intervention for the upholding of national rights in international trade; and, to a certain extent, to be to trade and traders, under the economic conditions of modern life, what the gilds and crafts and livery companies of former ages were to the merchants and craftsmen of their day.

This article is limited to commercial associations of the last class, and an attempt has been made to show how they arose, the rules which govern them, their sources of income, and the nature and extent of the services which they render to commerce. The systems in force in the United Kingdom and in the British colonies and India, in the United States, in France, Germany, Belgium, Austria-Hungary, Spain, Portugal, Russia, and Japan are the subjects of separate sections, in which will also be found a summary of the steps taken by governments to deal with the requirements of trade by the establishment of Ministries of Commerce, Official Commercial Information Bureaus, Commercial Museums, Consultative Committees, &c. In view of the interest attaching to consular action in trade matters, special attention has been paid to the instructions given to consuls on the subject.

British and French systems.

When, at the close of the 18th century and early in the 19th, the power of the old trade gilds and corporations of merchants had been broken by the almost universal proclamation of the liberty of trade and industry, and by the abolition of compulsory apprenticeship, both governments and commercial men soon realized that the ancient societies would not follow the commercial evolution, and that new organizations must be created to meet new requirements. Two systems were evolved, which, from their prototypes, are known as the British and the French systems. In the former, trade organizations were left to develop themselves in their own way, and in whatever directions they might think fit, without any official interference. In the latter, on the contrary, the Government constituted itself the creator of trade organizations, which it incorporated into the administrative system of the country, and to which it gave an official status as an integral part of the machinery of the state. The former have grown chiefly into associations for the promotion and defence of commercial interests, whilst the latter have mainly become sources of commercial information and means of action at the disposal of the Government. While organizations on the British system are, as regards the Government, purely advisory bodies whose opinion might or might not be asked in connexion with commercial matters, and whose duties are limited to the services which they are in a position to render to their members and to commerce generally, organizations on the French system not only must be consulted, in certain specified cases, by the Government, especially in connexion with the drafting of commercial legislation and of regulations affecting trade, but they have also administrative duties to perform, such as the control of public commercial institutions, of testing, standardizing, and conditioning establishments, port and dock works, &c. The former associations are self-supporting, their chief source of income being the annual subscriptions received from members. The latter are provided for out of the rates, and sometimes by government or municipal subsidies. The British system obtains in the United Kingdom and the British colonies, in the United States, and in Belgium, while the French has been adopted in most Continental countries, and in Japan.

Both systems have advantages, but both have also great drawbacks. The chief advantages of self-supporting associations, unfettered by official trammels, are that they are free to act as they deem best in the interests of the commercial community, and, if necessary, to bring pressure upon the Government and upon Parliament; that the expression of their views is not coloured by the natural inclination to support the acts of an administration of which they form part; that they can freely join hands with other associations in the advocacy of a common cause; and that they are at liberty, in all cases and at all times, to place their views before the Government. On the other hand, the fact that they have to depend almost exclusively upon the subscriptions of their members often cripples them in their work, as in many places the membership is not sufficient to allow them to develop as they should, and in consequence they are unable to render the services which are expected from them; their library is incomplete, their offices and staff are not in keeping with their character. Moreover, self-supporting associations have a strong tendency to overlook that they are public bodies, with consequent public duties: they naturally want to limit their services to their subscribers, and this gives rise to the taunt of the outsider that they represent nobody but themselves, and that they have no claim to be regarded as public institutions. Great difficulty is experienced in making them truly representative, and their efficiency is not unfrequently impaired by local jealousies. The fact that a particular firm or individual has become a member is often enough to prevent others from joining, and to make them look upon the institution as a mere organization of busybodies.

The Continental system avoids the latter drawbacks. Trade organizations, as a rule, merely consist of a Board the members of which, limited in number, are periodically elected by the general body of commercial tax-payers. Serious guarantees are thus afforded for securing representative organizations. These Boards have an official status, their members take rank after the magistrates in public functions, membership of them confers a standing, and is considered as a public recognition of commercial position and credit. Election to them is in consequence highly coveted. Expenses being borne by the rates, there is no difficulty in providing proper offices, staffs, and libraries, and in maintaining the dignity and in carrying on the work of these associations in a manner suited to their position and to their objects. But, on the other hand, Government control does not go without grave disadvantages. Organizations on the Continental system are, as a rule, so much under the hand of the State that they cannot always be trusted to express fully the views of their constituents, and even if they do express these views, they are powerless to take action to secure their enforcement. Their duties are carefully defined by law, and they have practically no initiative in commercial matters. As they lack the incentive given to associations under the British system by the necessity of continually increasing the number of their subscribers, they are apt to run in a groove, to limit themselves to what they are strictly bound to do, to ignore questions which are difficult or dangerous to deal with, and to confine themselves to matters of purely local interest.

I. GREAT BRITAIN AND COLONIES.

A. *Commercial Associations.*

In the United Kingdom, commercial associations arose with the growth of trade, without any assistance from the State and free from all Government restriction or control. The first in point of date were the "Commercial Societies" which were formed, chiefly during the last quarter of the 18th century, in Birmingham, Exeter, Halifax, Leeds, Liverpool, and Manchester, and which exercised a not unimportant influence upon commercial developments at the close of the 18th and in the early years of the 19th centuries. The modern associations which superseded these societies divided themselves into four classes, viz.:—

(*a*) Chambers of Commerce and Associations which aim at becoming representative of general commercial interests;

(*b*) Associations or Institutes which represent particular trades or branches of trades;

(*c*) Trade Protection Societies, which look after the interests of retail as well as wholesale traders, and undertake to supply them with information as to the standing and credit of firms, expose swindlers, collect debts, &c.; and

(*d*) Non-representative associations rendering general commercial services.

All the representative associations are on the same plan, being composed of members who pay a yearly subscription, and as a rule elect a governing body entrusted with the management of the affairs of the society. In some cases the governing body is not elected, but co-opts members to fill vacancies, whilst in others it is partly elected and partly co-opted. This body decides upon applications for membership of the association, which is only granted after inquiries, and when applicants have been duly proposed and seconded, and notice of their applications given.

(*a*) *Chambers of Commerce and General Associations.*—Most of the Chambers of Commerce in the United Kingdom were formed during the latter half of the 19th century, although a few were in existence much earlier. The oldest British Chamber is the Jersey Chamber, which dates from 1768. The Glasgow Chamber was founded in 1783. Dublin followed in 1785, Edinburgh in 1786, Manchester in 1794, Belfast in 1796, Birmingham in 1813, Newcastle-upon-Tyne in 1818, Liverpool in 1851, Sheffield in 1857, &c. The London Chamber was the last of the Chambers of importance to be established: it dates only from 1881. There are in the United Kingdom 113 Chambers of Commerce, of which ten are in Scotland and ten in Ireland. Some of the older chambers, notably the Glasgow Chamber, have been granted the status of a "body corporate and politic" by Royal Charters, which empowered them to acquire, hold, and dispose of property, and to sue and be sued in a corporate capacity, gave them a corporate seal, embodied the regulations adopted for the internal management of the Chamber, and ordained "that they and their successors in all time coming shall have perpetual succession for the purpose of better and more efficiently administering, directing, ordaining, and constituting in all matters and things" pertaining to the said Chambers and their funds. The obtainment of corporate capacity was rendered easier by the Companies Acts which have been enacted since 1862, and the practice of granting charters to Chambers of Commerce and similar associations was abandoned. Being non-trading bodies, and no part of their income being at any time payable, either directly or indirectly, to the members by way of dividend, bonus, or otherwise, Chambers of Commerce could obtain the Board of Trade licence for incorporation as companies limited by guarantee without the addition of the word "limited." Some twenty chambers, including those in London, Liverpool, Sheffield, Aberdeen, &c., availed themselves of this facility, and are known as Incorporated Chambers of Commerce. Their objects and regulations are embodied in the Memorandum and Articles of Association, and alterations can be made therein in accordance with the provisions of company law. In Chartered Chambers, the rules, which are recited in the charter, cannot be amended except by a supplementary charter, which is a cumbrous and expensive proceeding. The vast majority of Chambers of Commerce, however, did not take the trouble to seek incorporation, and in law are governed by the rules regulating ordinary partnerships, under which the members are personally liable for the debts of the Association.

The London Chamber.

The London Chamber of Commerce, which boasts over 4000 members, is one of the most representative associations of its kind, and the organization adopted has been very effective in securing this. The Chamber has been divided into trade sections, of which there are at present forty-four, and members specify the sections to which they desire to belong. Each section has a separate organization, and is presided over by a chairman elected by itself, who may be helped by an elected committee, if found advisable. The general council of the Chamber confirms the election of chairmen of sections, and no action can be taken by the Chamber on the recommendation of a section unless the council has authorized such action. The result is that, whilst general interests are safeguarded, particular trade interests are given opportunities of pressing themselves upon the attention of the general body. Questions are also sifted without needless loss of time, as they are in the first place submitted to those who are especially interested in them and especially competent to deal with them, and it is only upon their recommendation that the council is requested to take action. The Chamber has also placed itself in connexion with a number of mercantile associations which, whilst preserving their separate organizations and their independence of action, have found it advantageous to work in conjunction with it, either for general or for particular purposes, and to have a voice in its council. They are twenty-nine in number, the most important of which are the Institute of Bankers, the Institute of Chartered Accountants, the Society of Accountants and Auditors, the General Ship Owners' Society, the General Produce Brokers' Association, the Federation of Grocers' Associations of the United Kingdom, the West India Committee, the Corn Trade Association, the United Planters' Association of Southern India, &c. The general council is composed of 115 members, as follows: four *ex officio*, viz., the Lord Mayor, the Governor of the Bank of England, and the two members of Parliament for the City; two nominated, one by the committee of Lloyd's and the other by the Board of Elder Brethren at Trinity House; twenty-nine elected by the Mercantile Associations working in conjunction with the Chamber; the forty-four chairmen of trade sections; and thirty-six representing the general body of members of the Chamber. The latter are the successors of the original council which took charge of the Chamber at its foundation: they are not elected, but their number is kept up by co-optation as vacancies occur. Various attempts have been made by members of the Chamber to introduce the principle of election to the council, but so far unsuccessfully. An executive committee of the council transacts the general business of the Chamber. Individual members pay an entrance fee of £2, 2s. and an annual subscription of £1, 1s., and may compound for life membership by a single payment of £17, 17s.; firms or companies pay an entrance fee of £2, 2s. and an annual subscription of £2, 2s., and cannot compound. The yearly income of the Chamber is about £7000, and a reserve fund of £2000 has been invested.

The Liverpool Chamber.

Particular reference should also be made to the Liverpool Chamber, which, as regards division into trade sections and co-operation with independent associations, works on similar lines to those of the London Chamber. The African trade section of the Liverpool Chamber has been prominent in connexion with African questions, and since its foundation in 1884 has been the leading voice in all matters relating to West Africa; and its action with reference to health and sanitation questions on the West Coast, and to the establishment of the School of Tropical Medicine, has been effective and beneficent. It also was chiefly instrumental in bringing about the reform of the management of the Niger territory by the Chartered Company, and has been the chief recommendatory power in the making of roads and railways and in the provision of shipping facilities in those regions.

The Manchester Chamber.

The Manchester Chamber of Commerce is known as the champion of free trade, as the principal exponent of the doctrines of the Manchester school, and as the opponent not only of all attempts to introduce protective customs duties, but of any preferential arrangement in favour of the Colonies which would differentiate between the treatment of colonial goods and that of foreign goods. The Chamber may be said to have inherited its policy from the Anti-Corn Laws Agitation, and from the memorable *rôle* which it played from 1838 onwards in the free-trade campaign. Its action in connexion with factory legislation has also been important. It is more of an economic body than any other Chamber of Commerce in the United Kingdom.

Other Chambers of Commerce follow more or less closely the organization explained in connexion with the London Chamber, with the exception that, as a rule, their governing body is elected. Subscriptions are on about the same scale everywhere, viz., ranging from £1, 1s. to £2, 2s. per annum. The Glasgow Chamber has a £5, 5s. subscription.

Association of Chambers of Commerce.

The Association of Chambers of Commerce of the United Kingdom, which was formed in 1860, contributed much to give Chambers of Commerce as a whole a national importance and a standing which enabled them in course of time to become representative of the general commercial interests of the country, as distinguished from local interests. This Association, like the Chambers themselves, was of course purely voluntary, and at the time of its foundation only sixteen Chambers decided to join it. It was some time before the oldest and most important Chambers became members, as they were rather afraid of having their liberty of action tampered with, and of being compelled by the votes of other Chambers to countenance decisions of which they did not approve. But these fears proved to be groundless, and the only Chamber of importance which is still keeping aloof is the Glasgow Chamber. The Manchester Chamber joined in 1900. In 1902, 96 out of the 113 Chambers in the United Kingdom were members. The management is in the hands of a council composed of a president, two vice-presidents, a treasurer, two honorary secretaries, and twenty-five representatives of constituent Chambers, who are elected by ballot every year at the general meeting of the association. In the proceedings of the Association, Chambers with less than 100 members have one vote; those having from 100 to 250 members, two votes; from 250 to 600, three votes; over 600 and not exceeding 1000, four votes; over 1000, one additional vote per additional 500; but no Chamber can have more than six votes. The Association is kept up by an annual subscription from the constituent Chambers, which is based upon the number of members of each Chamber, and ranges from £8 for Chambers having less than 100 members to £32 for Chambers having up to 1000, and £8 additional for each further 500 members. Its income from subscriptions amounts to about £1000 per annum, and its budget from all sources to about £1500. It was incorporated under the Companies Acts in 1875, and its chief objects are stated to be:—To afford Chambers of Commerce opportunities of discussing matters of common interest and of deciding upon joint action in relation thereto; to act as intermediary between the constituent Chambers and the Government in matters in regard to which the intervention of the Association is requested; to petition Parliament, and to promote or oppose Bills affecting commercial, manufacturing, and shipping interests, &c. It has been instrumental in passing many useful Acts of Parliament, and in otherwise influencing legislation upon commercial topics. The general meetings, which are held annually in March, in London, and at which delegates are present from all parts of the country, have come to be considered as a kind of parliament of trade, and representatives of the Board of Trade, the General Post-Office, and the Foreign and Colonial Offices are generally in attendance. Special meetings take place in September, and are held in provincial towns on the invitation of the local Chamber. During the Exhibition of 1900 the special meeting for that year took place in Paris, on the invitation of the British Chamber of Commerce in that city, which is a member of the Association. The reception which was accorded to the visitors by the French Government and by the Chambers of Commerce of Paris and Calais, as well as the fact of the visit to France of such a representative body of British commercial men at a time when the relations between the two countries were not thought to be at their best, had a most beneficent effect both in France and in England, and opened up a vista of possibilities concerning the influence of Chambers of Commerce in international relations which had not hitherto received sufficient attention.

Congresses of Chambers of Commerce of the Empire.

The Association has limited its work to the United Kingdom, and has not taken advantage of the commercial development of the Colonies to afford colonial interests an opportunity of voicing their needs in the metropolis. To supply this need the London Chamber of Commerce organized Congresses of Chambers of Commerce of the Empire, of which up to 1902 four had taken place, viz., in 1886, 1892, 1896, and 1900. These Congresses, to which all Chambers of Commerce in the United Kingdom and in the Colonies and India were invited to send delegates resident in their district, enabled British commercial men, as well as the representatives of the Government who were invited to attend, to become acquainted with the views and needs of the outlying parts of the empire, by coming into actual contact with the colonial delegates, and discussing with them matters of common interest. Further extension was given to the movement by the decision to hold some of these congresses in the colonies, the first being at Montreal in 1903.

British Chambers abroad.

The home organization of Chambers of Commerce is supplemented by a few British Chambers which have been established in foreign countries. These institutions are self-supporting, and not, as seems often to be thought, branches of or subsidized or controlled by home Chambers. The British Chamber of Commerce in Paris, which is the oldest of them, dates from 1873, and was originally established by British merchants in Paris for the defence of their own trade interests. Its scope soon extended, however, and it admitted to membership British firms trading with France although not resident in France, and in course of time became representative of general British commercial interests in the French markets. It advises British firms with regard to the interpretation and application of French commercial and customs laws and regulations; takes up their cases with the French Customs authorities when difficulties arise; gives information as to the standing of French houses; and defends British and colonial interests generally in France. It is kept up solely by the subscriptions of its members, those resident in Paris paying £4, and those resident abroad £2, per annum. The scanty support which the home trade has given to such institutions has prevented their growth in foreign countries, and whilst the French have thirty-eight Chambers looking after their interests abroad, British Chambers are to be found only in Paris, Nice, Alexandria, Cairo, and Constantinople. In Brussels, an Anglo-

Foreign Chambers in England.

American Chamber jointly represents British and American interests. The following countries are represented in London by Chambers of Commerce, viz., Austria-Hungary, Belgium, France, Italy, the Netherlands, and Spain. The Italian Chamber is the only one which has sought incorporation under the Companies Acts, and is also the only one which is a member of the Association of Chambers of Commerce of the United Kingdom. The United States are represented in England by the American Chamber of Commerce in Liverpool (see p. 396). The foreign Chambers in London have joined in forming an Association of Foreign Chambers of Commerce which does, to a certain extent, for them what the Association of Chambers of Commerce of the United Kingdom does for the home Chambers.

Colonial Chambers.

Commercial organization in the Colonies is very much on the same footing as it is in the United Kingdom. The most representative associations are the Chambers of Commerce, whose constitution and functions are similar to those of the British Chambers. In *Canada* the Chambers, which are also sometimes called Boards of Trade, after the American custom, are about sixty in number, the most important being the Montreal and Toronto Boards of Trade and the Quebec Chamber of Commerce. The Canadian Chambers have no association, but hold periodical conferences. There is, in addition, the Canadian Manufacturers' Association, with headquarters in Toronto and branches in all the provinces, which incorporates all the associations of manufacturers in the Dominion. Its meetings, which are held annually in various cities, are frequently attended by ministers and representatives of Government departments. The *Australian* Chambers of Commerce, which number about thirty, have joined into an association called the General Council of the Chambers of Commerce of the Commonwealth of Australia. The Australian Chambers are generally considered to represent the interests of importers and of general merchants, and to incline as a rule towards a free-trade policy. Their influence is counterbalanced by that of the Chambers of Manufactures, the most important of which are those of Adelaide, Melbourne, and Perth, to which must be added the National Agricultural and Industrial Association of Queensland, whose headquarters are at Brisbane. The Chambers of Manufactures have been very active in the promotion of technical and commercial education, and have founded valuable libraries and museums, of which those at Adelaide are said to be the best organized. In *New Zealand* there are some fifteen Chambers of Commerce. At a conference held in 1902 they practically decided to form an association after the Australian model. In *South Africa*, Cape Town, Kimberley, Port Elizabeth, Johannesburg, Pretoria, Durban, and Bulawayo have important Chambers. The South African Chambers are joined in a Federation of Chambers of Commerce of South Africa. In the *West Indies* the Jamaica and the Trinidad Chambers are the most important. The *Indian* Chambers of Commerce, which are not federated, are for the most part very important and influential bodies, which the Government of India often consults. The Bombay and Madras Chambers, and the Bengal Chamber at Calcutta, have a predominant voice in the organization of Indian trade, notably in the settlement of the regulations of the cotton trade, and the first and last are intimately connected with the administration of the ports of Bombay and Calcutta. There are Chambers at Rangoon and Karachi. The Colombo Chamber represents Ceylon trade; there is a Chamber at Singapore for the Straits Settlements; one at Hong-Kong; one in Shanghai; one in Mauritius; one at Valetta, for Malta; one at Gibraltar; one in Georgetown, for British Guiana; and four in West Africa, viz., at Cape Coast, Accra, Sierra Leone, and Lagos.

With the exception of Australia none of the Colonies was in 1902 represented in London by Chambers of Commerce proper, and the Australian Chamber had only lately been established. The West India Committee and the Ceylon Association look after the commercial interests of their respective countries, whilst the United Empire Trade League, the British Empire League, and the Imperial Trade Defence League endeavour to promote inter-Imperial trade.

(*b*) *Associations representing Particular Trades.*—Associations representing particular trades are almost innumerable. Chambers of Shipping and Shipowners' Associations occupy the foremost place among them, for shipping is of such moment in the economic life of the empire that, although more representative of a particular interest than of the general commercial interests of the country, they have attained a position of influence which no other body limited to one particular trade has succeeded in obtaining. The London General Shipowners' Society, the Liverpool Shipowners' Association, the North of England Shipowners' and Steamship-Owners' Associations may be mentioned as representative. In shipping centres of secondary importance the shipping interests are taken charge of by the local Chamber of Commerce, which styles itself Chamber of Commerce and Shipping; this is the case in Bristol, Grimsby, Hull, Ipswich, and Cork. The various Chambers of Shipping and Shipowners' Associations joined forces in 1878 in order to establish the Chamber of Shipping of the United Kingdom, which does for them what the Association of Chambers of Commerce does for Chambers of Commerce. It is divided into two sections, viz., the Shipowners' Parliamentary Committee, which watches all public Bills affecting British merchant shipping and looks after shipping interests in Parliament, and the Documentary Committee, which deals with charter-parties, bills of lading, berth notes, and other maritime documents, settles forms to be used, &c. The development of the mining industry led to the foundation some years ago of the London Chamber of Mines, which serves as an intermediary between mining interests on the one hand and the British commercial and financial public and the Government and Parliament on the other. This Chamber was supplemented in 1897 by the London Chamber of Rhodesia, whose membership is restricted to companies interested in the territories of the British South Africa Company, and having a working capital exceeding £20,000. It acts as the London correspondent of the Incorporated Chamber of Mines of Rhodesia, and defends and promotes Rhodesian land and mining interests. The Chambers of Mines are of colonial origin. In Australia they are to be found in Melbourne, Charters Towers, Perth, Coolgardie, and Kalgoorlie; in South Africa, at Cape Town, Kimberley, Johannesburg, and Bulawayo; and in Canada the Central Canada Chamber of Mines looks after mining interests. The Iron and Steel Institute affords a means of communication between members of the iron and steel trades, and its general meeting is an event of importance. This meeting is sometimes held abroad on the invitation of foreign associations, when technical papers are read, and discussions take place concerning especially processes and improvements connected with the manufacture of iron and steel. One-fourth of the members of the Institute are foreigners. Of the associations of firms connected with the iron trade, the British Iron Trade Association is one of the most powerful. The nature of the other associations is sufficiently indicated by their titles, and we cannot do more than give the names of very few of them. In addition to those mentioned in connexion with the London Chamber of Commerce, there are the Cotton Association, the Drapers' Chamber of Trade, the Fish Trade Association, the Sugar Refiners' Committee, various tea planters' associations, the Oil Seed Association, the Petroleum Defence Committee, the Mansion House Association on Railway and Canal Traffic, &c., &c. Almost every trade has an association of its own, one of the most recently established being the Society of Motor Manufacturers and Traders, 1902. In addition to these, there are in almost every town of importance organizations known as Traders' or Tradesmen's Associations, which look after the interests of the retail trades. A number of these associations joined in 1897 to form a central organization called the National Chamber of Trade, which has its headquarters at Hull, and comprises fifty Traders' Associations and some 300 individual members. The National Chamber federates, whenever possible, the various Traders' Associations in a town in a Chamber of Trade for the town, which is afterwards incorporated in the National Chamber.

(*c*) *Trade Protection Societies.*—These seem to be, on the whole, more ancient bodies than Chambers of Commerce. In the early part of the 19th century they were already strongly organized, especially in the West Riding of Yorkshire. Outside of that district the Dublin Society was the most important. In 1902 they numbered 115 throughout the United Kingdom.

Manchester Guardian Society.

The Manchester Guardian Society, which dates from 1826, occupies a position of special prominence in the Midlands, and may be taken as the model of such associations. Its objects are—the making of private inquiries as to the respectability and credit of traders; the detection and exposure of swindlers; the collection of debts; the winding-up of insolvent estates; the issue of notices of bills of sale, judgments, bankruptcies, &c.; and generally the improvement of laws and regulations affecting trade. The Society charges an ordinary subscription of only 10s. per annum, which entitles members to all privileges, and to be supplied with confidential information as to the standing of firms at the rate of 6d. each for the first fifty inquiries in each year, and 1s. each for inquiries above that number. The collection of debts is done without commission and for fees on a moderate scale: for debts under £20, 1s.; above £20 and not exceeding £50, 1s. 6d.; and above £50, 2s. The Society has over 6000 members, and its usefulness may be gauged by the fact that it answers an average of 40,000 credit inquiries, represents members in over 300 bankruptcies, arrangements with creditors and liquidations, and is entrusted with the collection of debts amounting to about £150,000 every year.

Association of Trade Protection Societies.

Trade Protection Societies formed themselves, as early as 1848, into an Association, with offices at Nottingham, which was at first an Association of Secretaries, but in 1865, when it included seventeen societies, was transformed into an Association of Societies. The number of affiliated bodies in 1902 was 82, their membership varying from 6000 in the largest to 25 in the smallest. The Association issues a quarterly journal called *The Trade Protection Journal.*

(*d*) *Non-Representative Organizations.*—Apart from representative institutions, certain organizations have grown up which have proved of great value to the commercial community, owing to the means of information which they have placed at its disposal. It is sometimes difficult to draw the line between private businesses and those which, whilst remaining private corporations, perform duties and render services which in other countries are performed and rendered by public bodies.

Commercial Intelligence Bureau, Limited.

The most noteworthy of these is the Commercial Intelligence Bureau, Limited, which was established in 1900 through the efforts of Mr Henry Sell, for the purpose of rendering to British manufacturers and merchants services similar to those which the Philadelphia Commercial Museum was rendering to American commercial men in placing them in relation with likely foreign customers of standing in their own trade. This Bureau is, it is true, in the nature of a private concern, conducted on ordinary business lines, and distributing dividends to its shareholders, but the public importance of the work which it is doing and the efficient state it has reached render it advisable to explain its method, which is still but imperfectly understood by the public. Its work is limited to the compilation and supplying of Index File Cabinets, which place before manufacturers and merchants seeking facilities in export a list of trustworthy foreign buyers in particular lines and *vice versâ* supply foreign buyers with lists of British manufacturers. These Cabinets—each of which is devoted to a particular trade or branch of trade, as the case may be—are filled with cards, arranged alphabetically from the names of the firms inscribed on them, and giving, besides name and address, branches, and London office if any, date of establishment, amount of capital, class of business, and if buyers a detailed and accurate list of the goods bought, and if manufacturers the list of goods manufactured and supplied. Each Cabinet is also provided with an index classification by countries and one by articles bought or sold. The Bureau is not an agency to obtain information as to the standing and credit of firms, but it guarantees that only firms of recognized good standing are allowed to figure in its Cabinets, and the statements on each card are checked by the firm interested before the card is put into circulation. Thirty trades, each with its own subdivisions, are included in the collection of Cabinets. Cabinets are supplied to subscribers and kept up to date for an annual subscription which varies in accordance with the importance of the trade, but generally ranges from £5, 5s. to £10, 10s. In addition to this, the Bureau keeps collections of its Cabinets in public places of resort of merchants abroad, such as Bourses and Exchanges, Chambers of Commerce, British Consulates, &c., where they can easily be consulted by foreigners desirous to do business with the United Kingdom. This is in imitation of the practice inaugurated by the Philadelphia Commercial Museum. The Bureau has opened a similar establishment in Paris, to do for French trade what it does for British trade.

B. *State Departmental Organizations.*

Although the British Government allowed commercial organizations within its jurisdiction to grow independently of official control, it does not follow that it took no interest in the protection and promotion of British trade and the dissemination of commercial intelligence. As long ago as the reign of Charles II., the body which is now the British equivalent of what is known in most countries as the Ministry of Commerce, viz., the Board of Trade, was established. In addition to this, other Government departments, such as the Foreign and the Colonial Offices, within whose purview commercial matters often came, took a fairly active interest in them. The commercial jurisdiction of the Board of Trade does not extend beyond the limits of the United Kingdom, but the Foreign Office, through the negotiation of commercial treaties and by means of the consular body, came into touch with the larger interests of international trade. It was frequently appealed to, both by private firms and by Chambers of Commerce and other associations, to undertake the defence of British trade abroad against injurious action of foreign governments and administrations. With the development of the Colonies, the Colonial and India Offices also found themselves called upon to act, to a certain extent, as guardians of commercial rights and channels for the dissemination of commercial intelligence. They have now departments specially entrusted with commercial affairs, but it is only within recent years that their commercial work has become systematized, and that efforts have been made to render it really effective in view of the magnitude of the interests involved.

So long as Great Britain enjoyed unquestioned commercial supremacy, things were allowed to go on without serious attempts being made to improve the means of official action proportionately with the extension of international trade. But when competition, especially German and American, began to displace British goods from foreign markets, and when the British trader began to realize that his supremacy was threatened, he noticed the efforts which were being made by foreign governments for the promotion of trade, and he came to the conclusion that the British Government was not doing anything for him. This was of course an exaggeration, but it was perhaps necessary that the outcry should be exaggerated in order to impress upon the home Government the necessity of improving its methods with the requirements of the times.

Consular service.

Complaints were especially loud against the Consuls, who were accused of systematically disregarding commercial interests, whilst their American, German, French, and Belgian colleagues did not consider it below their dignity to take advantage of their position in order to promote the trade of the country they represented. British Consular Reports were also unfavourably compared with those issued by foreign consuls, notably the American, and the mode of their publication, which, at one time, consisted in waiting for all the reports to come in in order to publish them in one or two big volumes, was condemned as rendering the information they contained practically of no value when it reached the public. The result was that, in 1886, when Lord Rosebery was Secretary of State for Foreign Affairs, he instructed the Under-Secretary of State, Mr Bryce, to carry out, in view of the action of Chambers of Commerce, an extensive inquiry into the question of consular action in international trade, with the object of facilitating the dissemination of commercial intelligence, and of giving British consuls detailed instructions with regard to their duties in commercial matters and to the help to be given by them to British merchants. In consequence of Mr Bryce's recommendations, instructions were issued to the consular service which, for the completeness and fairness with which they deal with the subject, can hardly be equalled by anything that has been published in foreign countries, and which have frequently been quoted by foreign representatives in England as models which might advantageously be followed (see Parliamentary Paper, Commercial, No. 16, 1886). The preparation of Consular Reports, however, continued to be most unfavourably criticized, and frequent instructions were issued by the Foreign Office in regard to them, notably in 1888, 1889, 1891, and 1893. In 1895, Lord Kimberley issued a further circular, embodying the recommendations of Chambers of Commerce with regard to the kind of information to be given in Consular Reports, and the manner in which it should be set forth. The whole question was raised again in 1896, when, as the result of lengthy communications between the Foreign Office on the one hand and the Association of Chambers of Commerce and the London Chamber on the other, and under the incentive of the action which had just been taken by Mr Chamberlain as Secretary for the Colonies (see below), fresh instructions were sent to British consuls, reiterating with especial emphasis Lord Rosebery's instructions of 1886, and urging them to be particularly careful, not only in the preparation of their reports, but in reporting without delay, and even by telegraph, if advisable, matters which might be of interest to the British commercial community, and in giving to British traders and their agents all the help and information in their power (Parliamentary Paper, Commercial, No. 5, 1897).

From a perusal of these instructions, it is plain that if the British consular body does not render commercial services equal to those rendered by the representatives of certain other nationalities, the fault does not lie in the instructions furnished to them. If the best of instructions have been ineffectual, the reason is that sufficient care has not always been exercised in the selection of British consuls, and that the following practices, among others, have too often been indulged in, viz., appointments through influence, and without regard to qualifications; non-insistence upon commercial knowledge of a real and serious nature; frequent selection of men who have been brought up in circles out of touch or sympathy with commercial aims and commercial men, and who consider it below their dignity to have anything to do with trade matters; appointment of foreigners; too frequent appointment of unpaid trading consuls, who cannot always afford the necessary time or bring the necessary impartiality to the discharge of their functions; and distribution of appointments without due regard to commercial importance of districts, inland manufacturing centres being too often sacrificed to unimportant seaport towns.

Commercial attachés.

The consular service has of late years been supplemented by the appointment of commercial attachés, who in 1902 were seven in number, viz., one in Paris, for France, Belgium, and Switzerland; one in Berlin, for Germany, Denmark, Holland, and Sweden and Norway; one in Madrid, for Spain and Portugal; one in Constantinople, for European and Asiatic Turkey and Bulgaria; one in St Petersburg, for Russia and Siberia; one in Vienna, for Austria-Hungary, Italy, and Greece; and one at Shanghai, for China and Japan. No other country, with the exception of Russia, seems to have similar commercial representatives. The posts are of comparatively recent creation, the first commercial attaché having been the late Sir Joseph Crowe, who was appointed to Berlin and Vienna in 1880. The second post, which was to St Petersburg, was created in 1887, and the third one to Paris in 1889. The attachés' duties are to avail themselves of every possible source of information in regard to commercial questions within their jurisdiction; to prepare an annual report, and, whenever advisable, special reports, on matters of interest to trade and industry; to help consuls with advice; to pay special attention to all tariff questions and regulations; to follow the proceedings of legislatures within their jurisdiction, and furnish information as to any bills, or laws, or parliamentary discussions and papers affecting trade matters; to give assistance to British merchants and to British Chambers of Commerce, and to endeavour to meet their wishes so far as they properly can, "and, although not expected to act as agents or commercial travellers for private firms, or to push their particular business, yet to render them substantial assistance in the pursuance of legitimate enterprise as far as possible"; to cultivate friendly relations with the heads of the department concerned with industry and commerce, and also with the heads of the great manufacturing or commercial firms within their jurisdiction; and, in addition, to report upon matters connected with mining and industrial concessions, labour and sanitary questions, railways and canals, trade-marks and patents, bounties and subsidies, technical and commercial education, improvements in industrial methods and machinery, the state of agriculture, &c. (Instructions of 1896).

Commercial Intelligence branch of the Board of Trade.

The pressure exercised by the Chambers of Commerce upon the Government led to the appointment in 1897 of a Departmental Committee on the Dissemination of Commercial Intelligence, which was composed of representatives of the Board of Trade, the Foreign, Colonial, and India Offices, and the Treasury, and the presidents of the Association of Chambers of Commerce and of the London and Manchester Chambers, and which was charged with considering means of more adequately supplying traders with commercial information, of improving consular and colonial reports, and with reporting on the advisability of appointing commercial agents to the Colonies and establishing a Commercial Intelligence Office. The chief result of the committee's recommendations was the establishment of the Commercial Intelligence branch of the Board of Trade, of which Mr T. Worthington, who had acted as special commissioner to South America, was appointed principal. This branch was entrusted with the centralization of the commercial information received by the various Government departments, and the dissemination of this intelligence. It has the power to send commercial missions abroad for the purpose of inquiring and reporting upon trade matters, and can order the preparation of special reports upon particular trades or industries, collects and exhibits samples and patterns whenever advisable, and supplies general information in connexion with foreign customs and shipping duties and regulations, fees, trading licences, &c. It publishes the *Board of Trade Journal* weekly. Attached to the branch is an Advisory Committee, composed of representatives of the various Government departments and of the Association of Chambers of Commerce, who meet in private once a month, and hold office for a period of five years.

Imperial Institute.

The scope of the Commercial Intelligence branch was further increased, and its means of action strengthened, by the transfer of the Imperial Institute to the Board of Trade, which was effected in 1902 by the passing of a private Act of Parliament. The Commercial Intelligence Department and the Colonial and Indian Sections of the Institute, with their complete and efficient organization, are now controlled by the Commercial Intelligence branch of the Board of Trade, but the good work which they did when the Institute was a private corporation deserves special mention. They endeavoured to develop trade with the Colonies by organizing a valuable and complete system of colonial trade information at a time when no such thing was in existence in London, and by arranging collections of raw materials and produce, which afforded a comprehensive representation of natural wealth, and of its practical value and application to various arts and manufactures. The Research Department, whose duty it was to make experiments with samples of raw products in order to test their capacities and their uses, has also rendered great services to British commerce; as have also the expert referees, who experimented with new or little-known materials, and expressed competent opinion as to the probable demand for and marketable value of product. The Imperial Institute has two City offices—one in Cannon Street, which was opened for the purpose of affording business men general information, and of providing a proper office for the translation of documents in Eastern or little-known languages; the other in Eastcheap, for organizing exhibitions of colonial products, and for forming a Museum of Samples of Colonial and Indian Raw Materials, which could conveniently be resorted to by City men.

Colonial and Indian intelligence.

Official means of obtaining information in connexion with the Colonies and India are not on so satisfactory a basis as in the case of foreign countries. There are no representatives of the British Government in those parts of the empire whose duty it is to report upon trade prospects, and to render home manufacturers and merchants the services which are performed in connexion with foreign trade by commercial attachés and by the consular service. The Colonial Office publishes occasional reports concerning the Colonies, but they can hardly be said to be even as satisfactory as the consular reports, and they are not so freely distributed as the latter. Too often the British commercial community has to go, for commercial information of any value concerning British Colonies, to the reports issued by American, French, or Belgian consuls.

Agents-general.

Crown agents.

The self-governing Colonies are, however, represented in London by Agents-general, whose duties are mainly of a commercial nature, and who are especially entrusted with making the products of the Colonies known in England, looking after the interests of the Colonies in the matter of shipping arrangements and rates of freight, cable communications and rates, tenders for public works, &c. Their expenses and salaries are fixed and paid by the Government of the Colony they represent. The following Colonies have Agents-general in London, viz., Canada, whose representative is styled High Commissioner; New South Wales, Victoria, South Australia, Queensland, West Australia, New Zealand, Tasmania, Cape Colony, and Natal. The Canadian provinces of Nova Scotia and New Brunswick have separate Agents-general. Canada has also commercial agents in Liverpool, Cardiff, Glasgow, and Dublin; in Sydney, Cape Town, Kingston (Jamaica), St John (Antigua), St Kitts, and Port of Spain; and in Paris, Antwerp, Christiania, and Buenos Aires. The commercial interests of the Crown Colonies are in the hands of the Crown agents for the Colonies, who, however, are not colonial representatives like the Agents-general, but home Government officials, and whose duties are chiefly connected with the public works of the Colonies, with shipping contracts, port and dock regulations, and similar quasi-administrative functions. The India office looks, to a certain extent, after the commercial interests of India, but from both the British and Indian commercial point of view the system in force in 1902 was very inadequate.

Colonial trade.

When Mr Chamberlain took office for the first time as Colonial Secretary, in 1895, he was so much impressed by the results of the Congress of Chambers of Commerce of the Empire, which had taken place in the previous year, and by the statements there made as to the displacement of British goods from colonial markets, that he entered into communication with the London Chamber of Commerce, which had organized the congress, requesting it to make suggestions for the drafting of a despatch to colonial governors, asking for information as to the extent to which foreign competition displaced British goods from colonial markets, the causes of this displacement, and the means which might be adopted to induce colonial buyers to purchase British-made articles in preference to foreign manufactures. The despatch went most minutely into the question, and asked for specific and detailed information with regard to prices and conditions of payment by British and foreign exporters, suitability of goods for the market, native preferences, quality, finish, packing, &c. A list of sixty-eight principal articles was appended to the despatch, with a request that particular attention should be paid to them. The governors were at the same time requested to send samples of the foreign-made articles which sold in colonial markets in preference to English-made ones, and to affix to each sample the price at which the article was retailed to the public.

The samples were sent to the London Chamber of Commerce, where they were exhibited for some time, and were subsequently sent for exhibition to various Chambers of Commerce throughout the United Kingdom. Wide publicity was at the same time given to the replies received from the governors, and leading firms in each trade were requested to send representatives to examine the samples, and to give for publication a report as to what they thought of them, of the price at which they sold, and of the means which British manufacturers should adopt to oust them from colonial markets. The burden of the reports was typically British. There was a general consensus of opinion that the articles of which samples had been sent were, in the main, so poor that no British firm would lower itself to manufacture them, and that if the colonials preferred them to solid and thorough and expensive British-made articles, they were not worth catering for. General surprise was, nevertheless, expressed at the excellence and marvellous cheapness of American ironmongery, and the skilful and artistic way in which foreign goods in general were packed was contrasted with the rough-and-ready manner in which British-made articles were put up.

These matters led to the conference of Colonial Premiers with the Colonial Secretary at the time of Queen Victoria's Jubilee in 1897, when commercial questions affecting the Colonies and the mother country were under consideration. This first interchange of opinions was followed in 1902 by another similar conference, which took place on the occasion of the visit of the Colonial Premiers for King Edward's coronation.

II. UNITED STATES OF AMERICA.

A. *Commercial Associations.*

American trade organizations have been developed mainly on the lines of the British system. Of the associations which come within the scope of this article, the most important are the Chambers of Commerce, which in certain cases are called Boards of Trade. Theoretically there is a distinction between the two, Chambers of Commerce being entrusted with the protection of general commercial interests, especially in connexion with foreign trade, whilst Boards of Trade look after local commercial questions. But in practice the difference is of no importance, as Chambers of Commerce take cognizance of local as well as international trade matters, and the Boards of Trade in no way limit the sphere of their activity to purely American questions.

The New York Chamber.

The oldest American commercial organization is the New York Chamber of Commerce, which was founded in 1768, and incorporated by royal charter in 1770. In the words of its charter, its object was "to carry into execution, encourage, and promote by just and lawful ways and means such measures as will tend to promote and extend just and lawful commerce." It was the prototype of all the other Chambers of Commerce and Boards of Trade which have since been established in the United States, and which are said to exceed 1000 in number.

The National Board of Trade.

American trade organizations are associated in a National Board of Trade, which corresponds to the Association of Chambers of Commerce of the United Kingdom. The objects of this institution are to secure unity and harmony of action in reference to commercial questions, and to obtain, through its representative character, more satisfactory consideration of the matters which it brings under the notice either of the Federal Government or of the local State administrations. The expenses of the National Board of Trade are defrayed out of a fund formed by the subscriptions of the various associations belonging to it.

American Chambers abroad.

The Americans have a number of Chambers of Commerce established in foreign countries. They started the first institution of this kind so long ago as 1801, when the American Chamber of Commerce in Liverpool was established. This chamber was in 1902 the only one representing American commercial interests in the United Kingdom, there being no association of this nature in London. The American Chamber of Commerce in Paris is one of the most active, important, and representative foreign associations on the Continent. In some places where neither the American nor the British element is strong enough to maintain separate associations (notably in Brussels), they have joined hands to support an Anglo-American Chamber of Commerce, which is found to work fairly satisfactorily.

Commercial museums.

The American Commercial Museums, although of recent foundation, have attracted much notice owing to the practical and business-like manner in which they are conducted, and are considered to be among the best equipped institutions of this nature. They are two in number, one in Philadelphia and the other at San Francisco. The Philadelphia Museum, which came first and is better known, was established by an ordinance of the municipality in 1894, and is supported by subscriptions and by municipal subsidies, administered by a board of trustees, who are appointed for life and serve without remuneration. The work of the museum is supervised by an advisory board, composed of representatives of the principal commercial organizations in the United States. Its objects are to assist American manufacturers and merchants in securing wider foreign markets for their products, to aid them in forming connexions abroad, and to bring foreign buyers in touch with them. One of the chief ways in which this is done is by means of an index file of foreign customers supplied to American manufacturers, and *vice versâ*, on the principle which has been put in practice in London by the Commercial Intelligence Bureau, which, by the way, is an offshoot of the Philadelphia Museum (see p. 394). In addition to the regular service to members, the Museum also maintains abroad, in forty-five different cities, index files covering sixty American trades or trade divisions, containing the names of American manufacturers of standing, with full particulars of their various lines of manufacture. These files are generally entrusted to Chambers of Commerce, or similar commercial institutions, and are placed gratuitously at the disposal of foreign manufacturers and merchants. The Philadelphia Museum has also a most valuable library and a museum of samples, which it has endeavoured to make as complete and representative as possible, and to keep strictly up to date. It seems, however, that the policy of keeping such samples is open to question. At any rate, the use which has been made of the Philadelphia collections has not been such as to warrant the expense and care which they entailed, and latterly this feature, which was at one time the most prominent, has been allowed to drop into the background, as happened also in the case of the Vienna Handelsmuseum. The energies of the institution are now especially directed to the services which it is in a position to render its members in connexion with foreign markets, by finding them desirable houses with which to do business and supplying information to foreign firms desirous of doing business with America. The American Commercial Museums, in addition to the subsidies which they receive from municipalities and from commercial associations, have also subscribing members, who pay 100 dollars per annum to be entitled to all the services which the museum can render, and 25 dollars if they desire only the index file in their particular line of business.

B. *State Departmental Organization.*

The American state organization for dealing with commercial matters lacks the theoretical completeness of the organization of most European states, but is nevertheless found to give satisfaction. Official control is exercised through various bureaus placed, for the most part, under the Treasury Department. The most important of these are: the Interstate Commerce Commission, which deals with matters affecting the inland trade; the Industrial Commission, which looks chiefly after manufacturing; and the Fishery Commission. There is no Ministry of Commerce, nor any department centralizing the commercial functions fulfilled in England by the Board of Trade and abroad by Ministries of Commerce. Foreign commercial matters come within the cognizance of the Bureau of Foreign Commerce, a section of the State Department which also controls the consular body, and sees to the publication of their reports and to the dissemination of foreign commercial intelligence. The State Department corresponds to the British Foreign Office.

An institution deserving of special mention is the Bureau of American Republics, which was established in 1889, as a result of the Pan-American conference called together in that year by the late Mr James G. Blaine, then Secretary of State. This Bureau, which has its office in Washington, is supported by a contribution from all the republics of North, Central, and South America, which is fixed at the rate of 1000 dollars a year per million inhabitants. Its object is the dissemination of trustworthy commercial information concerning the republics of the American continent, and in pursuance of this object it has issued a large variety of publications, handbooks, compilations showing the trade usages, commerce, industry, tariffs, commercial and quasi-commercial laws, &c., of each republic, as well as an elaborate *Code of Nomenclature*, or dictionary of the business terms in use in the different republics, published in English, Spanish, and Portuguese. It has also issued a *Commercial Directory of the American Republics*, and publishes a monthly bulletin.

Consular service.

The American consular service has been frequently pointed out as a model to be followed in connexion with commercial matters. America, contrary to the European practice, has no *consuls de carrière*. Her consular representatives are appointed for a period of as a rule, four years, and are selected in preference from commercial circles. Their work, as compared with that of British consuls, is rather limited, and they have nothing to monopolize their time like the shipping interests with which the British consular body is entrusted in most countries. They have, in consequence, more opportunities of devoting themselves to the purely commercial side of their duties, and as most of them are business men, it is naturally towards this side that they first turn. As a body, they have displayed a decided business instinct, which has enabled them to secure the kind of information especially wanted by the American commercial world, and their reports have been particularly remarkable for their terseness and for the practical way in which they conveyed information. Since 1898, the Bureau of Foreign Commerce issues consular reports daily, as fast as they are received, and circulates them in advance sheets, printed on one side of the paper only, like printers' proofs. They are afterwards republished in permanent form.

The American consular body, which numbers about 400 members, and is exclusively composed of American citizens, is distributed according to the commercial importance of towns. Important inland manufacturing districts are not sacrificed to more or less insignificant seaport towns, as is too often the case in the distribution of the British consular body.

III. France.

A. *Commercial Associations.*

The French Government was the first to elaborate a regular system of trade organizations, which it endeavoured to make as complete as possible. This system as it exists at present comprises:—

(*a*) Chambers of Commerce;
(*b*) Consultative Chambers of Arts and Manufactures; and
(*c*) Syndical Chambers of Trade and Industry.

Origin.

(*a*) *Chambers of Commerce.*—Chambers of Commerce owe their origin to the city of Marseilles, where, in 1599, the Town Council, which had hitherto looked after the commercial interests of the city, found it no longer possible to combine commercial with municipal functions, and established an association which it called the "Chamber of Commerce" to take up the commercial part of its duties. This seems to be the first time that the title was used. The new Chamber soon became a most important body, and in 1650, during the minority of Louis XIV., *lettres patentes* were granted to it. It settled the law merchant and the customs of the port, was entrusted with the appointment of consuls and the control of French consulates in the Levant, fitted out expeditions against corsairs, owned fleets, sent embassies to the Barbaresque countries, organized commercial missions, &c. Its ordinary budget, at one time, amounted to over one million livres. Louis XIV. conceived the idea of a system of organizations which, whilst not being allowed to become so dangerously powerful as that of Marseilles, would nevertheless be useful in other towns, and in 1700 he caused an *arrêté* to be published, ordering the creation of Chambers of Commerce, which were entrusted with the nomination of deputies to the Royal Council of Commerce which had just been created in Paris. Chambers were consequently established in Lyons, Rouen, Toulouse, Montpellier, Bordeaux, La Rochelle, Lille, Bayonne, Amiens, &c. These bodies, however, did not exercise much influence under the monarchy. Including the Marseilles Chamber, they were suppressed, with all trade gilds and other trade associations, in 1789. Napoleon re-established the Chambers by decree of the 24th December 1802, and endowed them with a constitution similar, in essential particulars, to the one they have at present, which has served as a model for Chambers of Commerce on the Continent, but he submitted them to a uniform and narrow administrative jurisdiction which practically deprived them of all initiative, and rendered them almost useless as representative commercial associations.

Constitution.

They are now regulated by the law of the 9th April 1898, which codified, altered, and completed previous legislation on the subject. Under this law, Chambers of Commerce can only be established by a decree countersigned by the Minister of Commerce, upon the advice of the Municipal Council of the place where the Chamber is to be, of the General Council of the department, and of the existing Chambers of Commerce of the district. The members of Chambers of Commerce used to be elected by the "Notables Commerçants," who were a body of commercial electors selected by the prefects in accordance with the provisions of the Code of Commerce. They were abolished by law in 1871, but those who were then entitled to the designation still continue to use it, which explains the words "Notable Commerçant," so puzzling to foreigners in French commercial directories and on French business cards. At present, commercial houses paying *patente*—which is a special tax upon people engaged in trade—elect the members of the Chamber, the number of whom is fixed for each Chamber by the Minister of Commerce. It cannot be less than nine nor more than twenty-one, except in Paris, where it may be thirty-six. Members are elected for six years and retire by thirds every two years, but are re-eligible at all times. They elect, subject to the approval of the Minister of Commerce, their officers, who cannot remain in office more than three years. Attendance at least once every six months is compulsory under penalty of expulsion. It is paid for at all times by a *cachet* or token, ranging in value from ten francs to twenty francs. There are 142 Chambers of Commerce in France and in the French colonies. French Chambers are bound to give their services gratuitously, and their income is derived from a special addition to the *patente* paid yearly by commercial houses. Such other establishments as they may control have separate budgets, and these, as well as the Chambers' budgets, have to be examined and approved every year by the Minister of Commerce.

Functions.

Their functions, which are consultative and administrative, are set out in Part II. of the Law of 1898. The Government is bound to take their opinion regarding the regulation of commercial usages, the establishment of public institutions of a commercial or financial nature, and of tribunals of commerce, the improvement of transport and communications, the application of laws of a local character, the sale price of prison-made goods and the tariff for prison labour, and local public works, and loans or taxation in connexion therewith. On the other hand, they are allowed to submit observations to the Government, without being asked, on proposed changes in the commercial or economic legislation of the country; on customs tariffs and regulations; on railway, canal, and river rates; and on transport regulations. As regards their administrative functions, they may be authorized to establish and administer such institutions as bonded warehouses, public sale-rooms, fire-arm testing establishments, conditioning rooms for wool, silk, textiles, paper, &c., commercial, professional, or technical schools and museums, &c. They may be granted concessions for public works, and may undertake the carrying out of public services, especially in regard to the ports, docks, canals, and navigable rivers in their district, and be authorized to issue loans for the purpose. They have to ascertain the local prices of goods for official quotation, to issue certificates of origin and commercial travellers' certificates, and to submit every year to the Minister of Commerce a list of names of experts to form the Board of Experts called upon to decide difficulties arising between the customs authorities and importers of foreign goods.

Previous to 1898, it was illegal for Chambers of Commerce to hold joint meetings for the discussion of matters of public interest, and they were not even allowed to correspond or consult in any way, except through the medium of the Minister of Commerce. The new law relaxed to a certain extent this prohibition, by authorizing direct correspondence and permitting Chambers in a district to meet for the joint consideration of questions affecting their district, but for no other purpose. Such a thing as an Association of Chambers of Commerce, or a general meeting of Chambers for the consideration of questions such as are raised at the general meetings of the Association of Chambers of Commerce of the United Kingdom, has always been and is still illegal in France. Chambers of Commerce which fail to comply with the law, or which make themselves objectionable, may be dissolved by decree on the proposal of the Minister of Commerce.

French Chambers of Commerce abroad.

When, in 1873, British merchants in Paris started a British Chamber of Commerce in the French capital, the French Government looked rather askance at the new venture, and M. Léon Say, when Minister of Commerce, even threatened it with forcible dissolution unless the title "Chamber of Commerce" was dropped. This demand was not ultimately pressed, and the services rendered by the British Chamber soon opened the eyes of the French Government to the advantages which they might derive from the formation of similar institutions to represent French commercial interests abroad. In 1883, the Minister of Commerce started the organization of such Chambers, which endeavoured to combine to a certain extent the French and the British systems. These Chambers, of which the French Chamber in London is the oldest and may be taken as the model, belong to the British system in so far as they are formed by the election of members who pay a yearly subscription, and are not limited in number, have no administrative duties, and are not submitted to the restrictions imposed by the French law upon such bodies. They belong to the French system in so far as they receive a subvention from the French Government, as the sanction of the French Minister of Commerce is required for their establishment. and as the Government is represented upon them by the French consul of the locality, who is *ex officio* honorary president. The amount of the subvention depends upon the importance of each Chamber and the requirements of the locality. A sum of about 100,000 fr. is voted every year in the French budget for the purpose. The French Chamber in London gets between 6000 and 7000 fr., and the others in proportion. There were in 1902 thirty-eight such Chambers in existence.

Foreign Chambers of Commerce in Paris.

Foreign commercial interests are represented in Paris by seven foreign Chambers of Commerce, of which the British Chamber is the oldest. The others are the American, Austro-Hungarian, Belgian, Italian, Spanish, and Russian Chambers. In 1896, these Chambers formed themselves into an Association of Foreign Chambers of Commerce, but the French Government gave it to be understood that, as they did not allow associations of French Chambers, they could not treat foreign bodies more favourably, and the Association had to be dissolved.

Constitution. **Functions.**

(*b*) *Consultative Chambers of Arts and Manufactures.*—These institutions, organized somewhat after the model of Chambers of Commerce, represent manufacturing and industrial interests. They were established by Napoleon I. in 1803, and formed part of the complete system of commercial organizations which he intended to give France. They are now regulated by decrees of 1852 and 1863, and are composed of twelve members elected for six years by merchants and manufacturers inscribed upon an electoral list specially drawn up by the prefects. These Chambers, of which in 1902 there were forty-eight in existence, are placed under the control of the Minister of Commerce, but instead of being kept out of the *patentes*, like Chambers of Commerce, they are supported by the municipality of the town where they are situated, which has also to provide them with offices rent free, and with clerical assistance. In addition to giving advice in connexion with manufacturing and industrial matters, they have to look after and report upon improvements in manufactures and machinery, new industrial processes, &c. They are especially useful in the preparation of local and international exhibitions. They are also entrusted with the nomination of the Consultative Committee of Arts and Manufactures, a body whose functions are to advise the Ministers of Commerce and Finance, as well as those of the Interior and of Public Works, as regards the regulation of dangerous trades and industries, patents and trade marks legislation, and the interpretation of customs regulations, notably in the classification of goods not specifically mentioned in the tariff. This power gives them great importance from the commercial point of view, and brings them into daily contact with importers and foreign merchants.

(*c*) *Syndical Chambers of Trade and Industry.*—By the side of the official trade organizations, other associations have grown up, which, although regulated by law, are in the nature of voluntary and self-supporting bodies, viz., the Syndical Chambers of Trade and Industry. The repeal in 1884 of the law of 1791, which prohibited the formation of trade or professional associations, was the signal for the formation of those Chambers, which soon acquired great influence. A few Syndical Chambers existed before that date, the oldest, the Chamber of Master Builders, dating back as far as 1809, but they were only tolerated, and their existence, being illegal, was most precarious.

Constitution.

The Syndical Chambers, which are divided into Chambers of Employers and Chambers of Employed, are the official organs and representatives of the trade and professional syndicates authorized by the law of 31st March 1884, which was the work of M. Waldeck-Rousseau. Each syndicate has its separate Chamber. They may be established without Government authorization, but a copy of their rules and a list of their officials must be sent to the prefect. Membership is strictly limited to persons of French nationality. The only way in which the Government can dissolve them is by application to the courts of justice for an order of dissolution on the ground of infringement of the provisions of the law. In Paris, most of the Syndical Chambers have formed themselves into an association called the Union Nationale du Commerce et de l'Industrie—Alliance des Chambres Syndicales, which has built a hall in the Rue de Lancry in which they are all housed, and where one common staff of officials and attendants does the clerical and office work of all the Chambers. Another association, intended to take up the defence of the interests and rights of Syndical Chambers, has been formed under the title of Syndicat du Commerce et de l'Industrie—Syndicat des Chambres Syndicales. The Syndical Chambers are kept up by the subscriptions of their members, and have the right to hold real property, as have also the Associations of Chambers, which are kept up by subscriptions from the constituent Chambers.

Functions.

According to the law which authorized their formation, the objects of the Syndical Chambers are exclusively "the study and defence of economic, industrial, commercial, and agricultural interests," and for this purpose they have complete freedom of intercommunication and can hold congresses. They are authorized to establish for their members mutual benefit societies and pension and relief funds, to open employment agencies, to give legal advice to, and in certain cases to bring actions on behalf of their members, and to organize the settlement of disputes by arbitration. They take part in the election of judges of the Tribunals of Commerce and of the Conseils de Prud'hommes, and may be requested by the courts to make statements as to trade and industrial customs and usages. They are competent to offer advice and address representations to the Government affecting the interests which they represent, and are not compelled, like other non-official associations and private individuals, to use stamped paper for the purpose.

B. *State Departmental Organization.*

Ministry of Commerce.

The State commercial departments and offices are chiefly centred round the Ministry of Commerce, to which is assigned the commercial part of the duties fulfilled in England by the Board of Trade. A Ministry of Commerce existed for short periods in 1811 and in 1828, but it was ultimately suppressed in 1829, and from that date until 1886, when the department received its present form and separate existence, commerce was only represented in the French Government by a subsidiary Bureau attached sometimes to one ministry, sometimes to another. The ministry is divided into three main Bureaus,—the first entrusted with all matters connected with the home trade and industry, the second with foreign and colonial relations, and the third with the compilation of statistics.

Attached to the Ministry of Commerce is a body called the Conseil Supérieur du Commerce et de l'Industrie, which acts as an advisory council to the minister. Its origin goes back to the Council of Commerce established by Louis XIV., but it is now regulated by a decree of 1882. It is divided into two sections, a commercial and an industrial one, each composed of twenty-four members, who are nominated by the President of the Republic on the proposal of the Minister of Commerce. The members are selected from among senators, deputies, presidents of Chambers of Commerce and of Syndical Chambers, and men of recognized standing in the financial, industrial, and commercial worlds. The council only meets when summoned by the minister.

National office for foreign trade.

The Office National du Commerce Extérieur was established by a law of the 4th March 1898, and is carried on jointly by the Ministry of Commerce and the Chamber of Commerce of Paris, the latter having provided it with an installation at a cost of over 1,200,000 francs. The Office, which has been founded for the promotion of French trade with foreign countries and the dissemination of commercial intelligence, fulfils duties similar to those of the Commercial Intelligence Branch of the Board of Trade (p. 395). It also publishes the weekly *Moniteur Officiel du Commerce*. An ingenious system has been devised to secure for the Office the active co-operation of prominent French merchants residing abroad, by the creation of the title and functions of Councillor of Foreign Trade, which are conferred for a period of five years, by decree of the President of the Republic, upon a select number of such merchants, in return for their acting as information agents for the Office, and supplying regular reports upon the trade of the country in which they reside. The Office is governed by a council appointed partly by the Minister of Commerce and partly by the Chamber of Commerce of Paris, and its director and employés rank as civil servants.

Office Colonial.

The Office Colonial, whose duties are especially to furnish information concerning the French Colonies, to promote emigration thither, and to foster a demand in France for the produce of her Colonies, was established by a decree of the 14th March 1899. It is entrusted, in addition, with a permanent exhibition of colonial produce and a museum of samples of goods supplied by or required in the Colonies. The Office is also in charge of a colonial garden at Vincennes, where experiments are made for the acclimatization of colonial plants and produce in France, and the cultivation of French produce in the Colonies. The Office publishes a monthly bulletin of miscellaneous colonial information, and issues yearly commercial and other reports dealing with the Colonies. It is a dependency of the Ministry of the Colonies.

French consuls are instructed to transmit to their Government all information which they may consider useful for the prosperity of French trade and the development of French commercial influence abroad. It is also their duty to spread, in the country where

Consular service.

they reside, a knowledge of such French commercial and financial matters as they may consider most useful in the interests of their own country. The close relations which they are recommended to cultivate with the French commercial community within their jurisdiction through the local French Chamber of Commerce and the Councillors of Foreign Trade are intended to enable them to keep in better touch with commercial questions. They have had, however, to be frequently reminded of their commercial duties, and the French Chambers of Commerce have criticized them almost as much as the British Chambers have British consuls. The most important instructions issued to consuls were contained in circulars from the Minister for Foreign Affairs dated 15th March and 24th April 1883. French consuls have to make a return to their Government every fortnight—every month if the district is not of great commercial importance—showing, upon forms specially provided, the nature, quantity, origin, or destination, prices wholesale and retail, and chief trade marks of the goods imported into and exported from the district, the results of public sales of produce, the conditions of transport, contemplated public works and tenders advertised, state of the labour market, artistic enterprises, commercial failures and rumours concerning important local firms, effect of foreign competition, imitation of French trade marks, &c. These returns are mostly of a confidential nature, and are not intended for publication, but whenever the minister considers it advisable he causes information to be conveyed through the Chambers of Commerce, or other channels, to the parties chiefly interested. The ordinary Consular Reports are published in weekly instalments in the *Moniteur Officiel du Commerce*, which also contains selections from foreign consular reports and the reports of commercial students sent abroad by the high schools of commerce with travelling scholarships.

IV. Germany.

A. *Commercial Associations.*

German trade organizations are of three kinds, viz.:—

(*a*) Official organizations established by law, and called Handelskammern, or Chambers of Commerce;

(*b*) Semi-official associations; and

(*c*) Voluntary or "Free" associations.

(*a*) *Chambers of Commerce.*—Contrary to the idea prevalent in England, official trade organizations in Germany are in a somewhat chaotic state. They have been established under more or less different conditions and systems in each State of the empire, and in certain districts still bear the imprint of foreign origin. They are under the control of the local State governments and lack the homogeneity and unity of direction of the French official system.

Hanseatic organizations.

Before proceeding to a general examination of the German régime, special mention must be made of the Chambers of Commerce of the old Hanseatic Confederacy which stand apart, and whose duties, as well as constitution, differ from those of trade organizations in the rest of Germany. The Chambers of Commerce in Hamburg, Bremen, and Lübeck are not only the successors of, but (contrary to what happened in Germany as well as in other countries) have been evolved out of the old corporations which looked after the interests of the Hans traders in the olden days, and which, in the case of the Hamburg "Commerz-Deputation," for instance, dated as far back as 1665.

The Hamburg Chamber of Commerce, whose present constitution dates from 1860, is composed of twenty-four members elected for six years by the ancient "Versammlung eines ehrbaren Kaufmannes," that is to say, the merchants and commercial men whose names appear on the register of the "Honest Merchants" of the city. Its income is chiefly derived from special taxation, to which are added the proceeds of the sale of contract and transfer stamps, and also the amount paid every year for the re-registration of each "Honest Merchant." This latter source of income amounts to about 70,000 marks per annum. The Chamber has to submit its accounts for approval to the Senate of the Republic.

In addition to the general duties of Chambers of Commerce in connexion with trade matters, the Hamburg Chamber—the same may also be said of the other Hanseatic Chambers—fulfils the combined functions of a Chamber of Shipping and of a Port and Docks Board. It appoints inspectors of shipping, of sailors, of rigging and machinery, and controls the administration of the sailors' fund. It has the right of proposing judges and of nominating experts attached to the courts. The exchanges and public sale rooms of the city are under its control, and it publishes the official quotations, as well as a weekly price list of goods and produce at the port of Hamburg. It is entitled to elect members to the "Bürgerschaft," or Lower House of Representatives, who are especially competent to deal with trade and shipping questions, customs duties, and emigration. The Chamber must be consulted by the "Bürgerschaft" with reference to all proposals affecting trade and navigation.

In Bremen, the Chamber is composed of twenty-four members elected by the "Ausschuss des Kaufmanns-Konvents," which comprises all the important commercial houses of the city. Two members go out every year, and no one can remain a member for more than eighteen years. The Bremen Chamber is intimately connected with the Senate of the Republic, a standing committee of both being in existence to settle questions affecting trade and navigation. In addition to the usual sources of income, the Bremen Chamber receives a subvention of 3500 marks from the town, and the salaries of its officials are fixed by law.

The Lübeck Chamber is composed of twenty members elected for six years by the associations representing the wholesale and retail trades. The president must be approved by the Senate, and is sworn in as a State official. He holds office for two years, and is not paid for his services, but when he goes out of office is presented with a sum of money subscribed by the townspeople. The Lübeck Chamber is probably the wealthiest organization of its kind in Germany, and is entrusted with the administration of the property of the old corporation of the "Vorstand der Kaufsmannschaft," which is very important. The Senate must consult it not only in trade and navigation matters, but also with reference to all contracts entered into on behalf of the State.

Chambers of Commerce.

Chambers of Commerce in other parts of the German empire are not so important, nor are their duties so varied, as in the Hanseatic towns. The oldest ones were established by Napoleon in 1802 in Cologne, Crefeld, Aachen, Stolberg, and other towns which were then under the control of France, and they were submitted to the legislation which regulated the Chambers organized in France at the same time. The model set up by the French was more or less closely followed in the subsequent establishment of institutions of this nature in other German States. There were in 1902 eighty-eight Chambers of Commerce throughout the empire, the latest one established being, curiously enough, the Berlin Chamber, which was constituted on the 1st April 1902. A trade corporation called the "Aelteste der Kaufmannschaft" previously fulfilled, to a certain extent, the duties of a Chamber of Commerce. The new Chamber rests on a broader basis than the old corporation, which, however, remains intact, though the sphere of its action has been restricted.

A detailed account of the system in force in every State of the German empire is hardly required here, and would not in any case present much interest, as the differences are mainly on points of detail. Broadly speaking, the German Chambers are elected by the registered tradespeople and merchants. In some States, *e.g.*, Bavaria, all the people on the Commercial Register have the right to vote; in others, *e.g.*, Baden, this right is limited to people living in the district, and paying a certain amount of taxes. The period for which members are elected is not uniform, but generally averages six years, one-half of the members going out every three years. Re-election is generally allowed. In Bavaria, there is a curious proviso that a person elected member of the Chamber of Commerce cannot refuse to serve, but can decline to be re-elected. Throughout the whole of Germany, Chambers are under the strict supervision of the State Minister of Commerce, and cannot be established except with his permission. He fixes the number of members as well as the amount of the State allocation to the Chamber. In Prussia and Bavaria, the Government is entitled to dissolve Chambers whenever it considers it advisable to do so, and there is always a Government commissioner in attendance at all meetings. In most cases, the local Government allows a fixed sum for the expenses of Chambers of Commerce, and if this amount is exceeded the electors who are on the Commercial Register have to make good the excess by the striking of a special rate. In some States, *e.g.*, Brunswick, Würtemberg, and Baden, the electors cannot be called upon to pay for deficiencies more than an amount fixed by law. In Bavaria, Chambers get a subvention from the district and central funds.

The duties and powers of the German Chambers are practically the same as those of the French Chambers, viz., to look after the interests of trade and industry in their respective districts, to administer stock and other exchanges, bourses, public sale rooms and warehouses, and commercial institutes, manage public institutions founded for the promotion of commercial interests or commercial education, define and state rules and customs of trade, &c. In Prussia, they are, moreover, called upon to look after "the moral protection of clerks and apprentices."

The Prussian law of the 24th February 1870, amended by that of the 19th August 1897, regulates Chambers of Commerce and similar associations in Prussia. A Bill for the amendment of the law on the subject has been for some time under the consideration of the Reichstag, as the present system is very strongly criticized, and is in many quarters not considered satisfactory in view of modern trade requirements. The object of the promoters is to transform the Chambers into institutions of an imperial instead of a local character, and to enable them to be utilized more efficiently in promoting the general commercial interests of the empire.

The German Government did not, like the French, interfere with the liberty of association of Chambers of Commerce, and as a result German Chambers have united, together with other trade corporations, in an association called the "Deutsche Handelstag," which was founded in 1861, and has been carried on in its present form since 1886.

German Chambers abroad and foreign Chambers in Germany.

The German Government is understood to be opposed to the formation of German Chambers of Commerce abroad, and as a matter of fact there are no German Chambers in Europe outside of Germany. The writer is informed that a few have been established in South America, but that they are purely voluntary associations. No foreign Chambers of Commerce are known to exist in Germany. Steps were taken about 1898–1900 to bring about the creation of a British Chamber in Berlin, but they do not seem to have been successful.

(*b*) *Quasi-Official Corporations.*—Besides the Chambers of Commerce, there exist, chiefly in Prussia, various old-established and quasi-official corporations, whose views receive as careful consideration from the Government as do those of Chambers of Commerce. The Berliner Aelteste der Kaufmannschaft, previously mentioned, is one of the most important of these corporations, but the Gewerbekammer of Memel, the Kaufmännischen Verein of Breslau, the Vorsteher Amt der Kaufmannschaft of Koenigsberg, also deserve mention. Others exist in Elbing, Stettin, Danzig, Tilsit, and Magdeburg. They originated for the most part in ancient guilds or associations of commercial firms, and were organized in their present form between 1820 and 1825.

(*c*) *Voluntary Associations.*—Germany possesses also a large number of influential commercial associations of a voluntary character called the "Freie Vereine," which, especially in recent years, have greatly contributed to the commercial development of the Empire. One of the most important of these Freie Vereine is that of Düsseldorf. Similar ones also exist in Cologne, Kiel, Essen, Frankfort, &c. Some cover trade and industry in general, while others are limited to particular trades. They are all supported by the contributions of their members, and although they have no official standing, they are frequently consulted by both the imperial and local authorities.

B. *State Departmental Organization.*

The German empire has no Ministry of Commerce. As in the United States, commercial matters form only a department of the Ministry of State. Most of the States of the empire have, however, their own Ministries of Commerce, the oldest being the Prussian Ministry of Commerce and Industry, which dates from 1848.

Prussian Council of National Economy.

In Prussia, the Minister of Commerce is advised by the Volkswirthschaftsrath, or Council of National Economy, an official body constituted in 1880 by the Emperor William I. The functions of this council, which assembles periodically under the presidency of the Minister of Commerce, are almost similar to those fulfilled in France by the Conseil Supérieur du Commerce et de l'Industrie. It is composed of seventy-five members appointed for five years, of whom forty-five are selected from double that number of nominations submitted by Chambers of Commerce, mercantile corporations, trade associations, &c., the remaining thirty being appointed by the Government. It is divided into three sections—commercial, industrial, and agricultural, and its chief work consists in examining and advising as to bills and draft regulations affecting those interests brought forward in the name of the kingdom of Prussia in the Federal Council of the empire.

Commercial Museums.

Within recent years, the German Government has taken steps to facilitate the dissemination of commercial intelligence, by the establishment of Commercial Museums, which are variously called "Handelsmuseen," "Ausfuhrmusterlager," or "Exportmusterlager." The first of these, which are on the model of the Vienna Handelsmuseum, was opened in Berlin in 1883. Others followed in Munich, Karlsruhe, and Frankfort in 1884–85, in Cologne and Dresden in 1886–88, and later in Leipzig, Weimar, &c. They perform, to a certain extent, much the same functions as those performed in England by the Commercial Intelligence Branch of the Board of Trade, and the commercial and colonial departments of the Imperial Institute. They are centres of commercial information, and give advice to German manufacturers and merchants in their dealings with foreign countries. They keep samples of foreign manufactures which are competing successfully with German articles, as well as samples of goods suitable for export to certain countries. They examine and advise as to samples of raw materials and colonial produce, and endeavour to guide the German exporter in the direction in which his efforts are most likely to produce satisfactory results. The museums are free public institutions.

Consular service.

A perusal of the instructions given to German consuls with regard to commercial matters shows that the German consular body is in this respect very much in the same position as the British consular body. If German consuls as a whole have been especially active and successful in promoting German commercial interests, it is not on account of the nature of the instructions received from their Government, these instructions being to all intents and purposes similar to those issued to British consuls, but because particular care was taken to select consuls from a class of men imbued with the desire of increasing the greatness of their country by the promotion of German trade. Their action was prompted by their own personal feelings and business instincts and experience, and if it has been successful whilst remaining within the recognized bounds of consular work, it is because it was guided by an enlightened desire to place the general interests of the German empire before questions of personal convenience, or before the decorum of official inertia. The German consular body were not selected from a class of men trained from their early youth to look upon trade as below them, and to regard anything and anybody that "smells trade" as unworthy of their attention.

Agricultural attachés.

Of distinctly commercial attachés, like those of Great Britain and Russia, Germany has none; but in addition to the consular body, she is represented in foreign countries by five attachés or experts, whose duties are to study the movements of agricultural produce, and interest themselves in agricultural matters generally. They cover Great Britain France, Russia, the Danube district, and the United States.

V. BELGIUM.

A. *Commercial Associations.*

The important place which Belgium has taken in international trade has directed much attention to her commercial organization, which comes nearer to the British model than that of any other European country. Belgian Chambers of Commerce were on the French system until 1875, when all official ties between them and the Government were broken, and full liberty was given to Commercial Associations to establish and govern themselves in their own way. The Belgian Chambers have now no administrative functions of any kind, but the Belgian Government never fails to consult them in matters likely to interest the commercial community. The most important Chambers are those of Antwerp, Brussels, Ghent, Liège, Charleroi, Verviers, and Namur. Mention should also be made of the Federations of Industrial and Commercial Associations at Antwerp and at Brussels, and of the Syndical Union of Brussels. In some places there are Liberal and Conservative Chambers of Commerce.

In addition to institutions representative of the general interests of commerce and industry, the principal trades have also in the larger cities separate associations or syndicates. The coal and iron trades are particularly strong in such associations, which are mostly located in Charleroi, Liège, and Namur. There are also a large number of associations for the promotion of colonial trade, which have grown up since the establishment of the Congo Free State. A number of Belgian Chambers of Commerce also exist abroad, the first of which was established in New York in 1867. Others have since come into existence, notably in London and Paris.

B. *State Departmental Organization.*

The Belgian Ministry of Commerce, under whose control commercial matters are placed, dates only from 1895, previous to which time the Department of Commerce at the Ministry for Foreign Affairs fulfilled the same functions. The Ministry has established in Brussels a Commercial Museum, similar to those of Germany and Austria, to centralize commercial intelligence and facilitate its dissemination. The Minister for Foreign Affairs, before appointing consuls requests the advice of the most important Chambers of Commerce and trade associations, and submits for their consideration lists of candidates upon the relative merits of whom they are invited to express an opinion. The result is that the consular body is a remarkably capable one, and that, proportionately, it probably contains a smaller number of useless members than the consular body of any other nation. Attention to commercial duties is especially insisted upon, and in taking their oath of office Belgian consuls promise that they will contribute, by every means in their power, to forward the interests of Belgian commerce and navigation. Explicit instructions are given to them not only to keep themselves well informed as to the commercial conditions of the country to which they are accredited, and to transmit this information for the use of the home trade, but also to give the greatest possible assistance towards securing an increase of the nation's export trade.

VI. Other Countries.

Austria-Hungary.—The control exercised by the Government over commercial organizations in Austria and in Hungary is very close. The only institutions of this kind of any importance within the dual monarchy are the Chambers of Commerce, of which there are twenty-nine. They are official bodies, regulated by the law of the 29th June 1868, which is, as regards the functions of Chambers, almost similar to the French law. But the Austrian Chambers, in certain cases, have the right to elect members of Parliament, which right depends upon taxation. A ministerial representative is entitled to attend all meetings, and to take part in discussions, but not to vote. The Minister of Commerce may dissolve a Chamber if it does not confine its activity within the prescribed limits, but a Chamber so dissolved must be reconstituted within three months. Chambers of Commerce are entrusted with the registration of trade marks and industrial designs. Within the Trieste district, one-third of the members of Chambers of Commerce may be foreigners.

Austria and Hungary have each a Ministry of Commerce, the former since 1853 and the latter since 1867, whose jurisdiction is strictly confined to internal trade matters in each country. Whenever important questions arise affecting common interests, the Gemeinsame Zoll-Conferenz, or Common Customs Conference, is summoned. This Conference is made up of representatives of the various ministries of both countries. Matters arising out of commercial relations with foreign countries are under the control of the Commercial Department of the Imperial Foreign Office.

The Vienna Commercial Museum was the prototype of similar institutions. It was established in 1875, as a consequence of the Vienna International Exhibition of 1873, and was followed shortly afterwards by the establishment of a similar one in Budapest. These museums are under the control of the respective Ministers of Commerce, and their object is to bring together producers and consumers, and to disseminate information in connexion with foreign markets. Special attention was, for some time, paid to collections of samples, but, as in the case of the Philadelphia Museum, this feature has not been found satisfactory.

Italy.—The Chambers of Commerce and Arts, which are regulated by the law of 1862, are official bodies. They are instituted, and may be dissolved by royal decree, and their functions are almost similar to those performed by the French Chambers. They are, however, at liberty to unite for the consideration of commercial and industrial questions of common interest, and are entitled to own property and to levy taxes for their maintenance. Contrary to the practice of other nations which have official Chambers of Commerce, the membership of Italian Chambers is not limited to subjects of the country. One-third of the elected members may be foreigners. The Italian Chambers are seventy-two in number. In addition to the Chambers of Commerce, there are in most towns of importance Chambers of Trade, which are local institutions.

An Advisory Council is attached to the Ministry of Commerce, which dates from 1878. This Council is called upon to give an opinion with reference to all matters connected with trade and industry. It is composed of eighteen members appointed by the king, of the representatives of eighteen Chambers of Commerce, of those of six other commercial corporations and of two workingmen's associations, and of six *ex-officio* members belonging to various State Departments. There are also two commercial museums, one in Rome and one in Milan, the duties of which are similar to those performed by such associations in other European countries. Their expenses are paid by the Italian Government, under whose control they now are.

Spain.—Spanish Chambers of Commerce were organized by a royal decree of 1886, which places them under the control of the Ministro de Fomento. They are self-supporting bodies with unlimited membership, but have also an official standing. In order to belong to them one must be of Spanish nationality, be engaged in trade, have paid direct taxes to the State for at least five years for the business in connexion with which membership of the Chamber is sought, and pay annually the amount of the subscription provided by the regulations. The Government must consult Chambers of Commerce upon treaties of commerce and navigation, tariff changes, the creation of commercial exchanges and the organization of commercial education. The Spanish Chambers have played a prominent *rôle* during the last few years in connexion with the reform of the financial policy of the country and of taxation. The Madrid Chamber, especially, has taken a very pronounced line of action in these matters, which has not always been in accordance with the views of the Government. It must not be forgotten, however, that owing to the peculiarity of their constitution, the Spanish Chambers are much more representative of the feelings of the commercial community, and much less under the strict control of the Government, than similar institutions in other Continental countries. Spain has no Ministry of Commerce proper, the duties of this office being performed by the commercial sub-department of the Ministro de Fomento, which dates from 1847.

Portugal.—In Portugal, the organizations corresponding to Chambers of Commerce, which are called "Commercial Associations," are voluntary associations kept up by the subscriptions of their members. They have no official character, but cannot be established except by a royal decree approving their statutes, which approval can be withdrawn if they in any way depart from their object, or fail to send in annually their report to the Minister of Commerce, or to submit their accounts to him. These institutions, which are the only commercial associations of any kind in Portugal, are fifteen in number, including those in the adjacent islands and in the Colonies. The associations at Lisbon and Oporto are the only ones of importance.

The Portuguese Ministry of Commerce, which dates from 1852, is placed in contact with popular opinion on commercial and economic questions, by an institution called "The High Council of Commerce and Industry," which is composed of six members selected by the Government from persons whom it considers to be most competent to advise on matters connected with commerce and industry, three for each subject. The Minister of Commerce and two officials of his department are *ex-officio* members. The Government must consult this council with reference to customs and tariffs, railway rates, exhibitions, subsidies, banking, trade marks and patents, and labour in factories.

Russia.—Attached to the Department of Trade and Manufactures of the Ministry of Finance, which in Russia does duty for the Ministry of Commerce, there is an Official Council of Trade and Manufacturers which sits in St Petersburg, and is presided over by a representative of the ministry. It consists of six honorary members, six *ex-officio* members, and twenty-four ordinary members, of whom fifteen are Russian officials and nine merchants of the first class or gild. The latter are almost all foreigners. Half the Council retire every two years, and the remaining half co-opt members to replace them. Nominations must be approved by the Minister of Finance and sanctioned by the Emperor. A similar Council of twenty-four members is also in existence at Moscow. In addition to these there are six local bodies, called the "Local Committees of Trade and Manufactures," entrusted with the care of commercial interests in Archangel, Odessa, Rostov-on-the-Don, Tver, Tikhvin, and Ivanovo-Voznesensk. At Warsaw, there is a "Committee of Manufactures" consisting of six members chosen by the Government from among the notables of the city and presided over by the Governor. The other "local committees" are elected as follows: the first and the second Gilds of Merchants elect by ballot a council of seventy members, and this council elects the twelve members who are to form the committee. All the committees are purely consultative bodies, but their opinion carries considerable weight, and although the Minister of Finance is perfectly free to reject it, he does not do so without good reasons. As will be gathered from the above, there is a difference between the St Petersburg and Moscow councils and the Warsaw committee on the one hand, and the local committees on the other. The former are official bodies, though merchants are represented on them, whilst the latter are almost Chambers of Commerce elected by the merchants among themselves.

Closer, however, to what we know as Chambers of Commerce are the institutions called "Exchange Committees." They are eighteen in number, one in each of the most important cities of the empire, and their importance has greatly increased of late years. They are voluntary associations, chosen by a council elected for the purpose by the commercial community, after the principle already explained in connexion with the Local Committees of Trade and Manufactures. They generally consist of twelve members elected for five years, and the president is appointed by the Minister of Finance. Foreigners are eligible. The Committee meets once a week at the local exchange, hence its name. The opinion of the Exchange Committees is frequently taken not only by the Minister of Finance, but also by other ministers, and they have always the right to petition the Minister of Finance if they wish to draw his attention to any matter. The Minister of Finance receives the president of the St Petersburg Exchange Committee in consultation every Saturday. Two important commercial societies, although unofficial, are recognized and frequently consulted by the Government, viz., the Society for the Encouragement of Russian Trade and Industry, of St Petersburg, and the Society for the Encouragement of Navigation, of Moscow.

The Russian Government is represented abroad by commercial attachés, who are known as "agents of the Russian Ministry of Finance." The duties of these attachés, who are to be found in all the important capitals, are almost similar to those of the British commercial attachés, but they are entrusted with the promotion of Russian financial as well as commercial interests in the countries where they reside. There is also a Russian Chamber of Commerce in Paris.

Japan.—Commercial matters in Japan come within the cognizance of the Minister of State for Agriculture and Commerce. The chief commercial associations are the Chambers of Commerce, which are under the direct control of the Minister. Since the law of the 24th May 1902 they may be described as official bodies, with a constitution somewhat resembling that of the French Chambers. This law, which came into force on the 1st July 1902, provides that a Chamber shall consist of not more than fifty members, who must be Japanese subjects, elected by the commercial taxpayers of the town or district in which it is situated. Only Japanese commercial men, or companies and partnerships in which more than one-half of the directors or partners are Japanese, shall be entitled to vote. Permission to promote the establishment of a Chamber in a given district must be obtained from the Minister before any steps are taken, and the Chamber comes into existence only when the Minister has approved the steps taken by the promoters, and the proposed articles of association and bye-laws. The Minister has power to cancel anything done by a Chamber which seems to him detrimental to public interests, to dismiss officers or members, and, if he thinks fit, to dissolve the Chamber. The expenditure of Chambers of Commerce is met by a special rate, which is paid by those entitled to vote for the election of members, and is fixed by the minister or his representative, according to the requirements of each district. In addition to the usual consultative work of Chambers of Commerce, the Japanese Chambers may be authorized to build and manage commercial or industrial establishments. They also recommend judges and experts in commercial and industrial matters, and may be ordered by the Government to investigate commercial and industrial affairs. Chambers of Commerce which were in existence before the passing of the above law were given until 31st March 1903 to dissolve or reconstruct themselves in accordance with the new law. Since the exclusion of foreigners from the membership of Chambers of Commerce, foreign merchants resident in Japan have taken steps to establish foreign Chambers of Commerce, the chief of which are in Tôkyô and in Yokohama.

Authorities.—Correspondence respecting Diplomatic and Consular Assistance to British Trade Abroad. *Parliamentary Papers*, No. 16, 1886, and No. 5, 1897.—*Report of the Departmental Committee on the Dissemination of Commercial Intelligence.* 2 vols. (C. 8962 and 8963). 1898.—Reports on the Constitution and Functions of Ministries of Commerce and Analogous Branches of Foreign Administrations. *Parliamentary Paper*, No. 12, 1889.—Reports, Rules, Bye-laws, and Articles of Association of the Association of Chambers of Commerce; of the London, Liverpool. Manchester, and Paris British Chambers of Commerce; of the Association of Trade Protection Societies and of the Manchester Guardian Society; of the Imperial Institute, British Empire League, and Commercial Intelligence Bureau; Charters and Bye-laws of the Glasgow Chamber of Commerce, &c.—E. Helm. *Chapters in the History of the Manchester Chamber of Commerce.* 1902.—H. B. Adams. *Monographs on American Social Economics.* New York, 1900.—W. H. Schoff. *American Commercial Institutions.* New York, 1900. *Foreign Trade Policies.* American Consular Report, No. 307, 24th December 1898.—*The Bureau of American Republics Annual Report.* Washington, 1900.—W. Harper. *The Pan-American Conference.* New York, 1894.—Yves Guyot and Arthur Raffalovich. *Dictionnaire du Commerce, de l'Industrie et de la Banque.* Paris, 1901.—Maurice Block. *Dictionnaire de l'administration Française.* Paris, 1894.—*Almanach National.* 1901. —*Handwörterbuch der Staatswissenschaften.* Leipzig, 1900–02.—*Handbuch über den königlich-preussischen Hof und Staat.* Berlin, 1794–1868.—B. W. von König. *Handbuch des deutschen Konsularwesens.* Berlin, 1875; *Das K. K. Oesterreichische Handels-Museum*, 1875–1900. Wien, 1902.—Information has also kindly been supplied by the Principal of the Commercial Intelligence Branch of the Board of Trade; H.M. Consuls-General in Berlin and Vienna; the Directors of the Office National du Commerce Extérieur, Paris; and of the Commercial Museums of Philadelphia and Vienna; the High Commissioner for Canada and the Colonial Agents-General; the Belgian Consul-General in London; the Secretaries of the Belgian, Italian, and Austro-Hungarian Chambers of Commerce in London; of the American Chamber in Liverpool; of the British and American Chambers in Paris; of the Yokohama (Japanese) Chamber of Commerce; of the London, Liverpool, Manchester, Newcastle, and Glasgow Chambers, and of the Association of Chambers of Commerce; of the Manchester Guardian Society, and of the Association of Trade Protection Societies; of the Chamber of Shipping; of the Imperial Institute, &c. (J. G. C.)

TRADE UNIONS.

I. The United Kingdom.

The present article is supplementary to the article Trade Unions, on pp. 499–502 of vol. xxiii. of the ninth edition of this work, in conjunction with which it should be read, and to which reference should be made for a definition and general description of trade unions, and for an account of their legal position in Great Britain, and of the course of legislation concerning them. In the present, as in the former, article the term "trade union" is used mainly in its popular signification as an organization of workmen, for the purpose of improving the conditions of their employment, although legally the term is applicable also to associations of employers and to joint associations of employers and workmen.

So far as statute law is concerned, there has been no material change in the position of trade unions since the passage of the Trade Union Act of 1876, and for this part of the subject, therefore, the article in vol. xxiii. gives all the necessary information. The statement, however, at the end of the first paragraph, in small print (p. 500), with regard to registration, needs some qualification. The legal position of a registered trade union differs materially from that of a friendly or industrial and provident society. Thus, there is no legally enforceable contract between a trade union and its members binding it to pay the stipulated benefits and to carry out the rules, since no trade union can sue its members for contributions, or be sued by them for benefits; the right of a registered trade union to invest funds with the National Debt Commissioners is limited, and in certain other matters it does not enjoy the same privileges as a friendly society.

Since the legislation of 1876 there have been important decisions in the courts of law with reference to the provisions of the Conspiracy and Protection of Property Act, 1875, and the rights of trade combinations, for which see Strikes and Lock-Outs, *supra*, p. 19.

Important questions have also arisen as to the liability of individual officials of trade unions to civil actions for damages on account of recommendations they may have given to their members. The question has of course only been doubtful in case the action recommended is in itself lawful, but incidentally causes or is intended to cause the violation of some actionable private right. In the leading case on this point (*Allen* v. *Flood*) the delegate of the Boilermakers' Union informed an employer that the members of his society would give notice to leave work unless he ceased to employ two shipwrights who had given offence by working for a former employer on iron work. The employer therefore discharged the shipwrights, who brought an action against the boilermakers' delegate. The case was carried up to the House of Lords, whose final decision (14th December 1897) was in favour of the delegate, on the ground that his acts were in themselves lawful, and the action which they were intended to induce the employer to take was also lawful, and that such lawful acts would not constitute an actionable wrong to third parties who might incidentally be injured thereby.

But besides the liability of individual officials, it has been decided in the House of Lords, in the case of the *Taff Vale Railway Co.* v. *The Amalgamated Society of Railway Servants* (1901, A.C. 426), that persons acting in concert, whether combined together in a trade union or collected and united under any other form of association, were as liable to be sued in respect of any damage occasioned to any other person through their act or default as any individual person might be liable. Consequently, the agents of a trade union who, in furtherance of a strike sanctioned and directed by its authorized officers, committed wrongful acts were held to have rendered responsible the principals who caused them to be committed; and it was further held that the trade union could be sued in its registered name, and would be liable for damages out of its common fund. Opinions were also expressed in the House of Lords that, whether registered or not, a trade union could be sued by its proper officers on behalf of themselves and the other members of the society, and that the judgment could be enforced against all funds forming the common fund of the society by adding the trustees if necessary.

Trade unions, in the sense in which the term is now understood, appear to be almost exclusively of modern growth. Though combinations among various classes of workmen to improve their position have doubtless been formed from time to time from an early period, such combinations, up to comparatively recent years, were mostly ephemeral, almost the only class among whom permanent associations of journeymen are known to have existed in the Middle Ages being the masons, whose confederacies were prohibited by law in 1425. With this doubtful exception, there is little or no trace of permanent combinations corresponding to the modern trade union before the 18th century. During the period when wages and conditions of employment were the subject of State regulation (*e.g.*, under the Statute of Apprentices of Elizabeth), combinations to exact higher rates or other conditions than those so fixed were naturally regarded as illegal conspiracies.

History.

The craft gilds of the Middle Ages have sometimes been regarded as the true predecessors of trade unions, but the analogy must not be pressed too far. The structure, constitution, and functions of a gild of craftsmen, aiming at the protection and regulation of the craft as a whole, were essentially different from those of a trade union, formed to protect one class of persons engaged in an industry against another. Nor is there any trace of direct continuity between gilds and trade unions, for the claim of certain Irish trade unions to be descended from gilds will not bear scrutiny (see Webb, *History of Trade Unionism*, Appendix). The only true sense in which it can be said that there is a certain indirect historical filiation between gilds and trade unions is that, as pointed out by Brentano, some of the earliest trade unions had for their original object the enforcement of the decaying Elizabethan legislation, which in its turn had taken the place of the obsolete regulation of industry by the craft gilds, so that among the rules and objects of such unions would naturally be some bearing a likeness to gild regulations.

The actual way in which trade unions first came into being probably varied very greatly. In some cases, as stated above, their origin can be definitely traced to associations for enforcing the legal regulation of industry against the opposition of employers; in others, the meetings of journeymen belonging to the same trade for such purposes as sick or burial clubs became naturally the nucleus of secret combinations to raise wages. The growth of the "capitalistic" system of industry, under which the workman no longer owned the materials or instruments with which he worked, was one of the most potent causes of the development of workmen's combinations. The efforts of trade unions to revive the enforcement of the Elizabethan legislation not only failed, but led to its repeal (1813–14); but the laws against combinations, which had been made more stringent and more general by the Acts of 1799–1800, remained unaltered until 1824 (vol. xxiii. p. 499). In spite of these Acts, which made all combinations illegal, there is evidence that trade clubs of journeymen existed and were tolerated in many trades and districts during the first quarter of the 19th century, though they were always subject to the fear of prosecution if they took hostile action against employers; and in many cases strikes were suppressed by the conviction of their leaders under these Acts or under the common law of conspiracy. The partial protection accorded to societies for the purpose of regulating wages and hours of labour by the law of 1825 (vol. xxiii. p. 500) led to a rapid multiplication and expansion of trade unions, and to an outburst of strikes, in which, however, partly owing to the widespread commercial depression, the workmen were mostly unsuccessful. Thus the first impetus given to trade unions by the modification of the combination laws was followed by a collapse, which in its turn was followed (in the third decade of the century) by a succession of attempts on the part of workmen to establish a federal or universal combination, to embrace members not of one but of several trades. To this new form of combination, which excited a good deal of alarm among employers, the term "trades union," as distinct from trade union, was applied. All these general movements, however, proved short-lived, and the last and most extensive of them, the "Grand National Consolidated Trades Union," which was formed in 1834 and claimed half a million adherents, only had an active existence for a few months, its break-up being hastened by the conviction and transportation of six Dorchester labourers for the administration of unlawful oaths. In the years of depressed trade which followed, trade unionism once more declined, and the interest of workmen was largely diverted from trade combinations to more general political movements, *e.g.*, Chartism, the Anti-Corn-Law agitation, and Robert Owen's schemes of co-operation.

From 1845 we trace another revival of trade unions, the characteristic tendency of this period being the amalgamation of local trade clubs to form societies, national in scope, but confined to single or kindred trades. High rates of contribution, and the provision of friendly as well as trade benefits, were among the features of the new type of union, of which the Amalgamated Society of Engineers, formed in 1851, was the most important example (see vol. xxiii. p. 501 for description of this society). The growth of unions of the new type was followed by a development of employers' associations in the 'sixties, and by a number of widespread strikes and lock-outs, and also by various efforts to promote arbitration and conciliation by the establishment of joint boards of employers and employed (see ARBITRATION AND CONCILIATION, and STRIKES AND LOCK-OUTS).

A series of outrages at Sheffield in 1865–66, in which officials of some local trade societies were implicated, led to the appointment in 1867 of a Royal Commission on Trade Unions, whose report was followed by the passage of the Trade Union Act of 1871, which as amended in 1876 now governs the legal position of trade unions (vol. xxiii. p. 500).

The period of inflated trade which began in 1871 led, as usual, to another rapid growth of trade combinations, of which the most characteristic feature was their extension to agricultural and general labourers. To meet this new development of combination, the National Federation of Associated Employers of Labour was formed in 1873. The years of depression, 1875–80, were marked by a series of unsuccessful strikes against reductions of wages, and by a general decline of trade unions, which did not again revive until nearly ten years later, when the new wave of prosperous trade brought with it an outburst of strikes, chiefly among unskilled labourers, for improved conditions, of which the most notable was the strike of the London dock labourers in 1889. These trade movements were accompanied by the formation of a large number of unions of a type more akin to those of 1830–34 than to the more modern trade-friendly society with its high contributions and benefits. The "new unions" were chiefly among unskilled labourers; their rates of contributions were from 1d. to 3d. a week, and as a rule they only offered strike benefit. Another characteristic was the extent to which their leaders were permeated with the Socialistic doctrines which had then recently taken root in Great Britain, and which led them to advocate positive State interference with industry in the interests of the labourers (*e.g.*, the legal limitation of hours of labour).

The reports of the Royal Commission on Labour, which sat from 1891 to 1894, contain much valuable information on the state of facts and on the opinions of employers and workmen at this period.

From 1892 onwards the progress of trade unionism can be traced statistically (see below, p. 406). The depression of trade, 1892–95, brought with it, as usual, some decline in trade unionism; but though many of the "new unions" collapsed, some of the more important have survived to the present time. The revival of trade which began in 1896 has naturally been accompanied by an increase in the strength of trade unions; but the most marked characteristic of this period has been the extension and consolidation of employers' associations, of which perhaps the most notable is the Engineering Employers' Federation, which was originally formed on the Clyde, but gradually extended to other districts and became a national organization of great strength during its successful struggle with the Amalgamated Society of Engineers in 1897–98 (see STRIKES). Among the other more important employers' associations and federations of a national character may be mentioned the Shipping Federation, the Federated Coal Owners, the Federation of Master Cotton-Spinners' Associations, the National Federation of Building Trade Employers, and the Incorporated Federated Associations of Boot and Shoe Manufacturers.

Constitution.

The account given in the article on TRADE UNIONS in vol. xxiii. of the way in which the ordinary business of a trade union and its branches is conducted, applies fairly to the present state of things and need not be repeated here. As regards, however, the general structure and organization of trade unions, that article referred principally to a single important type of society, the national society, divided into districts and branches, of which the Amalgamated Society of Engineers served as an example. As a matter of fact, trade unions, both in their historical development and their present organization, present a very great variety of constitutions. The oldest type is that of the local trade club, consisting of a comparatively small number of men following the same occupation in the same locality. A large number of unions have never progressed beyond this primitive form of organization. The government is of the simplest kind, by a general assembly of all the members, while such officers as are required to carry on the necessary routine business of the society are chosen by rotation or even by lot.

Indisposition to concentrate power in the hands of permanent officers and a tendency to divide the business of management equally among all the members, instead of delegating authority to a few chosen representatives, are leading characteristics of trade unions in this primitive form. The organization here described, even if adequate for ordinary current requirements, is ill suited for conducting a contest with employers, and accordingly in times of strife an improvised "strike committee" often comes into existence and practically governs the conduct of the dispute. No doubt this double constitution of the old trade club as a loosely organized friendly society, converting itself from time to time into a more or less secret strike combination ruled by an irresponsible committee, is to be traced to the time when trade unions as such were illegal combinations and had to carry out their objects under the guise of friendly societies. The Friendly Society of Ironfounders (established in 1809), though it has to a great extent outgrown its primitive constitution, retains in its name the mark of its origin, while the government of the London Society of Compositors by mass meeting of its members offers an example of the persistence of traditional methods under wholly changed conditions. The Sheffield trade clubs, responsible for the outrages which led to the appointment of the Trade Union Commission in 1867, and subsequently to the passage of the Trade Union Acts, conformed as a rule to the primitive type. At the present time over 850 trade unions are known to exist which are purely local in character, with no branches. The next step in trade union evolution seems to have generally been an alliance or federation of two or more local clubs belonging to the same trade. This federation would make it necessary to provide some machinery for common management, the simplest and crudest expedient being for each of the allied clubs to act in rotation as the governing branch. Thus the government of the federation or "amalgamated society" was at any given time confided to the members of a single locality, and the seat of government was periodically shifted. Some federal societies (*e.g.*, the Mutual Association of Journeymen Coopers) still retain this primitive form of government.

As the tendency developed for local clubs to unite, the necessity of permanent officials to cope with the growing business of the amalgamation caused the institution of a paid secretary (usually elected by the whole body of members), and this led naturally to the fixing of the seat of administration at a particular centre instead of rotating among the branches. Some continuity of policy and of office tradition was thus made possible, but the executive committee almost invariably continued to consist of the local committee of the district where the seat of government happened to be. Thus up to 1892 the business of the Amalgamated Society of Engineers, a society with hundreds of branches all over the United Kingdom and even abroad, was conducted by a committee elected by the London branches.[1] The Boilermakers continued a somewhat similar form of government up to 1895; and many great societies, *e.g.*, the Amalgamated Society of Carpenters and Joiners, continue the system to the present day.

The plan of entrusting the government of a national society to a local executive has obvious conveniences, where the society consists of a body of working men scattered over a large area and with no leisure for travelling. But the control exercised by a locally-elected committee over a general secretary deriving his authority not from them but from the vote of a much wider constituency, could hardly be expected to be very effective; while the expedients of referring all important questions to a vote of the whole body of members, and of summoning at periodical intervals special delegate meetings to revise the rules, have proved in practice but clumsy substitutes for the permanent control and direction of the executive officers by a representative council. Quite as ineffective in some cases has been the authority of a mere local executive over the committees of other districts. Accordingly, some of the largest "amalgamated" unions have now adopted a representative system of government. Thus in 1892 the Engineers revised their rules so as to provide for the election of the executive council by vote of all the members divided into eight equal electorial districts. The members of council so elected are permanent paid officials, devoting all their time to the work of the society. The general secretary, however, continues to be chosen by the whole body of members, while the responsibility of the council is also weakened by the institution of "district delegates" nominally responsible to them, but chosen by direct election in the various districts. (This division of authority and consequent weakness of responsibility was one of the causes of the state of things which led to the great engineering dispute of 1897.) The Boilermakers adopted the system of a permanent executive in 1895.

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[1] This arrangement was in force when the article in vol. xxiii. was written.

In the case of certain highly-localized industries, such as cotton and coal, the conditions have admitted of a somewhat different form of constitution from that described above. Thus the Amalgamated Association of Operative Cotton-Spinners is a federal organization, consisting of a number of local associations, all, however, situated within a comparatively small area. The governing bodies of the association are—(1) a quarterly meeting of about a hundred representatives of the districts; (2) an executive committee of thirteen chosen by the above representative meeting, of whom seven must be working spinners and the other six are usually permanent district officials; (3) a sub-council to transact the ordinary daily work of the association, consisting of the six official members referred to above. The secretary is chosen by the representative meeting, and engages his own office assistants. Here we have the familiar features of representative institutions—a large legislative body, a small executive chosen by and responsible to this body, and a still smaller group of permanent officials to transact ordinary business.

Lastly, there are some large societies constituted not by the aggregation of local clubs or the federation of neighbouring associations, but originally founded as "national societies" divided into districts and branches for administrative convenience. An example is the Amalgamated Society of Railway Servants, founded in 1872.

Besides the tendency of the national society with branches to swallow up the local trade club, there is a further tendency among the larger societies to form federations for certain common purposes. Such federations are to be distinguished from national trade unions, inasmuch as their members are societies and not individuals, and as a rule their powers over their constituent organizations are limited to certain specific objects. On the other hand, they are more than merely consultative bodies (such as local trades councils).

Some federations consist of unions in the same industry in different districts (*e.g.*, the Miners' Federation). "Single trade" federations like this have usually considerable powers, including that of imposing levies.

In the cotton trade, the trade union organization has a federal character, and the Amalgamated Association of Operative Cotton-Spinners, in spite of its name, is strictly speaking a federation.

Other federations (*e.g.*, in the building trade) are formed of allied trades in the same locality, and usually have little executive power. The Federation of Engineering and Shipbuilding Trades has among its objects the settlement of disputes between members of its constituent societies as to the limits of their work. Some federations aim at embracing societies in all kinds of industries, but as a rule such organizations have not proved long-lived. The most recent example is the "General Federation of Trade Unions," formed in 1899, and now embracing 64 societies with nearly 400,000 members.

Since 1866, a congress of delegates from trade unions has met annually for discussion, and a parliamentary committee elected by this congress watches over matters in which trade unions are interested during the ensuing year.

Objects and methods.

The principal object of every trade union is to protect the trade interests of its members, and to strengthen their position in bargaining with their employers with regard to the conditions under which they work. The chief means by which they seek to attain these objects (apart from political methods such as the promotion of legislation or of administrative action by public authorities) are twofold: viz., the support of members when engaged in a collective dispute with employers by the payment of "dispute" benefit, and the insurance of members against loss from want of work by the payment of "unemployed" benefit, so as to enable them to refuse any terms of employment inferior to those recognized by the trade union. All trade unions in one form or another provide "dispute" benefit, but a separate "unemployed" benefit is by no means universal, though, except in certain groups of trades, it is usual among more powerful and well established societies. Thus in the mining, clothing, and even many branches of the building trade, comparatively little is spent by trade unions on "unemployed" benefit, while, on the other hand, in the metal, engineering, shipbuilding, printing, and other trades a large proportion of the total expenditure is devoted to this object (see *Statistics* below). In some important societies, such as the Amalgamated Society of Engineers, "unemployed" and "dispute" benefits are mixed up together, members engaged in a dispute receiving an addition of 5s. per week (known as "contingent" benefit) to the ordinary out of work pay (known as "donation").

Unemployed benefit may, of course, be regarded as a "friendly" benefit, *i.e.*, a provision against one class of the casualties to which a workman is exposed—the loss of employment through slackness of trade. But in practice it also operates as a method of maintaining the "standard" rate of wages, members being entitled to it who could obtain employment, but only on conditions disapproved by the society or branch.

The conditions under which the members of a union are entitled to financial support in a strike vary in different societies, and are prescribed in the rules. Usually, though the initiative may come from the localities, the central executive must approve of the strike before it takes place, and may at any time declare it to be closed, though in some societies the central authority is often unwilling to take the responsibility of curbing its members by exercising its powers in this respect.

"Dispute" and "unemployed" benefits are the only ones which are specially characteristic of trade unions, and as regards the latter benefit, it may be said that trade unions have hitherto been the only form of organization capable of meeting the difficulties arising from "malingering." Most of the more firmly established unions, however, add to their trade functions those of friendly societies, providing sick, accident, superannuation, and funeral benefits, or some of these. The position of a trade union, however, with regard to these benefits differs very materially from that of a friendly society. As stated above, the society is under no legally enforceable contract with its members to provide the stipulated benefits: it can change their scale, or even abolish them, by vote of its members, and a member who has contributed for years in hope of receiving them has no legal redress. Again, a member excluded from the society for some "trade" reason incidentally loses all claim to friendly benefits. The funds of a trade union applicable to trade and friendly purposes are never kept distinct (in the few cases in which some distinction is attempted, the society may "borrow" from the one fund in aid of the other in case of emergency); and a prolonged strike or depression of trade may so deplete the funds as to make it impossible for the society to meet its engagements as regards sickness or superannuation. Thus the friendly society operations of trade unions have strictly no actuarial basis, and in some cases the scales of contribution and benefit have been fixed with little regard to ultimate solvency.

On the other hand, the power of levying and varying the scale of contributions adds to some extent to the financial stability of the funds, and the provision of "friendly" as well as "trade" benefits by a trade union undoubtedly gives strength and continuity to the society, and increases its power of discipline over its members. Societies that only provide "dispute" pay are exposed to violent oscillations of membership, and also to a dangerous temptation to rush into an ill-considered strike owing to the mere accumulation of funds which can be used for no other purpose.

The statistics of trade union expenditure on benefits of various classes are given below. Of the 100 principal unions, all provide dispute benefit; 78 in the year 1900 provided unemployed benefit (including in some cases travelling pay); 75, sick or accident benefit; 39, superannuation benefit; and 89, funeral benefit.

One of the most important functions of trade unions in many industries is the negotiation of agreements with employers and employers' associations for the regulation of the conditions of employment in those industries. While undoubtedly the power of withdrawing its members from employment in the last resort adds to the power of a trade union in such negotiations, many of the most important agreements by which the conditions of labour of large bodies of workmen are governed are habitually concluded, and from time to time revised, by conferences of representatives of the trade union and employers without any strike taking place. To the functions of trade unions as fighting organizations and as friendly benefit societies should therefore be added that of providing the necessary machinery and basis for the conclusion of industrial agreements between bodies of work-people and their employers (see ARBITRATION AND CONCILIATION, and STRIKES AND LOCK-OUTS.

While the broad objects of trade union policy are generally similar, their methods and features vary greatly in detail. Among the objects most frequently met with (besides those of raising wages and shortening hours, which may be said to be universal) are the enforcement of a "minimum" wage; the limitation of overtime; the restriction of numbers in the trade through the limitation of apprentices, or the regulation of the age of entrance; the restriction or regulation of piecework (in trades accustomed to "time" work); the preservation for members of the trade of the exclusive right to perform certain classes of work claimed by other trades (leading to so-called "demarcation" disputes); resistance to the encroachment of labourers on work considered to be "skilled" (leading to disputes as to the class of persons to be employed on machines, &c.); and the securing of a monopoly of employment for members of the union by a refusal to work with non-unionists.

Statistics.

The statistics of trade unions are very complete for recent years, but for earlier years the records are so fragmentary that it is impossible to give exact figures showing the total growth of trade unions over a long period. The following table, based on the statistics published by the Board of Trade, shows the number and membership of trade unions in the United Kingdom for each of the nine years 1892–1900:—

	Number of Unions.	Membership of Unions.[1]
1892 . . .	1208	1,502,358
1893 . . .	1255	1,479,417
1894 . . .	1295	1,436,300
1895 . . .	1311	1,407,836
1896 . . .	1317	1,494,465
1897 . . .	1307	1,613,998
1898 . . .	1267	1,648,732
1899 . . .	1302	1,800,869
1900 . . .	1272	1,905,116

[1] Includes a small number (9072 in 1900) of members abroad.

The fluctuations in membership correspond in the main to the oscillations of trade, membership declining in the years of depression following 1892, and increasing with the revival of trade which began about 1895. The later decline in the number of separate unions is chiefly due to the growing tendency to amalgamate into large societies.

The following table shows the distribution of trade unions among the various groups of trades in 1900:—

Groups of Trades.	Number of Unions.	Membership in 1900.	
		Number.	Percentage of Total.
Mining and quarrying . . .	59	501,290	26
Metal, engineering, and shipbuilding	280	338,075	18
Building	131	253,822	13
Textile	237	220,685	12
Railway, dock, and other transport	66	171,219	9
Clothing	48	67,424	4
Printing and bookbinding . .	54	57,256	3
Wood-working and furnishing .	123	39,704	2
General labour	19	113,209	6
Public employment . . .	31	38,859	2
All other unions	224	103,573	5
Total	1272	1,905,116	100

This table shows that the strength of trade unionism lies in the four first-named groups of trades—mining, metal, engineering and shipbuilding, building and textile, which among them account for over two-thirds of the total membership.

In agriculture, trade unionism is at present practically non-existent, but in 1875 there were important unions of agricultural labourers, though at no time did they include any considerable proportion of the total agricultural population.

Taking the men belonging to all trade unions together, we find that their number does not amount to more than about one in five of the adult men who belong to the classes from which trade unionists are drawn. Only in a few groups do trade unionists form a high percentage of the total working population, *e.g.*, coal-mining and cotton manufacture. The number of women belonging to trade unions at the end of 1900 was 122,047, distributed among 138 unions, of which, however, only 27, with 8974 members, consisted exclusively of women. The great bulk (79 per cent.) of women trade unionists are found in the cotton trade, in which they actually outnumber the male members. Of all the women employed in factories and workshops, about one in twelve belongs to a trade union.

The available statistics with regard to the financial resources of trade unions, and their expenditure on various objects, are not so complete as those of membership, as the Board of Trade figures only relate to 100 of the principal unions. As, however, these unions include nearly two-thirds of the total membership, the figures showing their financial position may be accepted as being representative of the whole number of societies. In 1900 the income of these 100 societies was £1,974,611, or 34s. 1d. per head; and their expenditure £1,490,582, or 25s. 8¾d. per head; and at the end of the year the funds in hand amounted to £3,766,625, or 65s. per head. Of the income, £1 10s. 11¼d. per head was derived from members' contributions, and 3s. 1¾d. per head from various other sources, *e.g.*, interest, fines, entrance fees, subscriptions, &c.

The above figures represent the average, but the actual rates of contribution vary greatly among the unions—from 7s. up to £4 per annum. Generally speaking, the highest income per member is found among the unions in the metal, engineering, and shipbuilding group, where in 1900 it averaged £3 1s. 3¼d., while the average in the mining unions was only £1 2s. 10¾d., and among dock labourers still lower. The metal trades and the textile unions appear to hold the highest amount of funds compared with their membership, the amounts at the end of 1900 being £5 0s. 6d. and £4 18s. 10½d. per head respectively in these groups, while in the clothing trade unions it was only £1 12s 7d., and in some societies of unskilled labourers far less than this.

The main items of expenditure of trade unions are "dispute" benefit, "unemployed" benefit, various friendly benefits (including sick and accident, superannuation, and funeral), and working expenses. The proportions of expenditure on these various objects naturally vary greatly in different groups of unions, and also in different years, some of the items being affected largely by the general state of employment, and the occurrence or absence of important disputes. On the basis, however, of an average of the nine years 1892–1900, the following analysis of the proportionate expenditure of the 100 principal unions on various classes of objects has been made: on disputes, 20 per cent.; on unemployed, 22 per cent.; on friendly benefits (other than "unemployed"), 38 per cent.; on working expenses, 20 per cent. The 38 per cent. of expenditure on friendly benefits is made up of 17 per cent. on sick and accident, 10 per cent. on superannuation, and 11 per cent. on funeral and other benefits.

The mining unions devoted 40 per cent. of their expenditure to the support of disputes (friendly benefits in this industry being largely provided by other agencies), while the unions in the printing and bookbinding trades only used 6 per cent. for this object, over three-quarters of their expenditure going to unemployed or friendly benefits. As illustrations of the variation in the expenditure by the same group of unions on a particular object from year to year, it may be stated that within the nine years' period referred to the annual expenditure of the metal, engineering, and shipbuilding group on disputes varied from £12,633 in 1899 to £491,478 in 1897, the year of the great engineering dispute. Again, the expenditure of the same group of unions on unemployed benefit varied from £80,004 in 1899, a year of good trade, to £258,620 in 1894, a year of bad trade. The burden of superannuation payments by the 100 unions has steadily increased during the nine years from £102,578 in 1892 to £190,039 in 1900.

At the end of 1900 there were 110 federations, including societies with a gross membership of nearly a million and three-quarters; but a considerable deduction must be made from this total on account of duplication. In the same year 171 "Trades Councils" were known to exist, with an affiliated membership of about 754,000.

The number of employers' associations and federations known to exist in the United Kingdom at the end of 1900 was 870, including 47 federations and national associations. Of the total number of associations, nearly half are in the building trades.

II. Outside the United Kingdom.

Modern trade unionism has had its chief development in English-speaking countries, and especially in the United Kingdom, where the conditions necessary for its growth have been present to the fullest extent. With some exceptions, such unions as are found elsewhere are either derived or copied from English organizations, or are associations with political objects. It is therefore unnecessary to give more than a very brief summary of the position of trade unions in some of the principal countries and colonies outside the United Kingdom (for *United States* see p. 411).

Germany.—In Germany the majority of trade unions are of a political character, being closely connected with the Social Democratic party. These Socialist trade unions, termed "Gewerkschaften," were started by a congress held at Berlin in 1868, under the auspices of Fritscher and Schweitzer, two followers of Lassalle. In 1878 many of them were dissolved under the law prohibiting Socialistic organizations, but shortly after their place was taken by local unions termed "Fachvereine," which ostensibly abstained from politics, but which in various ways succeeded in evading the law and carrying on the work of the "Gewerkschaften." In 1887 a general committee of the German Gewerkschaften was formed. The last few years of prosperous trade have been marked by a rapid growth of membership of this group of unions. According to the *Correspondenzblatt*, their official organ, they included in 1899 a membership of 596,419, compared with 252,044 in 1894. Of the total members in 1899, 580,473 belonged to 7623 branches affiliated to 55 central federations, the membership of non-federated local unions being returned as only 15,946.

The total income of the federated trade unions in 1899 was £384,358, or about 13s. per member. The expenditure on trade purposes, including strikes, was £111,605, and on other benefits, unemployed, travelling, sick, &c., £74,245, the remaining expenditure being attributed to the publication of the journal, agitation, office, and miscellaneous expenses.

Another group of trade unions in Germany, less important as regards number and membership than the above, are the "Gewerkvereine," or non-political trade unions, sometimes known as "Hirsch–Duncker" unions, from the names of their founders. These unions were first formed in 1868, immediately after the Berlin congress referred to above. They were directly modelled on British trade unions. Since 1876 Social Democrats have been excluded. In their earlier years these unions suffered in membership from a series of unsuccessful strikes, and of late years they have been mostly benefit societies. At the end of 1899 the "Gewerkvereine" embraced 91,661 members belonging to about 1700 local unions affiliated to a central federation. Their expenditure on benefits amounted to less than £6000 a year, of which only about £600 was spent on disputes. The Christian trade unions ("Christliche Gewerkvereine") form another group, embracing, in 1899, 111,860 members in 36 trade unions, mainly in railway service, textile and mining industries.

As regards objects, methods, and organization, the National Printers' and Typefounders' Trade Union bears more resemblance to British trade unions than do any of the other German labour organizations. There seems to have been a long tradition of organization among journeymen in the German printing trade, going back to the 17th century. In 1848 the Gutenberg National Union of Printers was formed, but after an unsuccessful strike it broke up into local unions. The present union was formed in 1867, and became affiliated to the federation of "Gewerkschaften" in 1892. It has established a wages list, and secured other advantages for its members. It escaped the law of 1878 by changing its name. In 1899 its membership was 26,344, its income £79,000, and its funds amounted to £136,000.

It will be seen that German trade unions of one type or another include about 800,000 members. As regards, however, their direct influence on industrial conditions, they are not (with the exception of the printers' union) nearly so powerful as the British organizations.

France.—In France combinations of workmen as well as of employers were prohibited by the law of 1791, which overthrew the old gild or corporation system. They were also penalized under various articles of the Penal Code, and it was not till 1864 that the prohibition was modified by law. At present the status of trade unions in France is regulated by the law of 1884, which repealed that of 1791 and modified the articles of the

Penal Code so far as regards professional syndicates of employers or workmen. Since then there has been a considerable growth of workmen's unions, which in 1899 numbered 2685, with a membership of 492,647, compared with 2178 unions, with 403,440 members, five years previously. Of these unions, 1199 belonged in 1899 to 73 federations, of which the total affiliated membership is returned as 432,950, though there is here some duplication owing to the fact that some unions belong to more than one federation. The distribution of these unions among trades can only be stated for the year 1897, when out of a total membership of 437,793, 160,208 belonged to the group "transport and commerce," 41,760 to mining and quarrying, 38,316 to metal trades, 35,432 to textile industries, 33,795 to building trades, 27,967 to chemical trades, 20,262 to leather and skin trades (including boot, shoe, and glove trades), 18,552 to food-preparation trades, and the remainder to printing, furnishing, clothing, and other groups.

Austria-Hungary.—Apart from the Austrian gilds, membership of which is compulsory for persons engaged in non-factory handicrafts and trades (under a law of 1883) and in mining (under a law of 1896), there are a certain number of trade unions in Austria, though freedom of combined action among workmen is less complete than in many other European countries. Such right of combination as exists rests on the law of 1870, which removed the restrictions imposed by the Penal Code on combinations for influencing the conditions of labour. The impulse given to the formation of unions by this law, and by the advantages gained for the workmen during the years of prosperous trade that immediately followed, received a severe check during the succeeding depression of trade, when these advantages were mostly lost. Trade unionism did not revive until 1888, from which time the unions formed have mostly been on a Social Democratic basis, the majority being affiliated to a central organization in Vienna. In 1899, 409 trade unions and 604 "trade clubs" were known to be in existence in Austria. The latter class of associations are described as educational associations possessing to a greater or less extent trade union functions. The majority of trade clubs and a few trade unions are affiliated to a federation at Prague. Returns compiled by the committee of Austrian trade unions, and applicable to 391 trade unions and 492 trade clubs, showed a total membership of 157,773 persons in 1899 compared with 117,946 members in 313 trade unions and 527 trade clubs in 1896. Of the members in 1899, 128,504 belonged to trade unions in various groups of industries, of which the following are the principal in order of numerical importance: Metal trades, 18,374; transport (including railway service), 16,665; mining, 13,583; printing and allied trades, 12,750; glass and pottery, 9688; textile, 9470; clothing, 9083; building, 7790; wood-working, 7138.

The total receipts and expenditure of trade unions and clubs in respect of benefits other than dispute pay were, in 1899, £85,384 and £79,585 respectively. The expenditure on disputes was £14,977. The average annual expenditure per member of the organizations affiliated to the Vienna federation in 1899 was 11s. 4d., of which the amount spent on unemployed and travelling benefit was about 2s. 3d., on sickness 1s. 8½d., on superannuation 6¾d., on funerals 4d., on trade journals 1s. 7d., the remainder being accounted for by office and various miscellaneous expenses.

In Hungary trade unions are not far developed, the figures given on the authority of the Budapest Trades Council showing only 126 trade unions with 23,603 members in various industries, exclusive of unions of agricultural labourers, which it is stated brought up the membership to 64,000 in 1898–99.

Denmark.—In Denmark there were, in 1900, 1196 trade unions with 96,359 members—a very large membership compared with the total industrial population. The principal groups of trades represented were as follows in order of membership: General labourers, 29,044; building trades, 14,391; metal trades and shipbuilding, 10,954; transport, 8657; food, &c., trades, 7701; clothing, 6381; wood-working, 5520. Unemployed pay is said to be paid by 465 unions with 32,220 members, travelling benefit by 676 unions with 37,135 members, these being the most widely-spread benefits other than dispute pay. Over 80 per cent. of the members belong to unions affiliated to the General Federation of Danish Trade Unions. In 1896 unions with a membership of 63,377 had an income of £39,504 and an expenditure of £32,593.

Sweden and Norway.—In Sweden and Norway trade unions are of recent growth. There is a trade union membership of about 60,000 in Sweden, and of 24,000 in Norway. A National Federation of Swedish Unions was formed in 1898, and in 1900 was said to embrace 692 societies, with 39,132 members. In 1899 a federation was established in Norway.

Switzerland.—The only available statistics as to Swiss trade unions are the (avowedly incomplete) returns compiled by the Swiss "Arbeiter-Sekretariat," which show for 1899 a total of 758 local unions affiliated to 39 trade unions, with a membership of 49,034, of whom 17,451 belonged to unions affiliated to the General Federation of Swiss Trade Unions. Nearly a third of the total membership (16,066) is accounted for by seven trade unions of railway servants, the next largest group being Government employés (5655), followed by metal-workers (5373).

Holland.—In Holland in 1895 there were known to be 370 ordinary and 131 Roman Catholic trade unions, but little information is available as to membership or funds. Of the ordinary unions, 93 were in the building and kindred trades, 73 in food, drink, and tobacco trades, and 61 in transport industries. In 1893 a National Labour Sekretariat was formed, to which, in 1899, 45 societies with 13,050 members were said to be affiliated. The largest trade union in Holland was stated in 1900 to be the Diamond Workers' Federation, with 7000 members and an expenditure in 1899 of £12,260.

Belgium.—The status of trade unions in Belgium is regulated by the law of 1898, under which they can be incorporated, provided that their objects are non-political and are confined to the furtherance of the interests of particular trades. Belgian trade unions, nevertheless, are mostly political in character, the majority being connected either with the Socialist-Labour, Catholic, or Liberal parties. There are, however, a few unions (*e.g.*, the printers') independent of these parties. There are said to be altogether about 170 unions with from 60,000 to 70,000 members, of which about 100 unions are affiliated to the Labour party. In some trades (cigar-makers, woodworkers, printers, stoneworkers, painters, miners, and metal-workers) the unions have formed themselves into federations.

British Colonies.—Trade unionism has only developed to any important extent in a few of the industrial centres of the principal self-governing colonies. Unions in Canada are to a large extent branches of organizations having their headquarters in the United States or in England, and the purely Canadian unions do not present any features requiring special notice.

Between 1876 and 1890 all the principal Australian states passed statutes more or less resembling the Trade

Union Acts of the United Kingdom. A similar law was passed in New Zealand in 1878, but in this colony and in New South Wales trade unions can now become incorporated and acquire a special legal status by registering as industrial unions under the laws relating to industrial conciliation and arbitration. In the years immediately preceding 1890 certain Australian unions, especially among the shearers and the seamen and wharf-labourers, acquired great strength, and their determined attempts to secure a monopoly of employment for members of their organizations led to prolonged labour disputes in 1890 and 1891 (see STRIKES AND LOCK-OUTS, p. 27), which resulted in the defeat of the unions and a consequent diminution of their membership and influence.

AUTHORITIES.—For statistics of recent progress of trade unions, see annual reports on trade unions published by the Board of Trade (from 1887 onwards). Much information respecting trade unions is contained in the reports of the Royal Commission on Trade Unions (1867) and of the Royal Commission on Labour (1891–94). The reports of the Chief Registrar of Friendly Societies give information with regard to trade unions registered under the Trade Union Acts. On the history and constitution of trade unions the fullest information is given in WEBB's *History of Trade Unionism* and *Industrial Democracy*, both of which contain valuable bibliographical appendices which may be consulted as regards other sources of information respecting British trade unions.

On trade unions abroad (besides the reports on foreign countries and the colonies of the Royal Commission on Labour), see KULEMANN's *Die Gewerkschaftsbewegung* (Jena, 1900), dealing with trade unions in all countries, and the Board of Trade "Abstract of Foreign Labour Statistics" (1901) and *Labour Gazette*, both of which give numerous references to the foreign official sources of information on trade unions, together with a summary of the statistics which they contain.

III. ECONOMIC EFFECTS OF TRADE UNIONISM.

There is no general consensus of opinion as to the extent to which trade unions can attain success in achieving the objects which they set before themselves, or as to how far their action is beneficial or otherwise to the general community. One of the principal objects of trade unions being to maintain and increase the rates of wages paid to their members, the first question would be practically solved if statistical evidence were available to connect the course of wages with the action of combinations. Such evidence, however, is inconclusive. The period of growth of trade unionism in Great Britain has certainly been on the whole a period of rising wages. But many other causes tending to raise wages have been operative over the same period, and some of the facts might be explained as much by the tendency of rising wages to strengthen combinations as by that of combinations to raise wages.

Again, the observed fact that the rise has not been confined to industries in which organizations are strong might be explained either by the supposition that the rise brought about by trade unions has benefited a wider circle than their membership, or that the rise both within and outside the ranks of trade unions is due to causes other than their action. Perhaps the strongest statistical evidence of the power of trade unions to affect wages in particular districts is afforded by the local differences of wages in the same trade, which, it is contended, cannot be wholly explained by local differences of cost of living or industrial conditions, but which often correspond closely to differences of strength of trade union organization. This argument, however, does not touch the question of the effect of combination on the *general* level of wages.

Hardly more conclusive than the reasoning founded on statistics have been the attempts to solve the question by pure economic theory. During the prevalence of the old view of wages, known as the "wage-fund" theory, combinations were usually held to be powerless to affect the general rate of wages, because they could not alter the proportion between capital and population, on which wages were thought to depend. The question, however, was reopened by the change in theory which led economists to regard wages as depending primarily on the productivity of industry, and secondarily (and within comparatively narrow limits) on the relative power of bargaining as between the labourers or groups of labourers and the organizers of labour. According to this view, the effect of combinations on the rate of wages will ultimately depend, so far as the first and most important factor in the problem is concerned, on their effect on the general productiveness of industry. *Primâ facie,* we might expect that trade unionism would, on the whole, restrict productiveness, and this is undoubtedly a view widely held among employers. Strictly professional associations tend generally to become conservative so far as methods of work are concerned; and even trade unions which may not "officially" oppose the introduction of new processes and the use of machinery may nevertheless serve to focus and make effective the hostility felt by the artizan towards methods of business organization which seem to him likely to decrease the demand for his services or to alter the conditions of work to his detriment. In some trades also trade unions are charged with encouraging or permitting their members to restrict the amount of work performed by them in a given time, with the short-sighted object of making more work for others. Many unions have attempted also with varying degrees of success to keep up the value of their labour by creating an artificial scarcity by restricting the numbers entering the trade, and have in various ways sought to control the management of business to a degree which must restrict the freedom of experiment on which the attainment of the maximum productiveness of industry must depend. By the resort to strikes—an essentially wasteful method of settling differences with employers—they have also to some extent restricted production, though the loss directly due to this cause is often exaggerated (see STRIKES AND LOCK-OUTS). Moreover, by their insistence on the payment to all workmen on a fixed "minimum" wage they have diminished the field for the profitable employment of the old and less capable, and may to some extent have discouraged the expert workman from earning and receiving the full reward of his extra ability.

On the other hand, it is claimed that trade unions have in many cases acted in the interests of industrial peace by restraining their members from ill-considered strikes, and that, by providing a recognized channel through which the workmen's grievances may find expression, they have often assisted in adjusting differences which would otherwise have led to the interruption of production. It is also claimed that by protecting the "standard of life" of their members through the policy of securing a "minimum" rate of wages, trade unions may tend in the long run to build up a physically and industrially superior class of workmen, and thus ultimately increase the efficiency of industry.

The comparative weight of the above considerations differs somewhat according to the point of view from which the question is regarded. At any given time an individual employer may tend to feel most strongly the disadvantages of the restrictions under which he is placed by the action of a particular trade union, and may attach but little importance to the general effects, in the long run, on the national output of the pressure which such combinations exercise—which from the point of view of the general well-being of the community is the most important consideration. Generally speaking, any action of trade unions tending to diminish the efficiency and industry of the individual workman is as injurious to the community as to the individual employer, except in so far as such restriction may conceivably affect the health of the working community from over-strain. But the policy of "levelling up" the standard rate of wages, which may mean loss or ruin to a particular employer, may nevertheless act quite otherwise with respect to the national well-being, in so far as it tends to eliminate the "unfit" employer and to concentrate the industry in the hands of the more capable and more enterprising of the employing class, and in the localities most suited for the purpose. The pressure of rising wages has undoubtedly acted as a stimulus to the invention of labour-saving devices and the adoption of economical methods, as is shown in America, where the highest wages are often seen concurrently with the lowest labor cost. Advocates of trade unionism sometimes lay much stress on this aspect of their operation. On the other hand, it must not be forgotten that competition, both as between different grades of employing ability and of local advantages, is now international, and that the concentration of an industry in the most suitable localities and in the hands of the most capable organizers, which is claimed as a beneficial result of trade union action, may for any particular country mean the transference of the industry abroad; and this transference, especially in the case of industries dependent on export to neutral markets, may involve a considerable national loss.

Apart from the effect of trade unions on the total amount of the "national dividend," their supporters claim that they are able to alter the mode of distribution of this dividend. It is not usually claimed that they are able to affect the proportion of the total product which is paid as rent or interest for the use of the instruments of production, but that they can alter the proportions in which the residue is shared between the organizers of labour and the manual labouring class, to the advantage of the latter. The methods by which trade unions seek to achieve this result require separate examination.

The first group of methods are those which aim at creating a scarcity of some particular kind of labour so as to alter the relation of demand and supply. The particular methods employed for this purpose have been already sufficiently described. With regard to all of them, it may be remarked that they are ineffective as regards the raising of the general rate of wages throughout the country (*i.e.*, the average income per head of the manual labour classes), seeing that an artificial scarcity of one sort of labour implies a redundancy of some other kind. As regards the rate of wages in particular occupations, there is no doubt but that at least for a time such methods may cause a considerable rise of wages, only limited at first by the imperfection of the control exercised by the union over the number competing in the labour market, and by the extent to which the rise in the cost of production so caused is checked by the competition of goods imported from abroad, or of alternative commodities, or by the loss of foreign markets, or the diminution of home demand. But as time goes on other forces of a more subtle kind tend to come into play which further limit the power of the combination to keep up wages through restricting the supply of labour. Besides the substitution of alternative commodities, alternative processes of production may be invented, diminishing the demand for the services of the members of the exclusive trade union, while the artificial rise of wages is also likely to attract labour into the trade.

Generally speaking, it may be said that while the artificial restriction of the supply of workmen in a trade may raise wages for a time, it calls into play forces tending to restore the equilibrium of demand and supply by diminishing demand, and that these forces grow progressively stronger as time goes on, while the restrictive capacity of the combination usually tends to diminish. This is apart from the fact that restriction of the supply of labour entering a trade almost always involves the narrowing of the field of ability from which the trade can be recruited, and thus a lowering of the general standard of efficiency.

The other group of trade union methods which requires examination is that which aims at strengthening the economic position of the labourer by substituting collective for individual negotiations as regards wages, supported by a common reserve fund out of which the labourer may be maintained while waiting for his terms to be accepted. Undoubtedly these methods of mutual insurance and collective bargaining afford a powerful instrument for preventing "sweating," and for enabling the whole body of workmen to exact at the earliest moment and retain to the latest moment the full amount of the wages which a given state of trade and prices will enable the industry to support. The establishment of general working rules and standards of time or piece wages throughout a trade or district may also serve to protect the better and more capable employers against their more inefficient or unscrupulous competitors, and thus tend towards the survival of the "fittest" among the employing class. It is always to be remembered that the effect of collective bargaining is not in the long run one-sided. Combinations of workmen beget counter-combinations of employers, and the conditions of important industries tend to be settled more and more by "treaties" concluded between powerful bodies of employers and employed. Were the combinations on both sides which enter into these agreements conterminous with the entire trades which they represent, and especially if the trades were protected from foreign competition, the interests of the general unorganized mass of consumers might conceivably suffer from these agreements. But as a general rule there has hitherto been sufficient outside competition, either within or without the country, to obviate this danger.

As regards the future prospects of trade unions in Great Britain, it is difficult to prophesy. The hopes of those who look for a universal expansion of these organizations so as to include the whole or the majority of the members of the manual-labour classes are certainly extravagant. Not less chimerical is the expectation of the opponents of trade unions that a few defeats at the hands of determined employers or employers' organizations will permanently cripple them and lead to their decay and extinction. Probably for many years trade unions will include, as now, in their membership a powerful minority of the working classes, wielding an influence out of all proportion to their actual numbers. It is to be expected that experience and the spread of education may cause them gradually to abandon the rules and methods which interfere most with the economical application of labour and capital to industry, while continuing to protect the interests of their members in the fair distribution of the joint product of industry.

Lastly, it may be pointed out that trade unionism has been the result of the growth of a class of manual workmen working for wages for employers who provide the materials and instruments of industry, and into whose ranks it is relatively difficult for the average workman to rise. It is doubtful if the class feeling which enables trade unions to flourish can permanently be fostered and maintained except among workmen who expect to remain workmen most of their lives. If these conditions should be materially altered, trade unionism in its present form must decay or undergo a profound alteration. (x.)

IV. United States.

Labour organizations.

Trade unions in the United States are best treated from the broad standpoint of labour organizations generally, *i.e.*, associations of wage-earners having for their general purpose the improvement of their members, either through a lessened working day, increased wages, or more satisfactory rules and conditions of employment. They may or may not admit employers, but as a rule they do not admit them. Sometimes they are formed for a specific purpose, like the Eight-Hours League, but generally they have platforms comprehending all the demands which labour usually makes. Labour organizations in the United States cannot be given a definite birthday. Prior to 1825 there were very few of them. In colonial days we have hints of their existence, but their purpose was partly political, and their membership often consisted of politicians. The purpose of the Caulkers' Club, in the early days of Massachusetts, was "to lay plans for introducing certain persons into places of trust and power." Tradition has it that the word "caucus" was derived from this club. It is also said that Samuel Adams's father, as early as 1724, was active in the club's work. There was probably a union of journeymen bakers in the city of New York in 1741, and of shoemakers in Philadelphia in 1792. The shipwrights of New York City were incorporated 3rd April 1803, and the tailors and carpenters of that city were organized in 1806. The New York Typographical Society was in existence in 1817, and was probably organized in the early years of the 19th century. Peter Force was its president for a time, and Thurlow Weed was a member. A strike occurred in Mr Weed's office in 1821 on account of the employment of a non-union man, who was then designated a "rat." In 1823 was organized the Columbian Charitable Society of Shipwrights and Caulkers of Boston and Charlestown.

Formative period.

The period from 1825 to 1860 may be called the formative period. About 1825, and for some years afterwards, there was a general discussion of Socialistic theories, growing out of Robert Owen's experiments at New Lanark, in Scotland, and out of his communistic attempt at New Harmony, Ind., in 1825. These experiments gave a great impetus to Fourierism, more than 200 communistic villages being founded, among them the celebrated Brook Farm, in Massachusetts. A large proportion of these experiments lasted only for a few years, but their influence has not yet ceased. The wave of transcendentalism also, which swept over the country between 1825 and 1840, affected not only social but industrial life. Labour papers began to be established. The *Working Man's Advocate*, published in New York City in 1825, was probably the very first American labour journal. Soon afterwards there appeared the *Daily Sentinel* and *Young America*, projected by two Englishmen, George Henry Evans and Frederick W. Evans. The chief demands advocated by these journals were the freedom of public lands, the breaking up of monopolies, the adoption of a general bankruptcy law, a lien for the labourer upon his work for his wages, the abolition of imprisonment for debt, equal rights for women with men, and the abolition of chattel and wage slavery. These demands were endorsed by over 600 newspapers. In 1830 a Workingman's Convention was held in Syracuse, N.Y., the outcome of which was the nomination of Ezekiel Williams for governor. In 1832 a delegated convention which met in the State House at Boston initiated the 10-hours movement. The *Tribune* (New York), under the leadership of Horace Greeley, was opened to the advocacy of Fourierism, and so on all hands the movement towards organization was helped. In 1845 the New England Working Man's Association was organized, and such men as Charles A. Dana, George Ripley, Albert Brisbane, Wendell Phillips, William Lloyd Garrison, Theodore Parker, and others participated in its meetings. The first industrial congress of the United States was convened in the city of New York 12th October, 1845, but little came of it. Other and more important labour congresses were held in that city and in Chicago in 1847 and 1850 respectively. During the latter part of the formative period, that is, from 1825 to 1860, most of the great national trades unions that are now influential were projected and organized, though their great and rapid growth has been since the Civil War. The National Typographical Union was organized in 1852, its name being changed to International in 1862 in order to admit Canadian members; the National Union of Hat Finishers in 1854; the Iron Moulders' Union of North America on 5th July 1859, and in the same year the Machinists' and Blacksmiths' Union of North America. By 1860 the national unions already formed numbered 26.

Railway brotherhoods.

During the next few years, among other important organizations, were instituted what are known as the group of railway brotherhoods, the oldest and largest of which is the International Brotherhood of Locomotive Engineers. The grand division was founded at Detroit, Mich., 17th August 1863, under the name of the Brotherhood of the Footboard. The society was reorganized under its present title at Indianapolis, Ind., 17th August 1864. The second national association of railway employés that was organized was the Conductors' Brotherhood, formed at Mendota, Ill., 6th July 1868, by the conductors from various railways in the United States. This brotherhood was recognized, and a general governing board established, on 15th December of the same year. Ten years later the name of the organization was changed from the Conductors' Brotherhood to the Order of Railroad Conductors of America. The Brotherhood of Locomotive Firemen was organized at Port Jervis, N.Y., 1st December 1873. The Brotherhood of Railroad Trainmen was organized at Oneonta, N.Y., 23rd September 1883. It was called the Brotherhood of Railroad Brakemen until 1st January 1890, when the present name was adopted. The Brotherhood of Railroad Trackmen is one of the younger and smaller organizations. The first efforts to found it were made in the spring of 1887, but its permanent organization took place a year later. The Brotherhood of Railroad Carmen of America was founded 9th September 1890, by the consolidation of the Carmen's Mutual Aid Association, the Brotherhood of Railroad Car Repairers, the Car Inspectors, Repairers, and Oilers' Protective Association, and the Brotherhood of Railroad Carmen of Canada. The Switchmen's Union of North America is the outgrowth of the Switchmen's Mutual Aid Association, the present organization dating from 1897. At one time the Mutual Aid Association was a large and influential body. Several of these railway brotherhoods suffered materially in their membership and influence through the organization of the American Railroad Union in 1893.

National unions.

The Cigar-makers' National Union dates from 1864, the Bricklayers' and Masons' International Union from 17th October 1865, the United States Wool Hat Finishers' Association from 1869, and the National Union of Horse-shoers of the United States from 1875. The Amalgamated Association of Iron and Steel Workers resulted, as its name signifies, from the consolidation of various other orders and societies, the present order being organized at Pittsburg in August

1876. The consolidated societies were known previously to the new order of things as the United Sons of Vulcan, the Associated Brotherhood of Iron and Steel Heaters, Rollers, and Roughers of the United States, and the Iron and Steel Roll Hands' Union. The oldest of these bodies was the United Sons of Vulcan, originating in Pittsburg, 17th April 1858, and known as the Iron City Forge. The Granite Cutters' National Union was organized in 1877, the Brotherhood of Carpenters and Joiners in 1881, and the Journeymen Bakers' National Union in 1886. This ends the list of the leading trades unions of the United States. All are organized along what is known as trade union lines; each is devoted to its particular interests, and primarily has nothing to do with other unions. Many, such as the Cigar-Makers, the Carpenters, and others, have special publications relating to their particular work.

The International.

In sympathy each union is, of course, bound up with all unions, and there have been attempts to organize labour on a general or universal plan. The first of these was the International Association of Working-men, known as the "International," which was organized in London in the autumn of 1864. This society sought to associate working-men wherever manufacturing has been extended. The International grew for a while, but never at any time had a membership exceeding 100,000, and probably never over 50,000. It did not extend to the United States with much force; certainly no large number of the working-men of the country were involved in it, and branches were not organized in the Union until 1870 or 1871. The International took part in the Parisian difficulties in the latter year, and thus lost its influence with Americans; in fact, its experience there killed the society. Its programme and propaganda sowed some seeds, however, through its broad foundation. Its practices were generally condemned.

Knights of Labour.

The second attempt was the Noble Order of Knights of Labour of America, which was founded in Philadelphia on Thanksgiving Day 1869, through the efforts of Uriah S. Stephens and six associates, all garment-cutters. For several years the garment-cutters of Philadelphia had been organized as a trade union, but failed to maintain satisfactory rates of wages. Dissatisfaction prevailed, and resulted in the autumn of 1869 in the disbandment of the Union. Stephens, who was a far-seeing man, and anticipated the disruption of his union, had prepared the outlines of a plan for an organization embracing, as he said, "all branches of honourable toil." He advocated education, co-operation, and an intelligent use of the ballot as the proper means for gradually abolishing the present wage-system. The Order had a varied career. Mr Stephens, himself a Mason, brought into the ritual of the new Order many of the features of speculative Masonry. The obligations were in the nature of oaths, taken with much solemnity upon the Bible, and the members were sworn to the strictest secrecy. The Order was known for a long time as "Five Stars," that designation being used in printing and writing. Many expressions taken from Greek literature were introduced into the ceremonies. The instructions given to every person admitted into the order are perhaps the best exponent of the nature of the ritual:—

> Labour is noble and holy. To defend it from degradation; to divest it of the evils to body, mind, and estate which ignorance and greed have imposed; to rescue the toiler from the grasp of the selfish—is a work worthy of the noblest and best of our race. In all the multifarious branches of trade, capital has its combinations; and, whether intended or not, they crush the manly hopes of labour, and trample poor humanity in the dust. We mean no conflict with legitimate enterprise, no antagonism to necessary capital, but men, in their haste and greed, blinded by self-interests, overlook the interests of others, and sometimes violate the rights of those they deem helpless. We mean to uphold the dignity of labour, to affirm the nobility of all who earn their bread by the sweat of their brows. We mean to create a healthy public opinion on the subject of labour (the only creator of values), and the justice of its receiving a full, just share of the values or capital it has created. We shall, with all our strength, support laws made to harmonize the interests of labour and capital, and also those laws which tend to lighten the exhaustiveness of toil. To pause in his toil to devote to his own interests [*sic*], to gather a knowledge of the world's commerce, to unite, combine, and co-operate in the great army of peace and industry, to nourish and cherish, build and develop, the temple he lives in, is the highest and noblest duty of man to himself, to his fellow-men, and to his Creator.

The ritual was neither printed nor written, and in all probability there is not now in existence a copy of it. So long as the utmost secrecy was retained, the Order did not grow rapidly; gradually it lost its secrecy, and worked on more general plans. From the best evidence that can be secured, it is probable that the first Local Assembly of the Knights of Labour was organized as early as 1873, in Philadelphia. Attempts at outside organization had been unsuccessful. The second Assembly consisted of ship-carpenters and caulkers employed in Cramp's shipyard. After this the Order spread quite rapidly, 20 Assemblies being organized in Philadelphia during 1873. A District Assembly, consisting of delegates from Local Assemblies in Philadelphia, met in that city on Christmas Day 1873, and organized District Assembly No. 1. The Order increased during the years following this action, and in 1877 delegates were chosen to organize a General Assembly. These delegates met at Reading, Pa., 1st January 1878, and organized the first General Assembly, Mr Stephens, the founder, presiding as temporary chairman. Seven states were represented. General Assemblies have been held each year since that time, and changes in the constitution or work of the Order have been the subject of warm discussion. At the meeting of the first General Assembly the membership must have been small, probably only a few thousand. It did not reach 50,000 till five years later. The General Assembly of 1880, at Pittsburg, denounced strikes as injurious, and not worthy of support, except in extreme cases. At the fifth session, at Detroit, in 1881, the most important actions in the history of the Order were taken, and from this session the rapid growth of the Order may be dated. The Assembly then declared that on and after 1st January 1882 the name and objects of the Order should be made public. It also declared that women should be admitted upon an equal footing with men, and a strong committee was appointed to revise the constitution and the ritual. At the next General Assembly, September 1882, in New York, the revised constitution was adopted, as well as laws and regulations for supporting strikes. After this the Order began to grow rapidly. It antagonized the trade unions, the contention being that the Order embraced higher and grander principles than those underlying the organization of the former. The trade unions in existence at that time struggled to preserve their organizations against what they considered the encroachment of the Knights of Labour. The high-water mark of the Order was probably during 1883, 1884, 1885, and 1886, when, according to the very best information, it numbered not less than 1,000,000 members. In 1900 its membership was estimated at about 130,000.

Declaration of principles.

The declaration of principles of the Knights of Labour calls attention to the alleged alarming development and aggressiveness of great capitalists and corporations, and makes the following specific claims or demands: To make industrial moral worth, not wealth, the true standard of individual and national greatness; to secure to the workers the full enjoyment of the wealth they create; sufficient leisure in which to develop their intellectual, moral, and social faculties, and all of the benefits, recreations, and pleasures of association. As means for securing these results, they demand at the hands of the State the establishment of Bureaus of Labour Statistics; that public land, the heritage of the people, be reserved for actual settlers; the abrogation of all laws that do not bear equally upon capital and labour; the adoption of measures providing for the health and safety of those engaged in mining, manufacturing, and building industries, and for indemnification for injuries received; the recognition by incorporation of trade unions, orders, and such other associations as may be organized by the working masses; the enactment of laws to compel corporations to pay their employés weekly, and giving mechanics and labourers a first lien upon the product of their labour to the full extent of their wages; the abolition of the contract system on national, state, and municipal works; the enactment of laws providing for arbitration between employers and employed; the prohibition by law of the employment of children under fifteen years of age in workshops, mines, and factories; that the hiring out of convict labour be prohibited, and that a graduated income tax be levied. They demand of Congress the establishment of a national monetary system, in which a circulating medium shall issue directly to the people; that interest-bearing bonds, bills of credit, or notes shall never be issued by the Government; the prohibition of the importation of foreign labour under contract; the organization of financial exchanges, safe deposits, &c., in connexion with the post office; the possession by Government, by purchase, of telegraphs, telephones, and railways. The Order pledges itself, while making the foregoing demands upon the state and national governments, to endeavour to establish a co-operative institution to supersede the wage system, to secure for both sexes equal pay for equal work, to shorten the hours of labour by a general refusal to work for more than eight hours, and to persuade employers to agree to arbitrate all differences which may arise.

Organization.

The Order of the Knights of Labour is based on the federal plan, and has a hierarchy of assemblies—the Local Assembly, the District Assembly, the State and the General Assembly. The officers of the Local Assembly consist of a Master Workman, Worthy Foreman, Venerable Sage, Recording Secretary, Financial Secretary, Treasurer, Worthy Inspector, Almoner, Statistician, and some minor officers. These are elected semi-annually by ballot or by acclamation. The District Assembly is composed of duly accredited delegates from at least five Local Assemblies, and is the highest tribunal of the Knights of Labour within its jurisdiction under the general laws of the Order. It has the power to levy assessments for its maintenance upon all Locals, and has also the power to establish Locals in the territory governed by it. The officers and their duties are similar to those of the Local Assembly, except that the Master Workman is called the District Master Workman. The constitution of the General Assembly is a very imposing document, containing twenty articles. The Assembly consists of representatives chosen by the District Assemblies, and has full and final jurisdiction, being the highest tribunal of the Order. It alone possesses the power and authority to make, amend, or repeal the fundamental and general laws of the Order, to decide finally all controversies arising, and to issue charters to State, District, and Local Assemblies. The officers are elected at each annual session, and their titles correspond almost completely with those of the Local and District Assemblies, with the exception that the word "General" takes the place of "District," as "General Master Workman," &c. The General Master Workmen have been Uriah S. Stephens (the founder of the Order), Terence V. Powderly, James R. Sovereign, John N. Parsons, and Henry A. Hicks, the present incumbent. The Order has a publication known as the *Journal of the Knights of Labour*, published at Washington, D.C.

American Railroad Union.

The third attempt to bring into one order men employed in different vocations was the American Railroad Union, organized in Chicago on 20th June 1893. It included all railway employés born of white parents. It was organized for the protection of members in all matters relating to wages and their rights as employés, and affirmed that such employés were entitled to a voice in fixing wages and in determining conditions of employment. The union won a great victory on the North-Western railroad in April 1894, but its action in the great strikes in Chicago in 1894 cost it its life. Its membership reached at one time 150,000.

Federations of labour.

The separate unions found that the co-operation of other unions was needed to perfect and extend their work, and attempts were made from time to time to organize a federated body. The initial steps were taken in 1866, when the trades assemblies of New York City and Baltimore called a national labour congress, the 100 delegates sent by 60 secret and open organizations from different trades unions meeting on 20th August. In 1867 a second convention was called to meet in Chicago, the aim being to form a Trades Union Congress like that existing in Great Britain. The National Labour Union held two conventions in 1868, the first in May and the other in September; it met again in Chicago in 1869, in Boston in 1870, in Philadelphia in 1871, and in Columbus, O., in 1872. This closed the experience of the National Labour Union. During 1873, owing to the industrial depression, many of the trade unions were suspended. An Industrial Congress met in Rochester, N.Y., in April 1874, consisting of some of the leading trade unionists of the United States, and on the 14th of that month a convention was held representing the Sovereigns of Industry. The expectation was that the old National Labour Union should be taken up. The Industrial Brotherhood of the United States, another secret order, partaking largely of the character of the Knights of Labour, was represented in that convention. As might have been expected, the two ideas—that on which the Knights of Labour was organized, and the trade union idea—immediately became antagonistic, yet a platform containing most of the principles of the Knights of Labour was adopted. The movement ended with the Rochester meeting. The years 1875 and 1876 saw other attempts; but they were chiefly political in their character, and the temporary orders then organized were disbanded. Between 1876 and 1881 other attempts were made at federation. A call issued jointly by the Knights of Industry and a body known as the Amalgamated Labour Union, consisting of some dissatisfied members of the Knights of Labour, resulted in a convention held at Terre Haute, Ind., 2nd August 1881. The chief purpose was to supplant the Knights of Labour by the creation of a new secret order. The membership of the convention, however, had trade union proclivities, and did not believe in multiplying labour societies. The secret organization was not effected. Another convention was held in Pittsburg, 19th November 1881, as the result of the following statement:—

> We have numberless trades unions, trades assemblies or councils, Knights of Labour, and various other local, national, and international labour unions, all engaged in the noble task of elevating and improving the condition of the working classes. But great as has been the work done by these bodies, there is vastly more that can be done by a combination of all these organizations in a federation of trades and labour unions.

It is claimed that the 107 delegates represented 262,000 workmen. Their deliberations resulted in the Federation of Organized Trades and Labour Unions of the United States and Canada. Its platform differed but very little from that of the Knights of Labour, although it was in some respects more comprehensive. It demanded eight hours as a day's work; called for national and state incorporation of trade unions; favoured obligatory education of all children, and the prohibition of their employment under the age of fourteen; favoured the enactment of uniform apprentice laws; opposed bitterly all contract convict labour and the truck system for payment of wages; demanded laws giving to working men a first lien on property upon which their labour had been expended; insisted upon the abrogation of all so-called conspiracy laws; advocated the establishment of a national bureau of labour statistics; urged the prohibition of the importation of foreign labour; opposed Government contracts on public work; favoured the adoption by states of an Employers' Liability Act; and urged all other labour bodies to vote only for labour legislators. The second convention was held at Cleveland, O., 21st November 1882. The Federation had many very difficult problems under discussion during the next few years, among others being the attempt to include Socialism and the doctrines of Anarchists; but the Federation has always stood out against these attempts, although at one time it seemed likely that it would become a Socialistic body, in full alliance with the Socialist Labour party.

The American Federation of Labour is the largest labour organization in the United States. It was organized at Columbus, O., 8th December 1886, under the name it now bears. In 1888 it was declared that it owed its existence to the Federation of Organized Trades, &c., founded in 1881 at Pittsburg, and that the American Federation meetings or conventions should date from that year; hence it is generally stated that the Federation was founded in 1881. From the start in 1881 the Federation had a constitution, but it revised it at the convention held in Baltimore, 16th December 1887, under the name of the American Federation of Labour. The order is not secret, nor do individual members, through local trades unions or otherwise, owe any allegiance to it. Its object is the encouragement and formation of local trades and labour unions, and the closer federation of such societies through the organization of central trades and labour unions in every State, and the combination of such bodies into state, territorial, or provincial organizations for the purpose of securing general harmony not only in the interests of the working masses, but of legislation. While it is a federation, it cannot be called a federal body, like the Knights of Labour, although there are local trade unions, trade assemblies in cities, and state federations; nevertheless, there is not the hierarchical character of the other body. Most of the trade unions in the United States are affiliated with the American Federation. The great railway brotherhoods are not so affiliated, except the Amalgamated Association of Railroad Employés of America, the Order of Railroad Telegraphers, and the Brotherhood of Railroad Trackmen.

The following is a list of the principal unions affiliated :—

Affiliated unions.

Actors' National Protective Union; Allied Metal Mechanics, International Union of; Bakers and Confectioners International, Journeymen; Barbers National, Journeymen; Blacksmiths, International Brotherhood of; Blast Furnace Workers and Smelters of America, International Association of; Boiler Makers and Iron Ship Builders, Brotherhood of; Bookbinders, International Brotherhood of; Boot and Shoe Workers' Union; Brewery Workers, National Union of United; Brickmakers' National Alliance; Bridge and Structural Ironworkers; Broom Makers, International; Carpenters and Joiners of America, United Brotherhood of; Carpenters and Joiners, Amalgamated Society of; Carriage and Wagon Makers, International; Wood Carvers' Association of North America, International; Cigar-Makers' International Union of America; Clerks' International Protective Association, Retail; Coopers' International Union of North America; Coremakers' International Union; Curtain Operatives of America, Amalgamated Lace; Drivers' International Union, Team; Electrical Workers of America, National Brotherhood of; Engineers, National Brotherhood of Coal Hoisting; Engineers, International Union of Steam; Engineers, Amalgamated Society of; Engravers, International Association of Watch Case; Firemen, International Brotherhood of Stationary; Fitters and Helpers, National Association of Steam and Hot Water; Garment Workers of America, United; Glass Bottle Blowers' Association of the United States and Canada; Glass Cutters' League of America, Window; Glass Flatteners' Association of North America, Window; Glass Workers' Union, American Flint; Gold Beaters' Union, National; Granite Cutters' National Union; Grinders' National Union, Table Knife; Hatters of North America, United; Horse Shoers of United States and Canada, International Union of; Hotel and Restaurant Employés' International Alliance and Bar-tenders' International League of America; Iron, Steel, and Tin Workers, Amalgamated Association of; Lathers, International Union of Wood, Wire, and Metal; Leather Workers on Horse Goods, United Brotherhood of; Longshoremen's Association, International; Machinists, International Association of; Meat Cutters and Butcher Workmen of North America, Amalgamated; Metal Polishers', Buffers', Platers', and Brass Workers' Union of North America; Metal Workers' International Association, Amalgamated Sheet; Mine Workers of America, United; Mine Workers' Progressive Union, Northern Mineral; Moulders' Union of North America, Iron; Musicians, American Federation of; Oil and Gas Well Workers, International Brotherhood of; Paper Makers of America, United Brotherhood of; Pattern Makers' League of North America; Plumbers, Gas Fitters, Steam Fitters, and Steam Fitters Helpers, United Association of; Plate Printers' Union of United States, National Steel and Copper; Printing Pressmen's Union, International; Potters, National Brotherhood of Operative; Railroad Employés of America, Amalgamated Association of; Railroad Telegraphers, Order of; Railroad Trackmen, Brotherhood of; Seamen's Union, International; Spinners' Association, Cotton Mule; Stage Employés National Alliance, Theatrical; Stove Mounters, International; Tailors' Union of America, Journeymen; Textile Workers of America, National Union of; Tile Layers' Union, International Mosaic and Encaustic; Tin Plate Workers' International Protective Union of America; Tobacco Workers' International Union; Trunk and Bag Workers' International Union; Typographical Union, International; Weavers' Amalgamated Association, Elastic Web; Wood Workers' International Union of America, Amalgamated.

The state branches affiliated with it are those of Alabama, California, Connecticut, Florida, Georgia, Illinois, Iowa, Kentucky, Massachusetts, Michigan, Missouri, Nebraska, New York, New Jersey, North Carolina, Ohio, South Carolina, Texas, Utah, Virginia, and Wisconsin. The central labour unions, trades assemblies, or labour councils of cities are also affiliated with the American Federation. The chief officers of the Federation are a president, first, second, third, fourth, fifth, and sixth vice-presidents, treasurer and secretary. Samuel Gompers of New York was the first president, holding that position till 1894, when he was defeated through the endeavours of the Socialist Labour party, and John M'Bride elected. At the next session, however, he was re-elected, and has been the president ever since. The numerical strength of the American Federation of Labour is probably not far from 1,000,000. It maintains a journal called the *American Federationist*, published at Washington, D.C. The doctrine of the Federation relative to strikes is that each affiliated society has its own government, distinct from the government of the national convention, which has no power to order strikes, such matters being left to the affiliated societies, but is advisory, and not conclusive in its action.

Estimated strength.

Unions are often organized for temporary purposes, their existence ceasing as soon as the purposes succeed or fail. The total number of members of all kinds of labour organizations cannot be stated. There are many local societies and associations other than those belonging to the Knights of Labour or those affiliated with the American Federation of Labour, but which are distinctly labour bodies. In 1900, according to the best possible classification, there were 18,000,000 wage-earners in the United States, including men, women, and children. The most liberal estimate of the membership of all labour organizations places the total at 1,600,000. This would be about 8 per cent. of the whole body of wage-workers; but in some occupations, like that of the printing trade, the organization probably includes from 75 to 90 per cent.; and so of other organizations of workers found very largely in the unions. It is not safe, therefore, to make calculations from general estimates.

In the state of New York in 1901 there were known to be 1881 trade unions with 276,141 members, of which 84,401 belonged to the building trades, 41,883 to the clothing trades, 17,896 to the printing and kindred trades, 35,562 to iron and steel trades, 34,371 to railway service, and the others to various other trades and industries. In Connecticut there were, in 1900, 340 trade unions, of which 122 returned a membership of 14,244. The greater part of the expenditure appears to have been on sick and funeral benefits and management.

The law relating to trade unions varies somewhat in the different states. Both the Federal Legislature and several of the states (Massachusetts, New York, Pennsylvania, Michigan, Maryland, Iowa, Kansas, and Louisiana) have passed laws permitting the incorporation of unions. Michigan, Wyoming, and Nebraska have specially provided for incorporating assemblies of the Knights of Labour. Hardly any advantage, however, has been taken of these statutes. Some states have passed laws excepting trade unions from restrictions on combinations and conspiracies imposed by other statutes or the common law (*e.g.*, New York), and especially from the operation of anti-trust laws (Michigan, Wisconsin, Nebraska, Montana, North Carolina, and Texas). The Texas law, however, has been held unconstitutional. A number of states have passed laws, some of doubtful validity, prohibiting employers from making it a condition of employment that labourers should not belong to a union. Most states have adopted statutes legalizing union labels to indicate the products of members of trade unions.

By Act of Congress, associations of the nature of labour organizations, having branches in several states or territories, may, on filing articles of association for record in Washington, become corporations. American legislation generally is friendly to trade unions. Their purposes are regarded as lawful by the courts, but if they use unlawful means for their accomplishments, a remedy will be applied. Injury to property, intimidation by threats, personal violence, or boycotts enforced by terrorism, are such unlawful means. The liberty of action thus secured to organizations of labour is equally the right of the employer. Therefore, a statute making it an offence for one to require those whom he employs to withdraw from a trade union is unconstitutional and void (see *Reports of American Bar Association*, volume xxi. 367, 372).

AUTHORITIES.—Ely. *The Labour Movement in America.* New York, N.Y., 1886.—M'NEILL. *The Labour Movement.* Boston, Mass., 1887.—POWDERLY. *Thirty Years of Labour.* Columbus, O., 1889.—SIMONDS. *The Story of Manual Labour in all Lands and Ages.* Chicago, 1886.—BLISS. *The Encyclopædia of Social Reform.* New York, 1897.—ALDRICH. "The American Federation of Labour," *Economic Studies*, August, 1898.—WRIGHT. *Industrial Evolution of the United States.* Meadville, Pa., 1895.—"Historical Sketch of the Knights of Labour," *Quarterly Journal of Economics*, January, 1887.—"The Amalgamated Association of Iron and Steel Workers," *Quarterly Journal of Economics*, July 1893 and November 1901. (C. D. W.)

Traill, Henry Duff (1842–1900), English author and journalist, was born at Blackheath on 14th August 1842. When he left Oxford with the usual degree, he studied for the bar. He was called in 1868, but practised scarcely at all, and in 1871 obtained a post in the Education Office. This left him leisure to cultivate the literary gift which had clearly shown itself in him at Oxford, and in 1873 he became a contributor to the *Pall Mall Gazette*, then under the editorship of Mr Frederick Greenwood. He followed Mr Greenwood to the *St James's Gazette* when in 1880 the *Pall Mall Gazette* took for a time the Liberal side, and he continued to contribute to that paper up to 1895. In the meantime he had also joined the staff of the *Saturday Review*, to which he sent, amongst other writings, weekly verses upon subjects of the hour. Some of the best of these he republished in 1882 in a volume called *Recaptured Rhymes*, and others in a later collection of *Saturday Songs* (1890). He was also a leader-writer on the *Daily Telegraph*, and acted for a time as editor of the (Sunday) *Observer*. In 1897 he became first editor of *Literature*, when that weekly journal was established by the proprietors of *The Times*, and directed its fortunes until his death. But it was rather as a writer than an editor that Traill excelled. He wrote best when he wrote with least sense of the burden of responsibility. His playful humour and his ready wit were only given full scope when he was writing to please himself. One of his most brilliant *jeux d'esprit* was a pamphlet which was published without his name soon after he had begun to write for the newspapers. It was called *The Canaanitish Press and the Israelitish Question.* This told the story of the Exodus in articles which parodied very cleverly the style of all the leading journals of the day, and was at once recognized as the work of a born humorist. Traill sustained this reputation with *The New Lucian*, which appeared in 1884 (second edition with several new dialogues, 1900); but for the rest his labours were upon more serious lines. He directed the production of a vast work on *Social England* in 1893–98; he wrote, for several series of biographies, studies of Coleridge, Sterne, William III., Shaftesbury, Strafford, and Lord Salisbury; he compiled a biography of Sir John Franklin, the Arctic explorer; and after a visit to Egypt he published a volume on the country and another on Lord Cromer, the man who had done so much to bring it back to prosperity. Traill was certainly one of the most distinguished journalists of his day, and might well have left some enduring monument of his talent as a man of letters if he had not been so constantly occupied with ephemeral production. He died in London on 21st February 1900. (H. H. F.)

Tralee, a maritime town, market town, and urban sanitary district in the county of Kerry, Ireland, on the river Lee, 181½ miles W.S.W. of Dublin by rail. Large vessels discharge at Fenit, 8 miles westward, where a pier has been constructed, connected with the town by railway. In all 289 vessels of 1498 tons entered in 1900, and 120 of 23,459 tons cleared. Population about 9867.

Tranent, a police burgh of Haddingtonshire, Scotland, on the highroad between Edinburgh and Haddington, 9½ miles east of the former. The town thrives on the retail trade of its district and the surrounding coal mines and quarries. It has the oldest coal-mining charter (1202–18) in Great Britain. A fragment of a parish church said to have been built in the 11th century is still standing. Tranent is being largely reconstructed. There is a town hall, an Elizabethan school, and a Roman Catholic boarding school. Population (1881), 2235; (1891), 2389; (1901), 2584.

Tranmere. See BIRKENHEAD.

Tranquebar, a town of British India, in the Tanjore district of Madras, on the sea coast, 22 miles north of Negapatam. Population (1891), 5000. It lost its importance when the railway was opened to Negapatam. The Lutheran mission high school (combined with one at the village of Shiyali on the railway) had 120 pupils in 1896–97. There is a mission press, issuing a monthly periodical in the vernacular, besides a reading room and literary institute.

Transbaikalia (*Zabaikalskaya Oblast*), a province of Eastern Siberia, to the east of Lake Baikal, bounded on the W. by Irkutsk, on the N. by Yakutsk, on the E. by the province of Amur, and on the S. by Mongolia. Its area is 236,868 square miles, and its population, which was 497,760 in 1882, numbered 664,071 (domiciled only) in 1897, of whom 325,349 were women, and 36,823 lived in towns. The province is divided into five districts, the chief towns of which are Tchita (11,480 inhabitants), which is also the capital of the province, Barguzin (1378), Nerchinsk (6713), Selenghinsk (1076), and Verkhneudinsk (8002). Other towns are Kyakhta (4300), Nerchinskiy Zavod, and Sryetensk. The standard of education is low, there being less than 200 schools attended by less than 10,000 scholars. Mining, and especially gold mining, is important, but the production of gold has fallen off (4451 kilogrammes in 1882, 3882 kilogrammes in 1897). Silver mines have only a very small output (925 kilogrammes in 1897), and the production of iron is also insignificant (in 1897, 645 tons of pig iron and 532 tons of iron). Iron mining, however, is gradually developing, and explorations in connexion with the Trans-Siberian railway have led to the discovery of good coal mines, which are now being worked. Salt is raised from several lakes to the amount of about 750 tons per annum, and the extraction of Epsom salts has considerably developed, nearly 1000 tons being obtained every year. Agriculture, however, continues to remain the main occupation of the people, and the average yield of all cereals is estimated to be not less than a million quarters yearly. Cattle-breeding is also of great importance, there being in the province over 500,000 horses and an aggregate of 2,700,000 head of various cattle. Hunting for sables and (especially) squirrels, and the gathering of nuts are widely followed. Manufactures, though insignificant, have somewhat increased. Transbaikalia is crossed by the Trans-Siberian railway from Mysovaya on Lake Baikal, *viâ* Tchita, to Sryetensk, and from Kaidalovo, near Tchita, to the Mongolian frontier; this latter section is continued, as the main line, across Manchuria to Vladivostok and Port Arthur (see RUSSIA and SIBERIA). River navigation has been improved and extended; regular steamer communication has been established along Lake Baikal, not only for the transport of passengers and goods between the two railway stations of Listvenichnaya and Mysovaya, but also with the object of developing the fishing industry, which is of great importance. Steamers ply up the Selenga river as far as the town of Selenghinsk, considerable cargoes of tea being transported along this line. (P. A. K.)

Trans-Caspian Territory (*Zakaspiyskaya Oblast*), a province of Russia to the east of the Caspian Sea, bounded by Uralsk on the N., by Khiva and Bokhara on the N.E., by Afghan Turkestan on the S.E., and by the highlands of Afghanistan and Khorassan on the S. Its area is officially estimated at 220,540 square miles, but Strelbitzky reckons it to be only 214,240 square miles. In 1897 the domiciled population numbered 372,193, of whom 166,084 were women, and only 42,431 lived in towns; but, besides those of whom alone the census took account, there were about 25,000 strangers and troops. In 1895, when the population was estimated at 331,030, there were 240,200 Turcomans, 60,560 Kirghiz, 12,400 Russians (only 2174 peasants), 11,600 Persians and Tatars, 4170 Armenians, and 2100 of various nationalities. The province is divided into five districts, the chief towns of which are: Askhabad (19,428), which is also the capital of the province; Krasnovodsk (6359); Fort Alexandrovskiy (882), in the district of Manghishlak, on the Caspian Sea; Merv (8727), and Tejen (382). In 1898 there were only 24 schools with 1200 pupils.

The land is very rich in minerals: rock-salt covers over 80 acres on the island of Cheleken, and is also found at Bala Ishem, along the Uzboi, and in many lakes; while naphtha, ozokerite, and gypsum are found in several places. At the present time the chief minerals extracted are rock-salt, 18,300 tons in 1897; naphtha, 14,050 tons from Cheleken Island; gypsum, 1240 tons; sulphur, nearly 5000 tons. Nearly 300,000 acres are irrigated by the natives, and attempts are being made by the Government to increase the irrigated area by means of dams and new canals; it is considered that over 5,000,000 acres of land could be rendered suitable for agriculture. Strenuous efforts are being made to increase the forest area; several hundred thousand trees are planted every year, and a forest guard has been established to prevent useless destruction of the saksaul trees, which grow freely in the steppes. A model garden and a mulberry-tree plantation have been established at Askhabad in connexion with the gardening school. The land in the oases, especially those of the Atrek, is highly cultivated. In 1896, 1,300,000 cwt. of wheat and 220,000 cwt. of barley were grown, in addition to sorghum, Indian corn, rice, millet, and "kunjut" for oil. Raw cotton to the amount of nearly 3000 tons was obtained in 1896 in the Merv district, where nearly 10,000 acres were under this crop, and four factories were engaged in cotton cleaning. Gardening is well developed, and attempts are being made to encourage the spread of viticulture. Cattle-breeding is the chief occupation of the nomad Turcomans and Kirghiz. It was estimated in 1895 that there were in the province 106,000 horses, 44,000 horned cattle, 18,000 donkeys, 186,000 camels, and nearly 3,000,000 sheep and goats. Raw wool is exported to the value of 600,000 roubles per annum, as also over 60,000 hides and nearly 150,000 sheepskins. Considerable fishing is carried on off the coasts of the Caspian Sea, and seals are killed on the Manghishlak Peninsula. The natives follow a variety of domestic trades, in which they excel, chiefly the making of carpets, travelling bags, felt goods, and embroidered leather. The Russian population is chiefly limited to the military and the towns, only eight agricultural and three fishing villages containing Russians. Wheat, flour, wool, raw cotton, and dried fruit are exported, while tea, manufactured goods, timber, sugar, iron, paraffin oil are imported, as also rice and fruit from Bokhara, Turkestan, and Persia. The Trans-Caspian railway, constructed across the province from Krasnovodsk to Merv, with a branch to Kushka, and from Merv to Bokhara and Russian Turkestan, has accomplished quite a revolution in the trade of Central Asia. The old caravan routes *viâ* Orenburg have lost their importance, and goods coming from India, Persia, Bokhara, and even China are now brought to different stations on the railway. The export of raw cotton from Bokhara along this line supplies the Russian cotton mills with a considerable portion of the raw material which they require, and in the year 1895 the exports of cotton, wool, dried fruit, hides, sheepskins, &c., were estimated at nearly 100,000 tons, while the imports of corn, metals, paraffin oil, and timber amounted to 613,000 tons. (For the recent history see RUSSIA: *History*.)

See the researches of ANDRUSOFF, BOGDANOVITCH, KONSHIN, MUSHKETOFF, and OBRUCHEFF in the *Memoirs*, the *Bulletin* (*Izvestia*), and the *Annuals* of the Russian Geographical Society, 1890–1900.—LESSAR. *L'ancienne junction de l'Oxus avec la Mer Caspienne*, 1889.—ZAROUDNOI (zoology) in *Bulletin de la Société des Naturalistes de Moscou*, 1889 *seq.*—*Works of the International Commission*, in English and Russian.—*Obzor Zakaspiyskoi Oblasti* (annual reviews), published at Askhabad, since 1890.—*The Geographical Journal* (Royal Geographical Society, London), 1893. (P. A. K.)

Transformers.—An electrical transformer is the name given to any device for producing by means of one electric current another of a different character. The working of such an appliance is, of course, subject to the law of conservation of energy. The resulting current represents no more (in fact, always less) power than the applied current, the difference being represented by the power dissipated in the translating process. Hence an electrical transformer corresponds to a simple machine in mechanics, both transforming power from one form into another with a certain energy-dissipation depending upon frictional losses, or something equivalent to them. Electrical transformers may be divided into several classes, according to the nature of the transformation effected. The first division comprises those which change the form of the power, but keep the type of the current the same; the second, those that change the type of the current as well as the form of power. The power given up electrically to any circuit is measured by the product of the *effective value* of the current, the *effective value* of the difference of potential between the ends of the circuit, and a factor called the *power factor*. In dealing with periodic currents, the effective value is that called the root-mean-square value (R.M.S.), that is to say, the square root of the mean of the squares of the time equidistant instantaneous values during one complete period (see Electricity: *Electric Current*). In the case of continuous currents, the power factor is unity, and the effective value of the current or voltage is the true mean value. As the electrical measure of a power is always a product involving current and voltage, we may transform the character of the power by increasing or diminishing the current with a corresponding decrease or increase of the voltage. A transformer which raises voltage is generally called a *step-up* transformer, and one which lowers voltage is called a *step-down* transformer.

Again, electric currents may be of various types, such as continuous, single-phase alternating, polyphase alternating, unidirectional but pulsating, &c. Accordingly, transformers may be distinguished in another way, in accordance with the type of transformation they effect. (1) *An alternating current transformer* is an appliance for creating an alternating current of any required magnitude and electromotive force from another of different value and electromotive force, but of the same frequency. An alternating current transformer may be constructed to transform either single-phase or polyphase currents. (2) *A continuous current transformer* is an appliance which effects a similar transformation for continuous currents, with the difference that some part of the machine must revolve, whereas in the alternating current transformer all parts of the machine are stationary; hence the former is generally called a rotatory transformer, and the latter a static transformer. (3) *A rotatory or rotary transformer* may consist of one machine, or of two separate machines, adapted for converting a single-phase alternating current into a polyphase current, or a polyphase current into a continuous current, or a continuous current into an alternating current. If the portions receiving and putting out power are separate machines, the combination is called a *motor-generator.* (4) A transformer adapted for converting a single-phase alternating current into a unidirectional but pulsatory current is called a *rectifier*, and is much used in connexion with arc lighting in alternating current supply stations. (5) *A phase transformer* is an arrangement of static transformers for producing a polyphase alternating current from a single-phase alternating current. Alternating current transformers may be furthermore divided into (*a*) single-phase, (*b*) polyphase. Transformers of the first class change an alternating current of single-phase to one of single-phase identical frequency, but different power; and transformers of the second class operate in a similar manner on polyphase currents. (6) The ordinary induction or spark coil may be called an intermittent current transformer, since it transforms an intermittent low-tension primary current into an intermittent or alternating high-tension current.

Alternating Current Transformer.—The typical alternating current transformer consists essentially of two insulated electric circuits wound on an iron core constituting the magnetic circuit. They may be divided into (1) open magnetic circuit static transformers, and (2) closed magnetic circuit static transformers, according as the iron core takes the form of a terminated bar or a closed ring. A closed circuit alternating current transformer consists of an iron core built up of thin sheets of iron or steel, insulated from one another, and wound over with two insulated conducting circuits, called the primary and secondary circuits. The core must be laminated or built up of thin sheets of iron to prevent local electric currents, called eddy currents, from being established in it, which would waste energy. In practical construction, the core is either a simple ring, round or rectangular, or a double rectangular ring, that is, a core whose section is like the figure 8. To prepare the core, thin sheets of iron or very mild steel, not thicker than ·014 of an inch, are stamped out of special iron (see Electromagnet) and carefully annealed.

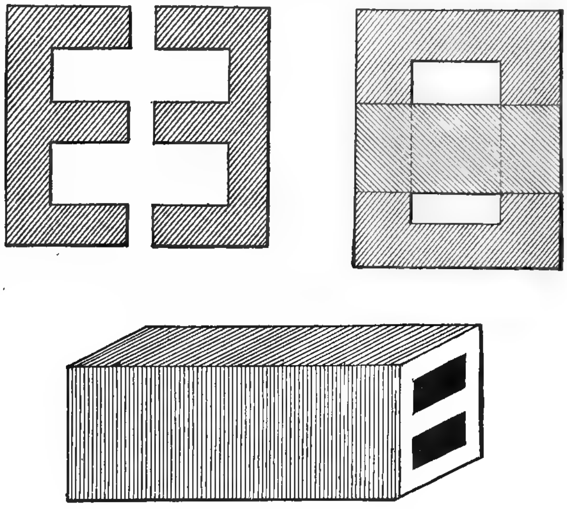

Fig. 1.—Transformer Stampings and Core.

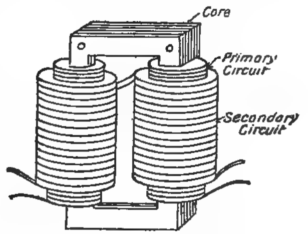

Fig. 2.—Closed Circuit Transformer.

Examples of the shapes in which these stampings are supplied are shown in Fig. 1. The plates when annealed are varnished or covered with thin paper on one side, and then piled up so as to make an iron core, being kept together by bolts and nuts or by pressure plates. The designer of a transformer core has in view, first, economy in metal, so that there may be no waste fragments, and second, a mode of construction that facilitates the winding of the wire circuits. These consist of coils of cotton-covered copper wire which are wound on formers and baked after being well saturated with shellac varnish. The primary and secondary circuits are sometimes formed of separate bobbins which are sandwiched in between each other; in other cases they are wound one over the other (Fig. 2). In any case the primary and secondary coils must be symmetrically distributed. If they were placed on opposite sides of the iron circuit, the result would be considerable magnetic leakage. Sometimes a metal shield is placed between the primary and secondary coils; in other cases safety sheets of mica or ebonite are used. The transformer is then well baked and placed in a cast-iron case sometimes filled in with heavy insulating oil, the ends of the primary and secondary circuits being brought out through water-tight glands. The most ordinary type of alternating current transformer is one intended to transform a small electric current produced by a large electromotive force (2000 to 10,000 volts) into a larger current of low electromotive force (100 to 200 volts). Such a transformer is called a step-down transformer, but it may be obviously employed in the reverse direction for raising pressure and reducing current, in which case it is called a step-up transformer. A transformer when manufactured has to be carefully tested to ascertain, first, its power of resisting breakdown, and, second, its energy-dissipating qualities. With the first object, the transformer is subjected to a series of pressure tests. If it is intended that the primary shall carry a current having an electromotive force of 2000 volts, an insulation test must be applied with double this voltage between the primary and the secondary, the primary and the case, and the primary and the core, to ascertain whether the insulation is sufficient. To prevent electric discharges from breaking down the machine in ordinary work, this extra pressure ought to be applied for at least a quarter of an hour. In some cases three or four times the working pressure is applied for one minute between the primary and secondary circuits. When such an alternating current transformer has an alternating current passed through its primary circuit, an alternating magnetization is produced in the core, and this again induces an alternating secondary current. The secondary current has a greater or less electromotive force than the primary current according as the number of windings or turns on the secondary circuit is greater or less than those on the primary. Of the power thus imparted to the primary circuit one portion is dissipated by the heat generated in the primary and secondary circuits by the currents, and another portion by *the iron core losses* due to the energy wasted in the cyclical magnetization of the core; the latter are partly eddy current losses and partly hysteresis losses.

In open magnetic circuit transformers the core takes the form of a laminated iron bar or a bundle of iron wire. An ordinary induction coil is an instrument of this description. It has been shown, however, by careful experiments, that for alternating current transformation there are very few cases in which the closed magnetic circuit transformer has not an advantage. An immense number of designs of closed circuit transformer have been elaborated since the year 1885. It suffices simply to mention the names of the principal modern types, such as those of Ferranti, Kapp, Mordey, Westinghouse, Berry, and Ganz. Diagrammatic representations of the arrangements of the core and circuits in some of these transformers are given in Fig. 3.

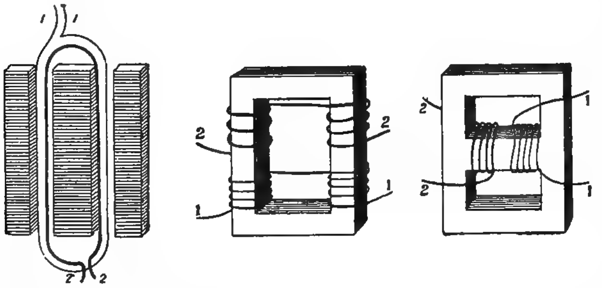

Fig. 3.—Diagrams of (A) Mordey (in section), (B) Kapp, and (C) Ganz Transformers.

1, 1, primary circuit; 2, 2, secondary circuit.

Alternating current transformers are classified into (i.) *Core* and (ii.) *Shell* transformers, depending upon the arrangements of the iron and copper circuits. If the copper circuits are wound on the outside of what is virtually an iron ring, the transformer is a core transformer; if the iron encloses the copper circuits, it is a shell transformer. Shell transformers have the disadvantage generally of poor ventilation for the copper circuits. Berry, however, has overcome this difficulty by making the iron circuit in the form of a number of bunches of rectangular frames which are set in radial fashion and the adjacent legs all embraced by the two copper circuits in the form of a pair of concentric cylinders. In this manner he secures good ventilation and a minimum expenditure in copper and iron, as well as the possibility of insulating the two copper circuits well from each other and from the core.

Efficiency.

The ratio between the power given out by a transformer and the power taken up by it is called its *efficiency*, and is best represented by a curve, of which the ordinate is the efficiency expressed as a percentage, and the corresponding abscissæ represent the fractions of the full load as decimal fractions. The output of the transformer is generally reckoned in kilowatts, and the load is conveniently expressed in decimal fractions of the full load taken as unity. The efficiency on one-tenth of full load is generally a fairly good criterion of the economy of the transformer as a transforming agency. In large transformers the one-tenth load efficiency will reach 90 per cent. or more, and in small transformers 75 to 80 per cent. The general form of the efficiency curve for a closed circuit transformer is shown in Fig. 4. The horizontal distances represent fractions of full secondary load (represented by unity), and the vertical distances efficiency in percentages. The efficiency curve has a maximum value corresponding to that degree of load at which the copper losses in the transformer are equal to the iron losses.

In the case of modern closed magnetic circuit transformers the copper losses are proportional to the square of the secondary current (I_2) or to qI_2^2, where q stands for the function $(R_1a^2+R_2)$; R_1 being the resistance of the primary and R_2 that of the secondary circuit, while a is the ratio of the number of secondary and primary windings of the transformer. Let C stand for the core loss, and V_2 for the secondary terminal potential difference (R.M.S. value). We can then write as an expression for the efficiency (η) of the transformer,

$$\eta=\frac{I_2V_2}{C+qI_2^2+I_2V_2}.$$

It is easy to show that if C_1, V_2, and q are constants, but I_2 is variable, the above expression for η has a maximum value when

$$C-qI_2^2=0,$$

that is, when the iron core loss C = the total copper losses qI_2^2.

Iron and copper losses.

The iron core energy-waste, due to the hysteresis and eddy currents, may be stated in watts, or expressed as a fraction of the full load secondary output. In small transformers of 1 to 3 kilowatts output it may amount to 2 or 3 per cent., and in large transformers of 10 to 50 kilowatts and upwards it should be 1 or less than 1 per cent. Thus the core loss of a 30-kilowatt transformer (one having a secondary output of 30,000 watts) should not exceed 300 watts. It has been shown that for the constant potential transformer the iron core loss is constant at all loads, but diminishes slightly as the core temperature rises. On the other hand, the copper losses due to the resistance of the copper circuits increase about 0.4 per cent. per degree Centigrade with rise of temperature. The current taken in at the primary side of the transformer, when the secondary circuit is unclosed, is called the *magnetizing current*, and the power then absorbed by the transformer is called the *open circuit loss* or magnetizing watts. The ratio of the terminal potential difference at the primary and secondary terminals is called the *transformation ratio* of the transformer. Every transformer is designed to give a certain transformation ratio, corresponding to some particular primary voltage. In some cases transformers are designed to transform, not potential difference, but current in a constant ratio. The product of the root-mean-square (R.M.S.), effective or virtual, values of the primary current, and the primary terminal potential difference, is called the *apparent power* or apparent watts given to the transformer. The true electrical power may be numerically equal to this product, but it is never greater, and is sometimes less. The ratio of the true power to the apparent power is called the *power factor* of the transformer. The power factor approaches unity in the case of a closed circuit transformer, which is loaded non-inductively on the secondary circuit to any considerable fraction of its full load, but in the case of an open-circuit transformer the power factor is always much less than unity at all loads. Power factor curves show the variation of power factor with load. A low power factor always implies a magnetic circuit of large reluctance.

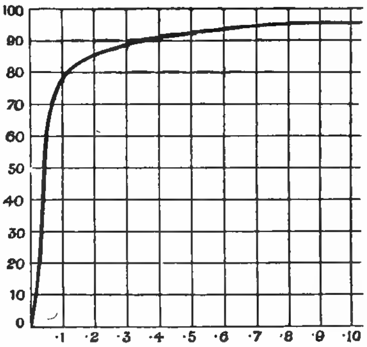

Fig. 4.—Efficiency Curve of Closed Circuit Transformer.

The operation of the alternating current is then as follows: The periodic magnetizing force of the primary circuit creates a periodic magnetic flux in the core, and this being linked with the primary circuit creates by its variation what is called the back electromotive force in the primary circuit. The variation of the particular portion of this periodic flux, linked with the secondary circuit, originates in this last a periodic electromotive force. The whole of the flux linked with the primary circuit is not interlinked with the secondary circuit. The difference is called the *magnetic leakage* of the transformer. This leakage is increased with the secondary output of the transformer and with any disposition of the primary and secondary coils which tends to separate them. The leakage exhibits itself by increasing the *secondary drop.* If a transformer is worked at a constant primary potential difference, the secondary terminal potential difference at no load or on open secondary circuit is greater than it is when the secondary is closed and the transformer giving its full output. The difference between these last two differences of potential is called the secondary drop. This secondary drop should not exceed 2 per cent. of the open secondary circuit potential difference.

Appraisement.

The facts required to be known about an alternating current transformer to appraise its value are (1) its full load secondary output or the numerical value of the power it is designed to transform, on the assumption that it will not rise in temperature more than about 60° C. above the atmosphere when in normal use; (2) the primary and secondary terminal voltages and currents, accompanied by a statement whether the transformer is intended for producing a constant secondary voltage or a constant secondary current; (3) the efficiency at various fractions on secondary load from one-tenth to full load taken at a stated frequency; (4) the power factor at one-tenth of full load and at full load; (5) the secondary drop between full load and no load; (6) the iron core loss, also the magnetizing current, at the normal frequency; (7) the total copper losses at full load and at one-tenth of full load; (8) the final temperature of the transformer after being left on open secondary circuit but normal primary potential for twenty-four hours, and at full load for three hours. The matters of most practical importance in connexion with an alternating current transformer are (1) the iron core loss, which affects the efficiency chiefly, and must be considered (*a*) as to its initial value, and (*b*) as affected by "ageing" or use; (2) the secondary drop or difference of secondary voltage between full and no load, primary voltage being constant, since this affects the service and power of the transformer to work in parallel with others; and (3) the temperature rise when in normal use, which affects the insulation and life of the transformer. The shellacked cotton, oil, and other materials with which the transformer circuits are insulated suffer a deterioration in insulating power if continuously maintained at any temperature much above 80° C. to 100° C. In taking the tests for core loss and drop, the temperature of the transformer should therefore be stated. The iron losses are reduced in value as temperature rises and the copper losses are increased. The former may be 10 to 15 per cent. less, and the latter 20 per cent. greater than when the transformer is cold. For the purpose of calculations we require to know the number of turns on the primary and secondary circuits, represented by N_1 and N_2; the resistances of the primary and secondary circuits, represented by R_1 and R_2; the volume (V) and weight (M) of the iron core; and the mean length (L) and section (S) of the magnetic section. The hysteresis loss of the iron reckoned in watts per pound per 100 cycles of magnetization per second and at a maximum flux density of 2500 C.G.S. units should also be determined.

Testing.

The experimental examination of a transformer involves the measurement of the efficiency, the iron core loss, and the secondary drop; also certain tests as to insulation and heating, and finally an examination of the relative phase position and graphic form of the various periodic quantities, currents, and electromotive forces taking place in the transformer. The efficiency is best determined by the employment of a properly constructed wattmeter (see MEASURING INSTRUMENTS, ELECTRIC). The transformer T (Fig. 5) should be so arranged that, if a constant potential transformer, it is supplied with its normal working pressure at the primary side and with a load which can be varied, and which is obtained either by incandescent lamps, L, or resistances in the secondary circuit. A wattmeter, W, should be placed with its series coil, Se, in the primary circuit of the transformer, and its shunt coil, Sh, either across the primary mains in series, with a suitable non-inductive resistance, or connected to the secondary circuit of another transformer, T^1, called an *auxiliary transformer*, having its primary terminals connected to those of the transformer under test. In the latter case one or more incandescent lamps, L, may be connected in series with the shunt coil of the wattmeter so as to regulate the current passing through it. The current through the series coil of the wattmeter is then the same as the current through the primary circuit of the transformer under test, and the current through the shunt coil of the wattmeter is in step with, and proportional to, the primary voltage of the transformer. Hence the wattmeter reading is proportional to the mean power given up to the transformer. The wattmeter can be standardized and its scale reading interpreted by replacing the transformer under test by a non-inductive resistance or series of lamps, the power absorption of which is measured by the product of the amperes and volts supplied to it. In the secondary circuit of the transformer is placed another wattmeter of a similar kind, or, if the load on the secondary circuit is non-inductive, the secondary voltage and the secondary current can be measured with a proper alternating current ammeter, A_2, and voltmeter, V_2, and the product of these readings taken as a measure of the power given out by the transformer. The ratio of the powers, namely, that given out in the external secondary circuit and that taken in by the primary circuit, is the efficiency of the transformer.

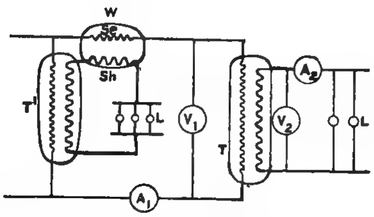

FIG. 5.—Arrangement for Testing Transformers.

In testing large transformers, when it is inconvenient to load up the secondary circuit to the full load, a close approximation to the power taken up at any assumed secondary load can be obtained by adding to the value of this secondary load, measured in watts, the iron core loss of the transformer, measured at no load, and the copper losses calculated from the measured copper resistances when the transformer is hot. Thus, if C is the iron core loss in watts, measured on open secondary circuit, that is to say, is the power given to the transformer at normal frequency and primary voltage, and if R_1 and R_2 are the primary and secondary circuit resistances when the transformer has the temperature it would have after running at full load for two or three hours, then the efficiency can be calculated as follows: Let O be the nominal value of the full secondary output of the transformer in watts, V_1 and V_2 the terminal voltages on the primary and secondary side, N_1 and N_2 the number of turns, and A_1 and A_2 the currents for the two circuits; then O/V_2 is the full load secondary current measured in amperes, and N_2/N_1 multiplied by O/V_2 is to a sufficient approximation the value of the corresponding primary current. Hence O^2R_2/V_2^2 is the watts lost in the secondary circuit due to copper resistance, and $O^2R_1N_2^2/V_2^2N_1^2$ is the corresponding loss in the primary circuit. Hence the total power loss in the transformer (=L) is such that

$$L = C + \frac{O^2}{V_2^2}R_2 + \left(\frac{N_2}{N_1}\right)^2 \frac{O^2}{V_2^2}R_1$$
$$= C + (R_2 + R_1 a^2)O^2/V_2^2.$$

Therefore the power given up to the transformer O+L and the efficiency is the fraction O/(O+L) expressed as a percentage. In this manner the efficiency can be determined with a considerable degree of accuracy in the case of large transformers without actually loading up the secondary circuit. The secondary drop, however, can only be measured by loading the transformer up to full load, and, while the primary voltage is kept constant, measuring the potential difference of the secondary terminals, and comparing it with the same difference when the transformer is not loaded.

Ageing. No test of a transformer is complete which does not comprise some investigation of the "ageing" of the core. The slow changes which take place in the hysteretic quality of iron (see ELECTROMAGNET) when heated give rise to a time-increase in iron core loss. Hence a transformer which has a core loss, say, of 300 watts when new, may, unless the iron is well chosen, have its core loss increased from 50 to 300 per cent. by a few months' use. In some cases specifications for transformers include fines and deductions from price for any such increase; but there has in this respect been great improvement in the manufacture of iron for magnetic purposes, and makers are now able to obtain supplies of good magnetic iron or steel with non-ageing qualities. It is always desirable, however, that in the case of large sub-station transformers tests should be made at intervals to discover whether the core loss has increased by ageing. If so, it may mean a very considerable increase in the cost of magnetizing power. Consider the case of a 30-kilowatt transformer connected to the mains all the year round; the normal core loss of such a transformer should be about 300 watts, and therefore, since there are 8760 hours in the year, the total annual energy dissipated in the core should be 2628 kilowatt hours. Reckoning the value of this electric energy at only one penny per unit, the core loss costs £10 19s. 0d. per annum. If the core loss becomes doubled, it means an additional annual expenditure of nearly £11. Since the cost of such a transformer would not exceed £100, it follows that it would be economical to replace it by a new one rather than continue to work it at its enhanced core loss.

Iron sheet for transformer cores is always furnished to specifications which state the maximum hysteresis loss to be allowed in it in watts per pound (avoirdupois) at a frequency of 100, and at a maximum flux-density during the cycle of 2500 C.G.S. units. When plates having a thickness t are made up into a transformer core, the total energy loss in the core due to hysteresis and eddy current loss when worked at a frequency n and a maximum flux-density during the cycle B is given by the empirical formulæ

$$T = \cdot 0032nB^{1\cdot 55}10^{-7} + \left(\frac{tnB}{10^8}\right)^2$$

or

$$T^1 = 0\cdot 88nB_1^{1\cdot 55}10^{-9} + \frac{1\cdot 4}{10^{10}}(t_1nB_1)^2,$$

where T stands for the loss per cubic centimetre, and T_1 for the same in watts per pound of iron core, B for the maximum flux-density in lines per square centimetre, and B_1 for the same in lines per square inch, t for the thickness of the plates in thousandths of an inch (mils), and t_1 for the same in inches. The hysteresis loss varies as some power near to 1·6 of the maximum flux-density during the cycle as shown by Steinmetz (see ELECTROMAGNET). Good sheet-iron for transformer cores should not have a hysteresis loss of more than 0·25 watt per pound per 100 cycles per 2500 B max.; it can be produced as low as 0·15 watt per pound, but with irons of very low hysteretic value there is always more risk of "ageing" than with the slightly higher values. The flux-density or induction in the core should never rise beyond a maximum value of 4000 to 5000, and it is preferably kept even lower. Since the hysteresis loss varies as the 1·6th power of the maximum flux-density during the cycle (B max.), the advantages of a low flux-density are evident. An excessively low flux-density increases, however, the cost of the core and the copper by increasing the size of the transformer. If the form factor (f) of the primary voltage curve is known, then the maximum value of the flux-density in the core can always be calculated from the formula

$$B = \frac{E_1}{4fnSN_1},$$

where E_1 is the R.M.S. value of the primary voltage, N_1 the primary turns, S the section of the core, and n the frequency.

Curve tracing. The study of the processes taking place in the core and circuits of a transformer have been greatly facilitated in recent years by the improvements made in methods of observing and recording the variation of periodic currents and electromotive forces. The original method, due to Joubert, was greatly improved and employed by Ryan, Bell, Duncan and Hutchinson, Fleming, Hopkinson, and Rosa and Callendar; but the most important improvement was the introduction and invention of the oscillograph by Blondel, subsequently improved by Duddell (see description in MEASURING INSTRUMENTS, ELECTRIC). This instrument enables us, as it were, to look inside a transformer, for which it, in fact, performs the same function that a steam engine indicator does for the steam cylinder.[1] Delineating in this way the curves of primary and secondary current and primary and secondary electromotive forces, we get the following result:—Whatever may be the form of the curve of primary terminal potential difference, or primary voltage, that of the secondary voltage or terminal potential difference is an almost exact copy, but displaced 180° in phase. Hence the alternating current transformer reproduces on its secondary terminals all the variations of potential on the primary, but changed in scale. The curve of primary current when the transformer is on open secondary circuit is different in form and phase, lagging behind the primary voltage curve (Fig. 6); but if the transformer is loaded up on its secondary side, then the primary current curve comes more into step with the primary voltage curve. The secondary current curve, if the secondary load is non-inductive, is in step with the secondary voltage curve (Fig. 7). These transformer diagrams yield much information as to the nature of the operations proceeding in the transformer.

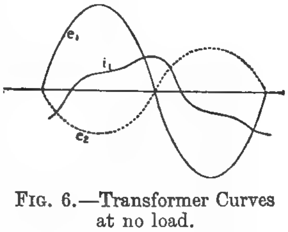

FIG. 6.—Transformer Curves at no load.

e_1, primary voltage curve; i_1, primary current curve; e_2, secondary voltage curve.

The form of the curve of primary current at no secondary load is a consequence of the hysteresis of the iron, combined with the fact that the form of the core flux-density curves of the transformer is always not far removed from a simple sine curve. If e_1 is at any moment the electromotive force, i_1 the current on the primary circuit, and b_1 is the flux-density in the core, then we have the fundamental relation $e_1 = R_1i_1 + SN_1db_1/dt$, where R_1 is the resistance of the primary, and N_1 the number of turns, and S is the cross-section of the core. In all modern closed circuit transformers the quantity R_1i_1 is very small compared with the quantity $SNdb/dt$ except at one instant during the phase, and in taking the integral of the above equation, viz., in finding the value of $\int e_1dt$, the integral of the first term on the right-hand side may be neglected in comparison with the second. Hence we have approximately $b_1 = \frac{1}{SN_1}\int e_1dt$. In other words, the value of the flux-density in the core is obtained by integrating the area of the primary voltage curve. In so doing the integration must be started from the time point through which passes the ordinate bisecting the area of the primary voltage curve. When any curve is formed such that its ordinate y is the integral of the area of another curve, viz., $y=\int y^1dx$, the first curve is always smoother and more regular in form than the second. Hence the process above described when applied to a complex periodic curve, which can by Fourier's theorem be resolved into a series of simple periodic curves, results in a relative reduction of the magnitude of the higher harmonics compared with the fundamental term, and hence a wiping out of the minor irregularities of the curve. In actual practice the curve of electromotive force of alternators can be quite sufficiently reproduced by employing three terms of the expansion, namely, the first three odd harmonics, and the resulting flux-density curve is always very nearly a simple sine curve.

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[1] For a useful list of references to published papers on alternating current curve tracing see a paper by W. D. B. Duddell, read before the British Association, Toronto, 1897; also *Electrician* (1897), vol. xxxix. p. 636; also *Handbook for the Electrical Laboratory and Testing Room* (J. A. Fleming), vol. i. p. 407.

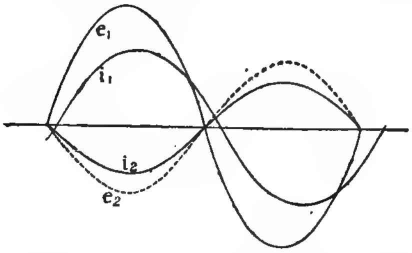

FIG. 7.—Transformer Curves at full load.

e_1, primary voltage curve; i_1, primary current curve; e_2, secondary voltage curve; i_2, secondary current curve.

We have then the following rules for predetermining the form of the current curve of the transformer at no load, assuming that the hysteresis curve (see ELECTROMAGNET) of the iron is given, set out in terms of flux-density and ampere-turns per centimetre, and also the form of the curve of primary electromotive force. Let the time base line be divided up into equal small elements. Through any selected point draw a line perpendicular to the base line. Bisect the area enclosed by the curve representing the half wave of primary electromotive force and the base line by another perpendicular. Integrate the area enclosed between the electromotive force curve and these two perpendicular lines and the base. Lastly, set up a length on the last perpendicular equal to the value of this area divided by the product of the cross-section of the core and the number of primary turns. The resulting value will be the core flux-density b at the phase instant corresponding. Look out on the hysteresis loop the same flux-density value, and corresponding to it will be found two values of the magnetizing force in ampere-turns per centimetre, one the value for increasing flux-density and one for decreasing. An inspection of the position of the point of time selected on the time line will at once show which of these to select. Divide that value of the ampere-turns per centimetre by the product of the values of the primary turns and the mean length of the magnetic circuit of the core of the transformer, and the result gives the value of the primary current of the transformer. This can be set up to scale on the perpendicular through the time instant selected. Hence, given the form of the primary electromotive force curve and that of the hysteresis loop of the iron, we can draw the curves representing the changes of flux-density in the core and that of the corresponding primary current, and thus predict the root-mean-square value of the magnetizing current of the transformer. It is therefore possible, when given the primary electromotive force curve and the hysteresis curve of the iron, to predetermine the curves depicting all the other variables of the transformer, provided that the magnetic leakage is negligible.

Elementary theory.

The elementary theory of the closed iron circuit transformer may be stated as follows:—Let N_1 N_2 be the turns on the primary and secondary circuits, R_1 and R_2 the resistances, S the section of the core, and b_1 and b_2 the co-instantaneous values of the flux-density just inside the primary and secondary windings. Then, if i_1 and i_2 and e_1 and e_2 are the primary and secondary currents and potential differences at the same instant, these quantities are connected by the two equations

$$e_1=R_1i_1+SN_1\frac{db_1}{dt},$$

$$e_2=SN_2\frac{db_2}{dt}-R_2i_2.$$

Hence, if $b_1=b_2$, and if R_1i_1 is negligible in comparison with SN_1db/dt, and $i_2=o$, that is, if the secondary circuit is open, then $e_1/e_2=N_1/N_2$, or the transformation ratio is simply the ratio of the windings. This, however, is not the case if b_1 and b_2 have not the same value; in other words, if there is magnetic leakage. If the magnetic leakage can be neglected, then the resultant magnetizing force, and therefore the iron core loss, is constant at all loads. Accordingly, the relation between the primary current (i_1), the secondary current (i_2), and the magnetizing current (i), or primary current at no load, is given by the equation $N_1i_1-N_2i_2=N_1i$. Then, writing b for the instantaneous value of the flux-density in the core, everywhere supposed to be the same, we arrive easily at the identity

$$e_1i_1=e_2i_2+(R_1i_1^2+R_2i^2)+S\frac{db}{dt}(N_1i_1-N_2i_2).$$

This equation merely expresses the fact that the power put into the transformer at any instant is equal to the power given out on the secondary side together with the power dissipated by the copper losses and the constant iron core loss.

The efficiency of a transformer at any load is the ratio of the mean value, during the period, of the product e_1i_1 to that of the product e_2i_2. The efficiency of an alternating current transformer is a function of the form of the primary electromotive force curve. Experiment has shown[1] that if a transformer is tested for efficiency on various alternators having electromotive force curves of different forms, the efficiency values found at the same secondary load are not identical, those being highest which belong to the alternator with the most peaked curve of electromotive force, that is, the curve having the largest *form factor*. This is a consequence of the fact that the hysteresis loss in the iron depends upon the manner in which the magnetization (or what here comes to the same thing, the flux-density in the core) is allowed to change. If the primary electromotive force curve has the form of a high peak, or runs up suddenly to a large maximum value, the flux-density curve will be more square-shouldered than when the voltage curve has a lower form factor. The hysteresis loss in the iron is less when the magnetization changes its sign somewhat suddenly than when it does so more gradually. In other words, a diminution in the form factor of the core flux-density curve implies a diminished hysteresis loss. The variation in core loss in transformers when tested on various forms of commercial alternator may amount to as much as 10 per cent. Hence, in recording the results of efficiency tests of alternating current transformers, it is always necessary to specify the form of the curve of primary electromotive force. The power factor of the transformer, or ratio of the true power absorption at no load, to the product of the R.M.S. values of the primary current and voltage, and also the secondary drop of the transformer, vary with the form factor of the primary voltage curve, being also both increased by increasing the form factor. Hence there is a slight advantage in working alternating current transformers off an alternator giving a rather peaked or high maximum value electromotive force curve. This, however, is disadvantageous in other ways, as it puts a greater strain upon the insulation of the transformer and cables. At one time a controversy arose as to the relative merits of closed and open magnetic circuit transformers. It was, however, shown by tests made by Fleming and by Ayrton on Swinburne's "Hedgehog" transformers, having a straight core of iron wires bristling out at each end, that for equal secondary outputs, as regards efficiency, open as compared with closed magnetic circuit transformers had no advantage, whilst, owing to the smaller power factor and consequent large R.M.S. value of the magnetizing current, the former type had many disadvantages (see Fleming, "Experimental Researches on Alternate Current Transformers," *Proc. Inst. Elec. Eng.*, 1892).

Magnetic leakage.

The discussion of the theory of the transformer is not quite so simple when magnetic leakage is taken into account. In all cases a certain proportion of the magnetic flux linked with the primary circuit is not linked with the secondary circuit, and the difference is called the magnetic leakage. This magnetic leakage constitutes a wasted flux which is non-effective in producing secondary electromotive force. It increases with the secondary current, and can be delineated by a curve on the transformer diagram in the following manner. The curves of primary and secondary electromotive force, or terminal potential difference and current, are determined experimentally, and then two curves are plotted on the same diagram which represent the variation of $(e_1-R_1i_1)/N_1$ and $(e_2+R_2i_2)/N_2$; these will represent the time differentials of the total magnetic fluxes Sb_1 and Sb_2 linked respectively with the primary and secondary circuits. The above curves are then progressively integrated, starting from the time point through which passes the ordinate bisecting the area of each half wave, and the resulting curves plotted to express by their ordinates Sb_1 and Sb_2. A curve is then plotted whose ordinates are the differences $Sb_1 - Sb_2$, and this is the curve of magnetic leakage.

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[1] See Dr G. Roessler, *Electrician*, vol. xxxvi. p. 150 (1895); Beeton, Taylor, and Barr, *Journal Inst. Elec. Eng.*, vol. xxv. p. 474; also J. A. Fleming, *Electrician*, vol. xxxiii. p. 580 (1894).

The existence of magnetic leakage can be proved experimentally by a method due to Mordey, by placing a pair of thermometers, one of mercury and the other of alcohol, in the centre of the core aperture. If there is magnetic leakage, the mercury bulb is heated not only by radiant heat, but by eddy currents set up in the mercury, and its rise is therefore greater than that of the alcohol thermometer. The leakage is also determined by observing the secondary voltage drop between full load and no load, and deducting from it the part due to copper resistance; the remainder is the drop due to leakage. Thus if V_2 is the secondary voltage on open circuit, and V_2^1 that when a current A_2 is taken out of the transformer, the leakage drop v is given by the equation

$$v = (V_2 - V_2^1) - \{R_2 A_2 + R_1 \left(\frac{N_2}{N_1}\right)^2 A_2\}.$$

The term in the large bracket expresses the drop in secondary voltage due to the copper resistance of the primary and secondary circuits.

In drawing up a specification for an alternating current transformer, it is necessary to specify that the maximum secondary drop between full and no load to be allowed shall not exceed a certain value, say 2 per cent. of the no-load secondary voltage; also that the iron core loss as a percentage of the full secondary output shall not exceed a value, say, of 1 per cent. after six months' normal work.

Transformer design.

In the design of large transformers, one of the chief points for attention is the arrangement for dissipating the heat generated in their mass by the copper and iron losses. For every watt expended in the core and circuit, a surface of 3 to 4 square inches must be allowed, so that the heat may be dissipated. In large transformers it is usual to employ some means of producing a current of air through the core to ventilate it. In these, called *air-blast transformers*, apertures are left in the core by means of which the cooling air can reach the interior portions. This air is driven through the core by a fan actuated by an alternating current motor, which does not, however, take up power to a greater extent than about one-quarter or one-tenth per cent. of the full output of the transformer, and well repays the outlay.

In some cases transformers are *oil-insulated*, that is to say, included in a cast-iron box which is filled in with a heavy insulating oil. For this purpose an oil must be selected free from mineral acids and water: it should be heated to a high temperature before use, and tested for dielectric strength by observing the voltage required to create a spark between metal balls immersed in it at a distance of 1 millimetre apart. Oils, however, are inferior in dielectric strength or spark-resisting power to solid dielectrics, such as micanite, ebonite, &c., as shown by the following table of dielectric strengths (see T. Gray, *Phys. Rev.*, 1898, p. 199).

Material.	Dielectric strength in kilowatts per centimetre.	Material.	Dielectric strength in kilowatts per centimetre.
Glass . . .	285	Lubricating oil .	83
Ebonite . .	538	Linseed oil .	67
Indiarubber .	492	Cotton-seed oil .	57
Mica . . .	2000	Air film ·02 cm. thick . .	27
Micanite . .	4000		
American linen paper paraffined	540	Air film 1·6 cm. thick . .	48

Polyphase transformers are appliances of similar construction to the single-phase transformers already described, but modified so as to enable them to transform two or more phase-related primary alternating currents into similar secondary currents. Thus, a three-phase transformer may be constructed with a core, as shown in Fig. 8. Each core leg is surrounded with a primary coil, and these are joined up either in star or delta fashion, and connected to the three or four line wires. The secondary circuits are then connected in a similar fashion to three or four secondary lines. In the case of two-phase transmission with two separate pairs of leads, single-phase transformers may be employed in each branch, but with two-phase three-wire supply, two-phase transformers must be supplied.

Phase transformers are arrangements of static or rotatory transformers intended to transform single-phase alternating currents into polyphase currents. An important system of phase transformation has been described by Mr C. F. Scott.[1] It is well known that if two alternating electromotive forces differing in phase are connected in series, the resulting electromotive force will in general differ in phase and value from either of the components. Thus, if two alternating electromotive forces differing 90° in phase, and having magnitudes in the ratio of $1 : \sqrt{3}$, are connected in series, the resulting electromotive force will have a magnitude represented by 2, and the three can be

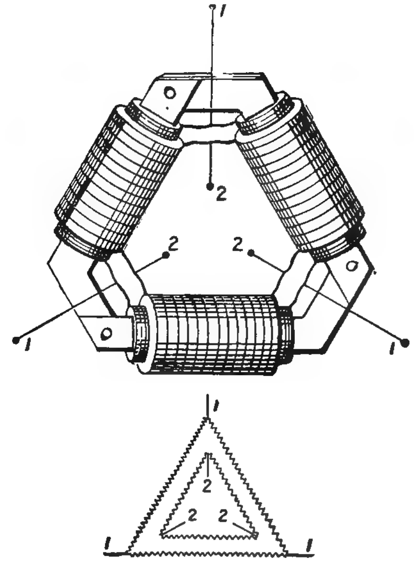

Fig. 8.—Three-phase Transformer.
1, 1, 1, primary circuits; 2, 2, 2, secondary circuits.

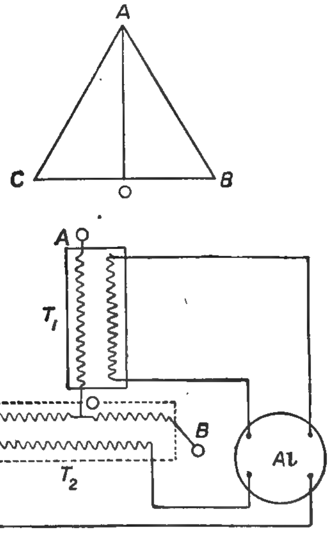

Fig. 9.—Scott's arrangement for transformation of two-phase to three-phase currents.

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[1] *Proceedings of the National Electric Light Association*, Washington, U.S.A., 1894; also *Electrician*, vol. xxxii. p. 640, 1894.

represented by the sides of a triangle which is half an equilateral triangle. If then a two-phase alternator, D, (Fig. 9) provides two-phase currents, and if the two circuits are connected, as shown, to a pair of single-phase transformers, T_1 and T_2, we can obtain three-phase alternating currents from the arrangement. The primaries of both transformers are the same. The secondary circuit of one transformer, T_2, has, say, 100 turns, and a connexion is made to its middle point O, and this is connected to the secondary of the other transformer which has 87 $(=50\sqrt{3})$ turns. From the points A, B, C we can then tap off three-phase alternating currents. The advantages of the Scott system are that we can transform two-phase alternating currents into three-phase for transmission, and then by a similar arrangement retransform back again into two-phase for use. In this manner an economy of 25 per cent. in copper is effected, for instead of four transmission lines we only have three. The system adapts itself for the transmission of currents both for power in driving three-phase motors and for working incandescent lamps. A somewhat similar system has been designed by Mr C. P. Steinmetz for producing three-phase currents from single-phase (see *Electrician*, vol. xliii. p. 236.) When a number of alternating electromotive forces are maintained in a closed circuit, the sum of all must be zero, and may be represented by the sides of a closed polygon. The fundamental principle of Mr Steinmetz's invention consists in so choosing the number of these electromotive forces that the polygon must remain stable. Thus, if three single-phase alternators are driven independently at constant speed and excitation, and if they are joined in series, then three wires led away from the junction points will provide three-phase currents to a system from which lamps and motors may be worked.

Continuous current transformers.

Reference must be made in the next place to the continuous current transformer. The conversion of a continuous current supplied, say, at 100 volts, into one having an electromotive force of 10 volts, can of course be achieved by coupling together on the same bedplate a suitable electric motor and a dynamo. The combination is called a *motor-dynamo set*, and each machine preserves its own identity and peculiarity. The same result may, however, be accomplished by winding two separate armature circuits on one iron core, and furnishing each with its own commutator. The two circuits are interlaced or wound on together. An arrangement of this kind constitutes a *rotatory transformer*, or continuous current transformer. It has the advantage of greater cheapness and efficiency, because one field magnet serves for both armature windings, and there is only one armature core and one pair of bearings; moreover, no shift or lead of the brushes is required at various loads. The armature reactions of the two circuits annul each other. Machines of this description are self-starting, and can be constructed to take in primary current at high pressures, say 1000 to 2000 volts, and yield another larger current of much lower voltage, say 100 or 150 volts, for use with electric lamps. They are used in connexion with public electric supply by continuous current in many places.

Another important class of rotatory transformer is that also called a *rotatory converter*, by means of which continuous current is translated into alternating current of one-, two-, or three-phase, or *vice versâ*. The action of such an appliance may best be understood by considering the simple case of a Gramme ring armature (see DYNAMO) having, in addition to its commutator, a pair of insulated rings on its shaft connected with opposite ends of the armature winding (Fig. 10). If such a ring is placed in a bipole field magnet, and if a pair of brushes make contact with the commutator C and another pair with the two rings called slip rings, S_1 S_2, and if continuous current at a constant voltage is supplied to the commutator side, then the armature will begin to revolve in the field, and from the brushes in contact with the slip rings we can draw off an alternating current. This reaches its maximum value when the points of contact of the rings with the armature circuit pass the axis of commutation, or line at right angles to the direction of the magnetic field, for it has at this moment a value which is double the steady value of the continuous current being poured into the armature. The maximum value of the electromotive force creating this alternating current is nearly equal to the electromotive force on the continuous current side. Hence if A is the maximum value of the continuous current put into the armature and V is the value of the brush potential difference on the continuous current side, then 2A is the maximum value of the outcoming alternating current and V is the maximum value of its voltage. Hence $2AV/2 = AV$ is the maximum value of the outcoming alternating current power, and if we neglect the loss in the armature for the moment, the power given out is equal to the power put in. Hence, assuming a simple harmonic law of variation, the effective value of the alternating current voltage is $V/\sqrt{2}$, and that of the alternating current is $2A\sqrt{2}$. This conclusion follows at once from the fact that the mean value of the square of a sine function is half its maximum value, and hence the R.M.S. value is $1/\sqrt{2}$ times the maximum value. The outcoming alternating current has its zero value at the instant when the ends of the diameter of the axis to which the rings are connected are in the direction of the magnetic field of the transformer. Hence the power output on the alternating current side varies from a maximum value AV to zero. The rotatory transformer thus absorbs continuous current power and emits it in a periodic form; accordingly, there is a continual storage and emission of energy by the armature, and therefore its kinetic energy is periodically varying during the phase. The armature is also creating a back-electromotive force which acts at some instants against the voltage driving the current into the armature and at others is creating an electromotive force that assists the external impressed voltage in driving a current through the alternating current side. If we put on another pair of insulated rings and connect them to points of the insulated diameter at right angles to the points of connexion of the first pair of rings, we can draw off another alternating current, the phase of which differs 90 degrees from that of the first. Similarly, if we provide three rings connected to points removed 120 degrees apart on the armature circuit, we can tap off a three-phase alternating current.

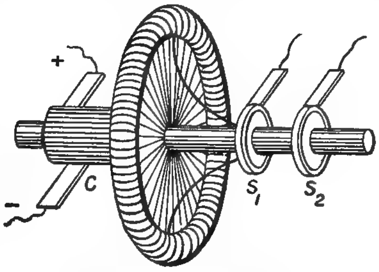

Fig. 10.—Converter, continuous two-phase.

Returning to the case of the single-phase rotatory transformer, we may notice that at the instant when the outcoming alternating current is zero the armature is wholly engaged in absorbing power and is acting entirely as a motor. When the alternating current is a maximum, the armature on the other hand is acting as a generator and adds current to the current put into it. The ratio between the potential difference of the brushes on the continuous current side and the root-mean-square or effective value of the voltage between any pair of rings on the alternating current side is called the transformation ratio of the converter.

The following table, taken from a paper upon rotatory converters by Professor S. P. Thompson (*Proc. Inst. Elec. Eng.*, November 1898), gives the voltage ratio or conversion ratio in the case of various forms of rotatory transformer :—

Number of slip rings.	Angle between points of connexions to armatures.	Type of current generated.	Voltage ratio.	Effective voltage on alternating current side as percentage of voltage on continuous current side.
2	180 deg.	Single-phase	$\sqrt{2} : 1$	70·71
3	120 ,,	Three-phase	$2\sqrt{2} : \sqrt{3}$	61·23
4	90 ,,	Two-phase	$\sqrt{2} : 1$	70·71
4	90 ,,	Four-phase	$2 : 1$	50
6	60 ,,	Three-phase	$3\sqrt{3} : \sqrt{3}$	61·23
6	60 ,,	Six-phase	$2\sqrt{2} : 1$	35·35

Neglecting the energy losses in the armature, and assuming that the continuous current side of the transformer is supplied with 100 amperes, the following table, also taken from a paper by Professor S. P. Thompson, shows the effective value of the current on the alternating side put out into each line :—

Number of slip rings.	Angle between points of connexion to armature.	Type of current generated.	Effective current put out on each line in amperes.
2	180 deg.	Single-phase	141·4
3	120 ,,	Three-phase	94·3
4	90 ,,	Two-phase	70·7
6	60 ,,	Six-phase	47·2

It is obvious that the same results of conversion can be obtained by coupling together two separate machines on the same shaft; thus we might obtain a single-phase alternating current from a continuous current by coupling together mechanically a continuous current motor and a single-phase alternator. Such a combination is generally called a *motor-dynamo.* In this case there are two field magnets and two separate armatures, and the hysteresis eddy current and copper losses are all in duplicate. If, however, the same armature winding is made to serve both purposes, the resulting machine is called a *rotatory* or *rotary converter.* In the former combination the brushes of the continuous current part require to be set with the usual lead or lag according as that part is generator or motor, but in the latter the armature reactions nearly annul each other, and lead or lag is no longer necessary. The fact was pointed out by S. P. Thompson, in connexion with continuous current transformers (*Phil. Mag.*, August 1888). One objection to the rotatory converter arrangement, as above described, is the rather awkward fractional values of the conversion ratio. An ingenious modification of the single armature winding for obviating this difficulty has been described by Heldt (*Electrical World*, vol. xxviii., 1896).

Rectifiers.

Finally, a brief allusion must be made to *rectifiers,* which are devices for transforming an alternating (generally single-phase) current into a continuous but pulsatory current. They may shortly be described as appliances for separating out each alternate current flux in an alternating current. An immense number of more or less imperfect methods of doing this have been proposed, but we have merely space for allusion to two which may be called respectively the mechanical and the electrolytic methods. Of the first class a good example is the Ferranti rectifier (Fig. 11). This consists of a synchronous alternating current motor which is started up and driven in step with the alternator supplying the current. The motor drives a commutator of insulated segments, each alternate segment being connected to two insulated rings, against which press a pair of brushes. Another pair of brushes, so adjusted as to be in contact simultaneously with a pair of adjacent commutator segments, are in connexion with the alternator supplying the current to be commutated. The insulated rings are in connexion with the external circuit. It will easily be seen that when the commutator revolves at proper speed the currents delivered from the insulated rings are unidirectional. The Ferranti rectifier is much employed for rectifying alternating current for arc lighting purposes. With this object it is associated with a constant current transformer which converts alternating current supplied at constant potential to one supplied at constant current. This is achieved by taking advantage of the repulsive force existing between the primary and secondary circuits of a transformer. These are wound separately, and so balanced that any increase in the current presses them away from each other and so reduces the secondary current to normal value. An appliance of the above description is useful for rectifying currents up to 10 or 15 amperes, but with larger currents it becomes troublesome, owing to the excessive sparking at the contacts.

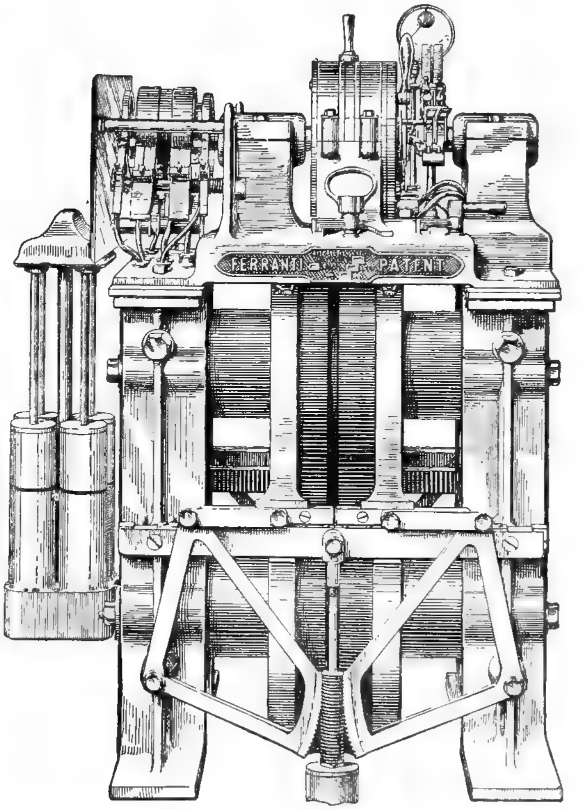

Fig. 11.—Ferranti Rectifier.

The electrochemical rectifier is based upon a phenomenon originally discovered by Buff in 1857 (*Lieb. Ann.*, lii. p. 296, 1857), and rediscovered by Ducretet in 1874 (*Comptes Rendus*, lxxx. p. 280, 1874). If plates of aluminium and carbon are placed in an electrolyte, say a solution of alum or dilute acids which yield oxygen on electrolysis, it is found that a current can be sent through the liquid from the carbon to the aluminium, but that great counter-electromotive force is created to a current in the opposite direction. Grätz and Pollak (*Elektrotechnische Zeitschrift*, 25, p. 359, 1897), taking advantage of this fact, have constructed a rectifying arrangement by arranging two series of carbon-aluminium (CAl) cells with alum or hydro-potassic phosphate solution as electrolyte. In one set the order of the plates is (CAl), (CAl), &c., and in the other series (AlC), (AlC), counting from the same end. These series being connected in parallel, it follows that if an alternating current is sent through the parallel series all the currents in one direction pass through one battery and all those in the opposite direction through the other. Thus the constituents of the alternating current are separated out. By using very large cells so as to reduce the internal resistance, an efficiency of 95 per cent. is said to be obtained. The first application of the unilateral conductivity of aluminium-carbon cells for the rectification of alternating currents was probably made by Hutin and Leblanc (*Études sur les courants alternatifs et leurs applications industrielles*, part ii. chap. x. p. 135; also French Patent No. 215945, 1891).

Theory of electrolytic rectifier.

The theory of the electrolytic rectifier has engaged the attention of a great many investigators, and although some progress has been made towards the elucidation of its action and in its application in electrotechnics, as illustrated by the numerous patents issued during the last few years, there are many points in its operation which have as yet been imperfectly explained. The action of the aluminium electrolytic rectifier, consisting as it does of an aluminium plate and a lead or carbon plate placed in an aqueous electrolyte, is to oppose a great obstruction to a current passing out of the aluminium plate, but little or no obstruction to the current passing into the aluminium plate, especially if the aluminium has been subjected to a previous treatment called *formation*. This unilateral conductivity is dependent on a certain voltage or potential difference between the plates not being exceeded, but within these limits a plate of carbon and aluminium placed in a solution, say of hydro-sodic phosphate, acts as an electrical *valve*, allowing current to pass in one direction but not in another. An examination of the aluminium plate after it has been so used shows that its appearance has changed and that its surface is covered by a thin film, the thickness of which varies with the electrolyte and the time of formation. After a certain period of use this film is seen as a grey, dull coating traversed by dark lines. It is impossible that the unilateral conductivity can be due to a true electrolytic polarization, because we know of no polarization of this latter kind which exceeds three volts, and the film can be made to resist the flow of a current under an electromotive force of 140 to 200 volts. The resistance of this film has been measured and found to be very high, so high as to be practically an insulation. Light was thrown upon the subject by F. Kohlrausch's discovery of the polarization capacity of metallic electrodes, and this discovery was applied to develop the theory of the aluminium cell by Streintz (1888), Scott (1899), and others.

This theory was expounded by Dr K. Norden in an article on the electrolytic rectifier (see the *Electrician*, vol. xlviii. p. 107). According to this view, the deposit covering the aluminium electrode forms the dielectric of a condenser. One plate of the condenser is formed by the aluminium plate and the other by an opposite layer of electrically-charged ions in the electrolyte. The dielectric film on the aluminium having been formed, the electromotive force of the circuit then charges the resulting condenser to the value of its own voltage, but immediately the impressed electromotive force is removed this condenser discharges itself. This condenser theory receives support from the behaviour of the aluminium cell when placed in the circuit of an alternating current dynamo, for it is found that in these circumstances the current through the cell is in advance in phase of the difference of potential. The question then arises, What is the nature of this insulating film? The first discoverer of the phenomenon (Buff) considered it to consist of silicon. Later Professor Beetz disproved this by experiment, and, with many others, assumed that a sub-oxide of aluminium was formed; but this has never been demonstrated in a satisfactory manner. By forming a sufficient quantity of the film Dr K. Norden was able to obtain sufficient of the material to make a chemical analysis, and this revealed the fact that it consists of normal aluminium hydroxide, $Al_2(OH)_6$.

According to the facts above stated, one wave of the alternating current produces the insulating film by converting the surface of the aluminium into hydroxide, practically, therefore, blocking its own path very quickly by the creation of this film. If, then, the electromotive force reverses its direction, the current immediately flows. According to Dr Norden, the rapid removal of the insulating film is due to the action of the electrolyte corroding or dissolving the weak points in the coating and thus breaking down its insulating power. The insulating film is therefore a conductor in one direction, but when the current is reversed and flows out of the aluminium plate, the insulating film is renewed and is continually being repaired and kept in order. Thus different electrolytes yield aluminium valves having very different efficiencies.

Rectifying cells have been made by Pollak which will bear a voltage of over 140 volts, and which are said to have an efficiency of 75 per cent. The plates, however, must be removed when not in use, otherwise the film of hydroxide is destroyed by the electrolyte. One great practical difficulty in connexion with the aluminium rectifier is the tendency to heat in working, and as the temperature cannot be allowed to exceed 104° F. without producing ill effects, it is necessary to employ a cell many times larger than the plate it contains in order that there may be a sufficient amount of liquid to keep down the temperature. In any event, after 500 to 800 hours' working the aluminium plate becomes furrowed and in the end falls to pieces. These difficulties have not so far been overcome as to make the aluminium valve of any great practical utility. At its first introduction it was hailed as a practical means of obtaining direct currents from alternating currents for the purpose of charging accumulators and doing other chemical work, but although it has been employed in this manner to a limited extent, considerable improvements must be made before it can realize all the expectations which were once formed concerning it.

The historical development of the discovery of this unilateral conductivity of an electrolytic cell with an aluminium electrode is as follows. The effect was first noticed by Buff in 1857, but was not applied technically until 1874, when Ducretet employed it in telegraphy. Beret in 1877 and Streintz in 1887 discussed the theory of the cell and sought for an explanation. In 1891 Hutin and Leblanc, in their study of alternating currents, showed its uses in rectifying an alternating current. Pollak and Grätz laboured to give it a practically useful form. Pollak took out patents in 1895, and made a communication to the Academy of Sciences in Paris in June 1897; and Grätz presented a memoir at a meeting of the German Association of Electrochemists in Munich in 1897. M. Blondin has summarized all the work so far done on the aluminium rectifier in two articles in *L'Éclairage Électrique*, vol. xiv. (1898) p. 293, and vol. xxviii. (1901) p. 117. The choice of an electrolyte is of great importance. Buff, Ducretet, and Grätz employed dilute sulphuric acid, and the greatest difference of potential which could then be applied to the cell without breaking down its insulation in one direction was 20 volts. Pollak in 1896 found that when aqueous solutions of alkaline salts were used, and when the aluminium plate was subjected to a preliminary formation, the back electromotive force or what is equivalent to it could be raised to 140 or 200 volts. Pollak found that the best results were given by the use of phosphate of potassium or sodium. It appears, therefore, that the ions of K or Na effect the breaking down of the film of aluminium hydroxide more quickly than the ion of hydrogen. The practical form of aluminium rectifier, according to Pollak, consists of plates of thick aluminium and lead placed in a large deep glass vessel filled with a solution of hydro-potassic phosphate.

Induction coils.

The ordinary induction or spark coil may be said to perform the operation of converting an intermittent low-tension continuous current into an intermittent high-tension one. An impetus has been given of late to the manufacture of large spark coils by the demand for them in Röntgen ray and wireless telegraph work. A modern induction coil for the production of long sparks is constructed as follows:—The primary coil consists of two or more layers of insulated wire wound on an iron core formed of a bundle of well annealed iron wire. This coil and core are entirely enclosed in a thick ebonite tube, leaving openings only for the entrance and exit of the primary coil and for a soft iron cylinder which is in magnetic connexion with the iron core. Over this tube is slipped a series of flat coils generally made of shellacked paper, the wire winding being in two vertical layers separated by an insulating disc. In this way the two ends of the coil are brought to the outside. These flat coils are electrically joined up so as to make one continuous bobbin of wire in which the insulated wire is so disposed that parts of the wire near to each other are not very different in potential. This secondary winding is likewise enclosed in an ebonite tube. The coil is completed by a contact breaker and condenser. The former is an automatic vibrator on the principle of the vibrating hammer of an electric bell, which is actuated by the magnetism of the core and interrupts the circuit of the primary coil. The condenser consists of interleaved sheets of tin-foil and paraffined paper, the alternate sheets of foil being connected together. This condenser is connected across the break to the two platinum points between which the rapid interruption of the primary circuit takes place. The function of the condenser is to assist in rapidly demagnetizing the core, and in destroying the electric spark between these points as they separate. When the contact points are together the condenser is discharged but the core is magnetized. When the contact points separate the condenser is charged through the primary coil, and the charge takes place by a series of electrical oscillations which rapidly remove the remanent magnetism of the core. As the electromotive force in the secondary circuit depends on the rate at which the flux of magnetic induction is removed from the core, the condenser has a remarkable effect in increasing the secondary electromotive force at the break of the primary current. Accordingly the electromotive forces set up in the secondary circuit at *break* and at *make* of the primary circuit are very different in value, the former being enormously greater than the latter. Hence, when the secondary circuit is interrupted by a spark gap and the primary current is intermitted, the secondary discharges are also intermittent and unidirectional, being those which correspond with the break of the primary current. Lord Rayleigh has, however, shown that if the primary circuit is interrupted with great rapidity, as by severing it with a bullet, the secondary spark of the coil may be even longer without the condenser across the break gap. The E.M.F. of the secondary is then greatly increased (see *Phil. Mag.*, December 1901, p. 581).

The manufacture of very large induction coils is a matter requiring great care and experience. The reader may be referred for details to a book by Mr A. T. Hare on *The Construction of Large Induction Coils* (London, 1900). Also for details of many large historical induction coils see *The Alternate Current Transformer* (Fleming, vol. ii.). If the induction coil has a condenser, such as a Leyden jar, connected across its secondary terminals, the sparks produced become much shorter and brighter, but more intermittent and noisier. The current flowing from the secondary circuit charges the condenser, and hence at each discharge a much larger quantity of electricity passes than when the condenser is not used. The reason the spark lengths are so much reduced is as follows:—To charge a condenser of capacity C to a voltage V through a resistance R, the electromotive force must be applied steadily for a period at least equal to ten times the value of the product C R, where R is measured in megohms and C in microfarads. If the condenser is a Leyden jar having, say, 1 square foot of contact surface, the glass being about 1/10 of an inch thick, then the capacity will be approximately 1/400 of a microfarad. The resistance of the secondary circuit of a 6-inch spark coil is usually about 10,000 ohms, or 1/100 of a megohm. Hence, the product C R, or the time constant of the jar circuit, is 1/4000 of a second. Now the vibrating break of the induction coil may make from 20 to 50 oscillations per second, and the time during which the secondary electromotive force in the coil has approximately its maximum value, or value corresponding to the ordinary spark length, is probably less than 1/100 of the time period of the break. Accordingly, the electromotive force of the coil is applied to the jar for a time too short to charge it up to the potential which corresponds to the full ordinary spark length (6 inches) of the coil.

The oscillatory discharges produced by discharging a large condenser through a low resistance can be transformed in potential, and we can construct an oscillation transformer. This is usually called a Tesla coil, but Mr Tesla was not by any means the first person to transform by induction the oscillatory discharges of a Leyden jar. A length of copper wire is coiled on an insulating cylinder in one layer, the turns being preferably separated by a silk cord. Over this is placed another cylinder of glass or ebonite, and on this second cylinder another coil of fine wire is wound in one layer. If the primary coil of the above arrangement is connected in series with a Leyden jar or battery of jars, and the two together connected across the secondary terminals of an ordinary induction coil, the spark balls of which are separated by a few millimetres, then loud rattling discharges of the jar take place when the induction coil is worked. These discharges are oscillatory, and consist of groups of rapidly alternating currents flowing through the primary circuit of the oscillation transformer; these oscillations are transformed up in potential by the secondary circuit, and from these latter terminals we can draw off a secondary discharge of higher potential and much higher frequency than the ordinary secondary spark of the induction coil (see Telegraphy: *Wireless*). These high potential, high frequency discharges produce many interesting effects, and can be passed through the human body without producing painful shock. The secondary terminals of the oscillation transformer produce powerful brush discharges in air when separated beyond their sparking distance, and also very brilliant discharges through highly exhausted vacuum tubes.

The reader desirous of additional information is referred to the following works and original papers:—J. A. Fleming. *The Alternate Current Transformer*, 3rd edition. London, 1901; "Experimental Researches on Alternate Current Transformers," *Proc. Inst. Elec. Eng.*, 1893; "Alternate Current Transformers," *Cantor Lectures*, Society of Arts, 1896; "Electric Oscillations and Electric Waves," *Cantor Lectures*, Society of Arts, 1900–1901; *Handbook for the Electrical Laboratory and Testing Room.* London, 1901.—S. P. Thompson. *Dynamo Electric Machinery.* London, 1896; *Polyphase Electric Currents and Alternate Current Motors*, 2nd edition. London, 1900; "Rotatory Converters," *Proc. Inst. Elec. Eng.*, 1898.—G. Kapp. *The Electric Transmission of Energy and its Transformation.* London, 1895; *Alternating Currents of Electricity.* London, 1896; *Transformers for Single and Multiphase Currents.* London, 1896.—C. C. Hawkins and F. Wallis. *The Dynamo*, 2nd edition. London, 1896.—W. E. Goldsborough. "Transformer Tests," *Proc. Nat. Electric Light Association, U.S.A.*, 1899.—C. P. Steinmetz. *The Theory and Calculation of Alternating Current Phenomena*, 2nd edition. New York, 1899.—A. Still. *Alternating Currents of Electricity and the Theory of Transformers.*—D. C. Jackson. *Text-Book on Electromagnetism*, vol. ii. London, 1896.—Loppe. *Alternate Currents in Practice.*—Martin. *Inventions, Researches, and Writings of Nikola Tesla*, New York, 1894. (J. A. F.)

Transkei. See Kaffraria.

TRANSVAAL COLONY.

I. Geography and Statistics.

Transvaal Colony, formerly the South African Republic, Africa, lies between 22° and 28° S. and 25° and 32° E. The boundaries laid down by the Convention of 27th February 1884 were modified by the Conventions of 1894 and 1897 relating to the district of Vryheid and the territory of Swazieland, and in 1902 as the result of the extension of Natal (*q.v.*). As thus delimited the Transvaal presents the outlines of an irregular oblong disposed in the direction from south-west to north-east, and truncated in the north by the east to west direction of the Limpopo, which forms the frontier river towards Bechuanaland and southern Rhodesia as far as the Limvubu confluence. The southern boundary coincides with the Vaal and its Klip headstream as far as Natal, where it follows the Drakensberg range to the head-waters of the Pongola river, which it follows to the border of the Utrecht district, while the Lobombo range forms the dividing line towards Zululand and Portuguese territory northwards to the Limvubu confluence. From this point to the lower Vaal at Platberg there was, before the alteration of the boundary, an extreme length of about 500 miles, and a breadth of nearly 400 miles from the western border near Mafeking to Komati Poort, where the Delagoa Bay railway enters the Transvaal from Portuguese territory. Within these limits there is a total area of about 126,000 square miles, and a population approximately estimated in 1898 at 1,094,000, of whom about 245,000 were whites, mostly Boers and British, and 748,000 natives of Bantu (Zulu and Bechuana) stock and speech. Some 8000 whites and 50,000 natives were added by the 1902 rectification of the frontier.

Mineral Wealth.—The Transvaal is one of the most highly mineralized regions in the world. The gold-bearing reefs are widely distributed over the whole land, ranging from Lydenburg, De Kaap, Komati, Barberton, and Swazieland in the extreme east to the Marico district in the extreme west, and from the Zoutpansberg and Murchison Hills in the north to Rustenburg, Krugersdorp, Schoonspruit, Rooderand, and especially the Witwatersrand ("The Rand," with chief centre Johannesburg) in the south. Although many of the reefs in these districts have scarcely yet been tapped, the annual output rose from £2,924,000 in 1891, from which year date the first official returns, to £8,570,000 in 1895 and no less than £16,044,000 in 1898, the year before the outbreak of hostilities. The total yield from 1884 to 1900 probably exceeded £80,000,000, while with the institution of orderly government it is expected that at least 20,000,000 tons of quartz will be annually dealt with on the Rand alone. But the mineral resources of the Transvaal are by no means confined to gold. Diamonds are found in the Pretoria district and other places, and in 1898 the product exceeded 22,000 carats, valued at nearly £44,000. Extensive deposits of good coal, including some very thick seams of steam coal, occur near the Rand and other goldfields, and although mining operations are yet in their infancy, the output rose from 1,437,000 tons in 1896 to 1,600,000 in 1897 and 1,907,000 in 1898. It appears that the rich Carboniferous beds of the Newcastle district in northern Natal extend with little interruption northwards far into the Vaal basin, and are already used by Boer farmers for domestic purposes. Like that of Newcastle, the Transvaal coal burns with a clear flame and leaves little or no ash. Amongst other mineral treasures are lead, sulphur, cobalt, saltpetre, iron, and copper. The last two are widely distributed, and the Yzerberg, "Iron Mountain," near Marabastad, which is now reached by rail from Pretoria, consists of a huge mass of exceedingly rich iron ore, which has been smelted and wrought into divers implements by the natives from the remotest times.

Agricultural Resources.—The agricultural prospects of the country, including both tillage and stock-breeding, are also much brighter than is commonly supposed. Husbandry, however, is still in a very backward state, and in 1898 not more than 50,000 acres altogether had been brought under cultivation. There are no doubt over 12,000 farms, averaging about 6000 acres each, but the Boers are essentially stock-breeders, and cultivate very little land, not enough even for the local demand, so that cereals and other produce have to be imported in considerable quantities—corn, vegetables, preserves, &c., to the value of £1,200,000 in 1898. All this and much more might be grown several times over in the country itself, where the Potchefstroom and Pretoria districts are specially suited for cereals, fruits, tobacco, the vine, and vegetables; Rustenburg, with its sub-tropical climate, for cereals, ground-nuts, tobacco, coffee, cane-sugar, bananas, and oranges; Lydenburg, for cereals, tobacco, sugar, and coffee; and all or most of these crops might also be easily raised in the Marico, Middelburg, Waterberg, and several other districts. The great drawbacks are the tsetse-fly, which, however, is mainly confined to the swampy tracts in the middle and lower Limpopo valley; horse-sickness, which is being dealt with apparently with some success; the locust plague, which might be abated by such measures as those adopted in Cyprus and Algeria; lastly, the deficient rainfall, which it is proposed to neutralize to some extent by regulating the discharge of the Vaal and Limpopo affluents, and husbanding the flood-waters which now run waste. By these and other irrigation works it is calculated that, as in Cape Colony, many hundred thousand acres of land now arid might be brought under cultivation.

Trade, &c.—No accurate returns are available for the exports, which consist chiefly of gold, wool, cattle, hides, grain, ostrich feathers, ivory, and minerals. The total exports rose from 8500 tons in 1895 to 51,400 tons in 1898, and of this quantity (value not stated) 47,645 tons represented such local produce as coal (38,800 tons), wool (2540), hides and skins (2100), ores (1920). The imports advanced from £6,440,000 in 1894 and £9,816,000 in 1895, to £14,088,000 in 1896; but owing to the political unrest fell to £13,564,000 in 1897 and £10,633,000 in 1898, and in 1901 to £3,670,000, but this was exclusive of Government and military supplies. They consist chiefly of machinery, cottons, clothing, chemicals, cutlery, provisions, haberdashery, and furniture. In 1898, of the total imports £6,332,000 came from Europe, £1,159,000 from Cape Colony, £1,203,000 from Natal, £537,000 from the Orange Free State, £537,000 from Lourenço Marquez, and £481,500 from America and other countries. The revenue rose from £1,703,000 in 1893 to £4,807,000 in 1896, and then fell to £4,480,000 in 1897 and £3,984,000 in 1898, the expenditure being for the corresponding years £1,302,000, £4,671,000, £4,394,000, and £3,971,000. The communications are still in a backward state, the roads especially being generally very rough. But railway enterprise has made some progress since the development of the gold-mining industry. In 1898 there was a total length of 774 miles open, connecting Pretoria with the Cape through Bloemfontein, with Durban through Standerton, Newcastle, and Ladysmith, with Delagoa Bay through Middelburg and Komati Poort, with Johannesburg, Pietersburg, and other places by branch lines ramifying from the capital. In the same year 270 miles were in progress and 250 projected.

II. History.

Earlier years.

From the time of the Great Trek out of Cape Colony to lands north of the Vaal river in 1833–37, down to the Sand River Convention in 1852, the history of the Transvaal Boers was one of continued strife with the natives. The Apprentice Law of 1856 practically legalized slavery, and the opposition which this measure excited in the minds of many Englishmen was one of the most fertile causes of irritation between the Boers and the British authorities. Apart from the Trek Boers' attitude towards the natives, their history in the Transvaal until 1877 shows that they carried with them to their new home a spirit hostile not merely, as has been represented by many writers, to British rule, but to civilized rule in any shape or form. They and their fathers had, while still resident in the frontier districts of the colony, rebelled first of all against the government of the Dutch East India Company, and at a later date against the British Government, because they resented in both cases any interference with their relations either to the natives or to one another. Governments within the Transvaal appointed by themselves, as a review of their history will show, fared no better, but even worse than those from the rule of which the Boers had withdrawn.

Potchefstroom assembly, 1856.

In 1856 a series of public meetings among the Boers, summoned by Commandant-General M. W. Pretorius was held at different districts in the Transvaal for the purpose of discussing and deciding whether the time had not arrived for abolishing the system of petty district governments which had hitherto existed. The result was that a representative assembly of delegates was elected, empowered to draft a constitution. In December this assembly met at Potchefstroom, and for three weeks was engaged in modelling the constitution of the country. The new constitution made provision for a Volksraad to which members were to be elected by the people for a period of two years, and in which the legislative function was vested. The administrative authority was to be vested in a President, aided by an executive council. It was stipulated that members both of assembly and council should be members of the Dutch Reformed Church. In reviewing an incident so important in the history of the Transvaal as the appointment of the Potchefstroom assembly, it is of interest to note the gist of the complaint among the Boers which led to this revolution in the government of the country as it had previously existed. In his *History of South Africa*, Theal says, “The community of Lydenburg” (the oldest district government) “was accused of attempting to domineer over the whole country, without any other right to pre-eminence than that of being composed of the earliest inhabitants, a right which it had forfeited by its opposition to the general weal.” In later years this complaint was precisely that of the Uitlanders at Johannesburg. In order to endeavour to conciliate one of these district governments at Zoutpansberg, the new-born assembly at Potchefstroom appointed Mr Schoeman, a commandant of the Zoutpansberg district, commandant-general. This offer was, however, declined by Schoeman, and both Zoutpansberg and Lydenburg indignantly repudiated the new assembly and its constitution. The executive council, which had been appointed by the Potchefstroom assembly with Pretorius as President, now took up a bolder attitude: they deposed Schoeman from all authority, declared Zoutpansberg in a state of blockade, and denounced Boers of the two northern districts as rebels.

Presidency of Pretorius.

In order further to strengthen their position, Pretorius and his party also endeavoured to bring about a union with the Free State. With this intention they sent emissaries to the Free State Government to make overtures on the subject. These overtures were rejected. Nothing daunted, Pretorius determined to win by force what he had failed to obtain by persuasion. There was a certain number of Free State Boers prepared to accede to the proposals of Pretorius, and relying on their aid, Pretorius entered into an intrigue to overthrow the President of the Free State, Boshof, and his Government. Pretorius placed himself at the head of a commando and crossed the Vaal, being joined by a certain number of Free State burghers. On learning of the invasion, President Boshof immediately took energetic measures to defend his country. He proclaimed martial law, called out his burghers, and marched towards Kroonstad to meet the invaders. At the same time Boshof received an offer from the outraged and deposed General Schoeman of Zoutpansberg to gather a force and come to his assistance. The forces of Pretorius and Boshof at length faced each other on opposite banks of the Rhenoster river. Threatened from the north as well as the south, Pretorius now recognized that he was engaged in a dangerous enterprise. He had as his lieutenant on this occasion no less a personage than Mr Stephanus Johannes Paulus Kruger, and to Mr Kruger was entrusted the task of bearing a flag of truce to the Free Staters, with an expression of hope that a peaceful settlement might be arrived at. A treaty, containing an apology from Pretorius, was agreed upon, and the invading force withdrew. By the year 1860, the foregoing events notwithstanding, Zoutpansberg and Lydenburg had become incorporated with the republic. Schoeman had accepted the post of commandant-general, and Pretoria was made the seat of Government and capital of the country. The state was now apparently united, and the Government founded on the will of the people. The Separatist Church of Holland in the year 1858 sent out a young expositor of its doctrines named Postma. This minister settled at Rustenburg and founded the first branch of the the Dopper sect, a sect which has since become famous in the Transvaal, as well as in the Free State and even Cape Colony. The tenets of the Separatist Reformed (or Dopper) Church do not call for close analysis here. It will be sufficient to say that they approached somewhat those held by the Scottish Covenanters. They raised strong objection to the singing of hymns, other than paraphrases of Scripture, as part of the church service. Of this sect Paul Kruger, who resided near Rustenburg, became an adherent.

Internal dissensions.

In 1860 a curious sequel to the invasion of the Free State by Pretorius occurred. Pretorius, while still President of the Transvaal, was elected President of the Free State. He thereupon obtained six months' leave of absence and repaired to Bloemfontein, in the hope of peacefully bringing about a union between the two republics. He had no sooner left the Transvaal than the old Lydenburg party, headed by Potgieter, landdrost of Lydenburg, protested that the union would be much more beneficial to the Free State than to the people of Lydenburg, and followed this up with the contention that it was illegal for any one to be President of the South African Republic and the Free State at the same time. Pretorius, apparently in disgust at the whole situation, resigned. Mr J. H. Grobelaar, who had been appointed President during the temporary absence of Pretorius, was requested to remain in office. The immediate followers of Pretorius now became extremely incensed at the action of the Lydenburg party, and a mass meeting was held at Potchefstroom, where it was resolved that: (*a*) the Volksraad no longer enjoyed its confidence; (*b*) that Pretorius should remain President of the South African Republic, and have a year's leave of absence to bring about union with the Free State; (*c*) that Schoeman should act as President during the absence of Pretorius; (*d*) that before the return of Pretorius to resume his duties a new Volksraad should be elected.

In view of later events, the anarchy which has existed among the Trek Boers, north of the Vaal, from the earliest times demands the closest study, in order that the true character and aspirations of the Boers may be understood. The action of the Volksraad, incited by the jealousies of the old district governments and their followers in Lydenburg and Zoutpansberg, was antagonistic to anything in the shape of a patriotic and truly republican government. If at this stage of their existence the real ambition of the Transvaal Boers was to found a strong and compact republican state, their conduct in opposing a scheme of union with the Free State was foolish to a degree. The events of the year 1860, as well as of all the years that followed down to British annexation in 1877, show that licence rather than liberty, a narrow spirit of faction rather than patriotism, were the dominant instincts of the Boer. Had the fusion of the two little republics which Pretorius sought to bring about, and from which apparently the Free State was not averse, actually been accomplished in 1860, it is more than probable that a republican state on liberal lines, with some prospect of permanence and stability, might have been formed. But a narrow, distrustful, grasping policy on the part of whatever faction might be dominant at the time invariably prevented the state from acquiring stability and security at any stage of its history. On no less than three occasions, unique opportunities were afforded for consolidating and establishing this republic. The first of these occasions we have dealt with. The second occurred in 1887, and the third in 1895. Of these opportunities no advantage was taken.

The complications that ensued on the action of the Pretorius party subsequent to his resignation were interminable and complicated. Some of the new party were arraigned for treason and fined; and for several months there were once more two acting Presidents and two rival governments within the Transvaal. At length Commandant Paul Kruger called out the burghers of his district and entered into the strife. Having driven Schoeman and his followers from Pretoria, Kruger invaded Potchefstroom, which, after a skirmish in which three men were killed and seven wounded, fell into his hands. He then pursued Schoeman, who doubled on his opponent and entered Potchefstroom. At this stage Pretorius intervened. A temporary peace was no sooner secured than Commandant Jan Viljoen rose in revolt and engaged Kruger's forces. At length in 1864, after a series of intestine quarrels, a conference was held lasting six days, followed by a new election for President, and once more Pretorius was called upon to fill that office. Kruger was appointed commandant-general.

Civil strife for a time was now at an end, but the injuries inflicted on the state were deep and lasting. The public funds were exhausted; taxes, always an abomination to the Transvaal Boer, were not only in arrear, but impossible to collect; and the natives on the borders of the country and in the mountains of the north, taking advantage of the anarchy that prevailed, had thrown off all allegiance to the state. The prestige of the country was practically gone, not only with the world outside, but, what was of still more moment, with her neighbour the Free State, which felt that a federation with the Transvaal, which the Free State once had sought but which it now definitely foreswore, was an evil avoided and not an advantage lost. A charge frequently laid at the door of the Boers, at that time and since, was that of enslaving the black races. It is true that laws prohibiting slavery were in existence, but the Boer who periodically took up arms against his own appointed Government was not likely to be, nor was he, restrained by laws. Natives were openly transferred from one Boer to another, and the fact that they were described as apprentices by the farmers did not in the least alter the status of the native, who to all intents and purposes became the property of his master. Missionaries were not at this time allowed to reside wherever they chose in the country, the Boers dreading an inculcation of doctrines among the natives likely to be subversive of their rule. Education, as need hardly be said, was in the 'sixties at a very low ebb. Even institutions for children were few in number, and nothing approaching the standard of a high school existed. The private tutor was a good deal in demand, but his qualifications were of the slightest. An unsuccessful European carpenter or other mechanic or even labourer not infrequently occupied this position. At the various churches such elementary schools as existed were to be found, but they did not profess to teach more than a smattering of the three "R's" and the principles of Christianity.

Zoutpansberg native rising, 1865.

In 1865 an empty exchequer called for drastic measures, and the Volksraad determined to endeavour to meet their liabilities and provide for further contingencies by the issue of notes. Paper money was thus introduced, and in a very short time fell to a considerable discount. In this same year the farmers of the Zoutpansberg district were driven into laagers by a native rising which for some considerable time they were unable to suppress. Schoemansdal, a village at the foot of the Zoutpansberg, was the most important settlement of the district, and the most advanced outpost in European occupation at that time in South Africa. It was just one degree north of the tropic, and was situated in a well-watered and beautiful country. It was used as a base by hunters and traders with the interior, and in its vicinity there gathered a number of settlers of European origin, many of them outcasts from Europe or Cape Colony. They earned the reputation of being the most lawless white inhabitants in the whole of South Africa, and to-day a considerable number of these men or their descendants are still to be found in the northern Transvaal. When called upon to go to the aid of this settlement, which in 1865–66 was sore pressed by one of the mountain Bantu tribes known as the Baramapulana, the burghers of the southern Transvaal objected that the white inhabitants of that region were too lawless and reckless a body to merit their assistance. Attempts on the part of the Government to raise a relief force met with very partial success. At length a small relief party proceeded to the district, but they had no sooner arrived than dissension arose between them and some of the more turbulent spirits of the Zoutpansberg. Ultimately Schoemansdal and a considerable portion of the district were abandoned, and Schoemansdal finally was burnt to ashes by a party of natives. For some time after the destruction of Schoemansdal a settlement continued to exist in the district known as Potgieter's Rust. For ten years it had been occupied by Europeans without ill effects, but in 1870 the inhabitants were attacked with fever, from which nearly the whole community perished. The only village which remained under European occupation after this in the Zoutpansberg was Marabastad, at which the Boer landdrost continued to reside. Meanwhile the public credit and finances of the Transvaal went from bad to worse. The paper notes already issued had been constituted by the law legal tender for all debts, but in 1868 their power of actual purchase was only 30 per cent. compared with that of gold, and by 1870 it had fallen as low as 25 per cent. Civil servants, who were paid in this depreciated scrip, naturally suffered considerable distress. The revenue for 1869 was stated as £31,511; the expenditure at £30,836. The discovery of gold at Tati led President Pretorius in 1868 to issue a proclamation extending his territories on the west and north so as to embrace the goldfield, and on the east so as to advance considerably over the Portuguese boundary. This proclamation was followed by protests on the part of Her Majesty's High Commissioner, Sir Philip Wodehouse, as well as on the part of the consul-general for Portugal in South Africa. The boundary on the east was settled by a treaty with Portugal in 1870; that on the west was dealt with in 1871.

Keate award.

The Sand River Convention of 1852 had not clearly defined the western border of the state, and the discovery of gold at Tati to the north-west, together with the discovery of diamonds on the Vaal in 1867, doubtless offered Pretorius every inducement to extend his boundary. Although to-day the great diamond mines are south of the Vaal river, it so happened that the early discoveries of diamonds were made chiefly on the northern bank of the Vaal, near the site of the town now known as Barkly West. This territory was claimed by the South African Republic, by some of the Batlapin tribe, and also by Mr David Arnot, on behalf of Nicholas Waterboer, the chief of the Griquas, a race of bastards sprung from the illicit intercourse between Boers and native women, who had been settled north of the Orange since 1834. In order to settle the boundary question, an arbitration court was appointed, consisting of a Transvaal landdrost, Mr O'Reilly, on behalf of the South African Republic, and Mr John Campbell on behalf of the other claimants, with Lieutenant-Governor Keate of Natal as final referee. The two judges disagreed, and the final decision, afterwards known as the Keate award, was given by the referee. The decision was in favour of Waterboer, and conceded to him the boundary line to the north and north-east which his agent Arnot had claimed for him. Following on this decision, Waterboer offered his territory to Queen Victoria. The offer was accepted, and the territory became British under the title of Griqualand West. The Keate award practically brought Bechuanaland into existence as a separate state, and thus kept the great trade route to the north open to British enterprise.

The award caused a strong feeling of resentment among the Boers, and led to the resignation of President Pretorius and his executive. The Boers now cast about to find a man who should have the necessary ability, as they said, to negotiate on equal terms with the British authorities should any future question of dispute arise. With this view they approached Brand, President of the Free State, and asked him to allow them to nominate him for the Presidency of the South African Republic. To this Brand would not consent. He recognized that, even at this early stage of their history, in addition to having neither credit, nor resources, nor power of organization, the Transvaal Boers were filled with the wildest ideas as to what steps they would take in the future to counteract the influence of Great Britain. A number of them openly advocated a repudiation of such conventions as then existed, the extension of a road to Delagoa Bay so as to exclude British trade, and the establishment of a gunpowder factory. Brand did not, in declining the Transvaal invitation, merely content himself with an official communication. He intimated clearly to many of the leading Transvaal Boers that in his opinion they were embarking on a rash and mistaken policy. He urged that their true interests lay in friendship with, not in hostility to, Great Britain and the British. Having failed with Brand, the Boers now invited the Rev. Thomas François Burgers, a member of a well-known Cape Colony family and a minister of the Dutch Reformed Church, to allow himself to be nominated. Burgers accepted the offer, and in 1872 was duly elected President. In 1871 gold reefs were discovered in the Zoutpansberg district near Marabastad, and already a few gold-seekers from Europe and Cape Colony began to prospect the northern portions of the Transvaal. The miners and prospectors did not, however, exceed a few hundred in number for several years, and it was not until 1882 that they began to make themselves felt as a political and an important commercial factor in the development and future of the country.

Burgers becomes President, 1872.

The appointment of Burgers to the Presidency in 1872 was a new departure. Hitherto the Boers had always chosen one of their own number as President, but in Burgers they had selected a man from outside for the express purpose of securing an educated and capable leader. In a measure Burgers may be said to have fulfilled their choice. He was able, active, and enlightened, but he was unfortunately a visionary rather than a man of affairs or sound judgment. Instead of reducing chaos to order and concentrating his attention, as Brand had done so wisely in the Free State, on establishing security and promoting industry in the country, he took up with all its entanglements, the old misguided policy of intrigues with native chiefs beyond the border and the dream of indefinite expansion. Thus he had no sooner taken office than he endeavoured to support the claims of Moshette against Montsioa as paramount chief of Bechuanaland, and having failed in bringing about this change, he made overtures to Montsioa in the following year to induce him to alter the Barolong boundary as settled by the Keate award. In this endeavour he was equally unsuccessful, and Montsioa, fearing further aggression, made a formal request to be taken under British protection (see Bechuanaland). In 1875 Burgers proceeded to Europe with the project of raising a loan for the construction of a railway to Delagoa Bay. He was empowered by the Volksraad to raise £300,000, but with great difficulty he obtained in Holland the sum of £90,000 only, and that at a high rate of interest. With this inadequate sum some railway plant was obtained, and subsequently lay for ten years at Delagoa Bay, the scheme having to be abandoned for want of funds. On his return to the Transvaal in 1876 Burgers found that the condition of affairs in the state was worse than ever. The acting President had in his absence been granted leave by the Volksraad to carry out various measures opposed to the public welfare; native lands had been indiscriminately allotted to adventurers, and a war with Secocoeni, a native chief on the eastern borders of the country, was imminent. A commando was called out, which the President himself led. The expedition was an ignominious failure, and many burghers did not hesitate to assign their non-success to the fact that Burgers' views on religious questions were not sound. Burgers then proceeded to levy taxes, which were never paid; to enroll troops, which never marched; and to continue the head of a Government which had neither resources, credit, nor power of administration. In 1877 the Transvaal one-pound notes were valued at one shilling cash. Add to this condition of things the fact that the Zulus were threatening the Transvaal on its western border, and the picture of utter collapse which existed in the state is complete. In 1877 the condition of the Transvaal appeared so menacing to the peace of South Africa that Sir Theophilus Shepstone was despatched to the country by the High Commissioner, Sir Henry Barkly, to confer with President Burgers as to its future government. By this time Burgers had had his eyes opened to the true state of things. He was no longer blinded by the foolish optimism of a visionary who had woven fine-spun theories of what an ideal republic might be. He had lived among the Boers and attempted to lead their Government. He had found their idea of liberty to be anarchy, their native policy to be slavery, and their republic to be a sham. His was a bitter awakening, and the bitterness of it found expression in some remarkable words addressed to the Volksraad: "I would rather," said Burgers in March 1877, "be a policeman under a strong Government than the President of such a state. It is you—you members of the Raad and the Boers—who have lost the country, who have sold your independence for a drink. You have ill-treated the natives, you have shot them down, you have sold them into slavery, and now you have to pay the penalty. . . . We should delude ourselves by entertaining the hope that matters would mend by-and-by. . . . Do you know what recently happened in Turkey? Because no civilized government was carried on there, the Great Powers interfered and said, 'Thus far and no farther.' And if this is done to an empire, will a little republic be excused when it misbehaves? . . . If we want justice, we must be in a position to ask it with unsullied hands. . . . To-day a bill for £1000 was laid before me for signature, but I would sooner have cut off my right hand than sign that paper, for I have not the slightest ground to expect that when that bill becomes due there will be a penny to pay it with."

After spending some months at Pretoria, Shepstone satisfied himself that annexation was the only possible salvation for the Transvaal. The treasury was empty, the Boers refused to pay their taxes, and there was no power to enforce them. A public debt of £215,000 existed, and

British annexation, 1877.

Government contractors were left unpaid. Out of a male population of less than 9000, 3000 had already signed a petition for annexation. Sir Theophilus Shepstone therefore, in April 1877, issued a proclamation annexing the country. The proclamation stated: "It is the wish of Her Most Gracious Majesty that it [the state] shall enjoy the fullest legislative privileges compatible with the circumstances of the country and the intelligence of its people." The wisdom of the step taken by Shepstone has been called in question. Unfortunately, for many years subsequently the matter was so surrounded with the sophistry of English party politics that it was difficult for Englishmen to form any impartial opinion. The history of the Transvaal is more complete and better understood to-day than it was in 1877, and no one who acquaints himself with the simple facts of the position will deny that Shepstone's task was an extremely difficult one, and that he acted with care and moderation. The best evidence in favour of the step is to be found in the publicly expressed views of the state's own President, Burgers, already quoted. Moreover, the menace of attack on the Zulu side was a pressing and serious one. Even before annexation had occurred, Shepstone felt the danger so acutely that he sent a message to Cetewayo, the Zulu chief, warning him that British annexation was about to be proclaimed and that invasion of the Transvaal would not be tolerated. To this warning Cetewayo, who, encouraged by the defeat of the Boers at Secocoeni's hands, had already gathered his warriors together, replied: "I thank my father Somtseu [Shepstone] for his message. I am glad that he has sent it, because the Dutch have tired me out, and I intended to fight with them . . . and to drive them over the Vaal." A still further reason for Shepstone's annexation, given by Sir Bartle Frere, was that Burgers had already sought alliance with Continental Powers, and Shepstone had no reason to doubt that if Great Britain refused to interfere, Germany would intervene. The only military force at Shepstone's command at the time of annexation was twenty-five policemen, and it is quite certain that, apart from the attitude of President Burgers, which cannot be said to have been one of active opposition, a large number, probably a majority of the Boers, accepted the annexation with complacency. Burgers himself left the Transvaal a disappointed, heart-broken man, and a deathbed statement published some time after his decease throws a lurid light on the intrigues which arose both before and after annexation. He shows how, for purely personal ends, Mr Kruger allied himself with the British faction who were agitating for annexation, and in order to undermine him and endeavour to gain the Presidency, actually urged the Boers to pay no taxes. However this may be, Burgers was crushed, but as a consequence the British Government and not Mr Paul Kruger was, for a time at least, master of the Transvaal. In view of his attitude before annexation, it was not surprising that Mr Kruger should be one of the first men to agitate against it afterwards. The work of destruction had gone too far. The plot had miscarried. And so Kruger and Jorissen, by whom he was accompanied, were the first to approach Lord Carnarvon with an appeal for revocation of the proclamation. To this request Lord Carnarvon's reply was that the act of annexation was an irrevocable one. Unfortunately, the train of events in England favoured the intrigues of the party who were bent on getting the annexation cancelled. In 1878 Lord Carnarvon resigned, and there were other evidences of dissension in the British cabinet.

Agitation for independence.

Mr Kruger, who since the annexation had held a salaried appointment under the British Government, again became one of a deputation to England. On this occasion Sir T. Shepstone not unnaturally determined to dispense with his further services as a Government servant, and terminated the engagement. In the beginning of 1879 Shepstone was recalled and Colonel Owen Lanyon, an entire stranger to the Boers and their language, was appointed his successor as administrator in the Transvaal. In the meantime, the Zulu forces which threatened the Transvaal had been turned against the British, and the disaster of Isandhlwana occurred. Rumours of British defeat soon reached the Transvaal, and encouraged the disaffected party to become still bolder in their agitation against British rule. Thus Sir Bartle Frere wrote at the time: "All accounts from Pretoria represent that the great body of the Boer population is still under the belief that the Zulus are more than a match for us, that our difficulties are more than we can surmount, and that the present is a favourable opportunity for demanding their independence." In April Frere visited Pretoria and conferred with the Boers. He assured them that they might look forward to complete self-government under the Crown, and at the same time urged them to sink political differences and join hands with the British against their common enemy, the Zulus. The Boers, however, continued to agitate for complete independence, and with the honourable exception of Piet Uys, a gallant Boer leader, and a small band of followers, who assisted Colonel Evelyn Wood at Hlobani, the Boers held entirely aloof from the conflict with the Zulus, a campaign which cost Great Britain many lives and £5,000,000 before the Zulu power was finally broken. In June Sir Garnet Wolseley went to South Africa as commander of the forces against the Zulus, and as High Commissioner "for a time," in place of Sir Bartle Frere, of the Transvaal and Natal. After the settlement of the Zulu question, Sir Garnet Wolseley proceeded to Pretoria and immediately organized an expedition against the old Transvaal enemy Secocoeni, who throughout the Zulu campaign had been acting under the advice of Cetewayo. Secocoeni's stronghold was captured and his forces disbanded.

Effect of Mr Gladstone's speeches in England.

It will be seen from this review of the events following annexation that the first work accomplished, over and above establishing a solvent and responsible Government in the country, was the demolition by the British of the two native foes who for so long had harassed the Boers. In speaking, after the conclusion of the native wars, on the question of the revocation of the Act of annexation, Sir Garnet Wolseley assured the Boers at a public gathering that so long as the sun shone the British flag would fly at Pretoria. In May 1880 he returned to England. Meanwhile events in Great Britain had once more taken a turn which gave encouragement to the disaffected Boers. Already in November 1879 Gladstone had conducted his Midlothian campaign. In his speeches he denounced in the strongest terms the annexation which had been carried out by the Beaconsfield Government. Referring to Cyprus and the Transvaal, he went so far as to say, "If those acquisitions were as valuable as they are valueless, I would repudiate them, because they were obtained by means dishonourable to the character of our country." Expressions such as these were translated into Dutch and distributed among the Boers by some of their leaders, and it is impossible not to admit that they exercised a good deal of influence in fanning the agitation for retrocession already going on in the Transvaal. So keenly were the Midlothian speeches appreciated by the Boers that the Boer committee wrote a letter of thanks to Mr Gladstone, and expressed the hope that, should a change in the Government of Great Britain occur, "the injustice done to the Transvaal might find redress." In April 1880 this change in the British Government did occur. Gladstone became Prime Minister, and shortly afterwards Frere was recalled. Could events be more auspicious for the party seeking retrocession? If words in the mouth of an ex-minister at election-time meant anything, retrocession could only be a matter of time. The loyalists, not only in the Transvaal, but throughout South Africa, were disheartened and disgusted. The retrocession party in the Transvaal redoubled their efforts and their appeals. They were not destined to meet with such immediate success as the British premier's speeches, delivered during the heat of an election, very naturally led them to anticipate. On being directly appealed to by Kruger and Joubert, Mr Gladstone replied that the liberty which they sought might be "most easily and promptly conceded to the Transvaal as a member of a South African Confederation." This was not at all what was wanted, and the agitation continued. Meanwhile in the Transvaal itself, concurrently with the change of Prime Minister and High Commissioner, the Administrator, Colonel Lanyon, began vigorously to enforce taxation among the Boers. Men who would not pay taxes to their own appointed governments, and who were daily expecting to be allowed to return to that condition of anarchy which they had come to regard as the normal order of things, were not likely to respond willingly to the tax-gatherer's demands. That many of them refused payment in the circumstances which existed was natural.

Outbreak of war, 1880.

In November matters were brought to a head by Bezuidenhout's waggons being seized in respect of the non-payment of taxes, and promptly retaken from the sheriff by a party of Boers. Lanyon began to recognize that the position was becoming grave, and wired to Sir George Colley, the High Commissioner of South-East Africa, for military aid. This, however, was not immediately available, and the Boers in public meeting at Paardekraal resolved once more to proclaim the South African Republic, and in the meantime to appoint a triumvirate, consisting of Kruger, Pretorius, and Joubert, who were to act as a provisional government. Within three days of the Paardekraal meeting a letter was sent to the Administrator demanding the keys of the Government offices within forty-eight hours. Hostilities forthwith began, and then followed a series of the most disastrous skirmishes, the most contradictory and most vacillating changes of policy, which have ever embarrassed a military force or discredited a Government. No outbreak or rebellion ever occurred under more anomalous conditions. While the administrator and High Commissioner were endeavouring to carry out with very inadequate resources the declared policy of the British Government and their own instructions, continual pressure was being put on the British Prime Minister, not only from the insurgent Boers, but from his own followers, to carry out the policy he had avowed while out of office, and to grant the retrocession of the country. But it was not until Great Britain was suffering from the humiliation of defeat that the Premier was convinced that the time for granting that retrocession had arrived. The first shots fired were outside Potchefstroom, which was then occupied by a small British garrison, who, aided by the loyal inhabitants of the town, successfully sustained a siege of the place until after the close of the war. On 29th December a small body of some 240 men, chiefly belonging to the 94th Regiment, while marching from Lydenburg to Pretoria, were surprised and cut up by the Boer forces. Half the men were killed and wounded, the other half, including some officers, were taken prisoners. Of the prisoners, Captains Elliott and Lambert were subsequently treacherously shot by the Boers while crossing a stream, after they had been released on parole. In the meantime Pretoria, Rustenburg, Lydenburg, and other smaller towns had been placed in a position of defence under the directions of Colonel Bellairs, who remained in command at Pretoria, the garrison consisting of a small number of troops and the loyal inhabitants. Sir George Colley, with about 1400 men, marched towards the Transvaal frontier, but before reaching it he found, on 24th January 1881, that the Boers had already invaded Natal and occupied Lang's Nek. He pitched his camp at Ingogo. Having been defeated at Lang's Nek, and suffered considerable loss in an engagement near Ingogo, Colley took a force to the top of Majuba, a mountain overlooking the Boer camp and the Nek. He went up during the night, and in the morning was attacked and overwhelmed by the Boers (February 27). Of the 554 men who constituted the British force on Majuba, 92 were killed and 134 wounded, Sir George Colley himself being amongst the slain.

Majuba Hill, 1881.

Ten days previous to the disaster at Majuba, Sir Evelyn Wood had arrived at Newcastle with reinforcements. On Colley's death he assumed command, and on 6th March concluded an armistice with Joubert at Lang's Nek. Lord Kimberley then telegraphed offering an amnesty to the Boers. Gladstone announced in Parliament that an opportunity for a settlement of affairs in the Transvaal had arisen. On 6th March the terms of peace were arranged between the Boers and Sir Evelyn Wood. The most important of these terms were, that the Transvaal should have complete self-government under British suzerainty, and that a British Resident should be stationed at Pretoria. The treaty of peace practically conceded all that the Boers demanded, and was never regarded as anything else than surrender either by the Boers or the loyalists in South Africa. It had hardly been concluded when Sir Frederick Roberts arrived at the Cape with 10,000 troops, and after spending forty-eight hours there returned to England.

Pretoria Convention.

In the meantime, while the English general was making a treaty under the instructions of British ministers on the frontier, the beleaguered garrisons of Pretoria, Potchefstroom, and other smaller towns were stoutly and gallantly holding their own. The news of the surrender reached Pretoria through Boer sources, and when first received there was laughed at by the garrison and inhabitants as a Boer joke. When the bitter truth was at length realized, the British flag was dragged through the dust of Pretoria streets by outraged Englishmen. At Potchefstroom the garrison under Colonel Winsloe were hard pressed. During the siege a third of their number had been killed and wounded. The Boer commander, Cronje, was duly informed of the armistice by his leaders, but in spite of this knowledge continued the siege for ten days afterwards, until Winsloe and his little band were compelled to surrender. In May the terms of settlement already agreed upon were drawn up at Pretoria in the form of a convention and signed. The preamble to the Pretoria Convention of 1881 contained in brief but explicit terms the grant of self-government to the Boers, subject to British suzerainty. In later years, when the Boers desired to regard the whole of this convention (and not merely the articles) as cancelled by the London Convention of 1884, and with it the suzerainty which was only mentioned in the preamble, Mr Chamberlain pointed out that if the preamble to this instrument were considered cancelled, so also would the grant of self-government be cancelled. The Pretoria Convention contained thirty-three articles. The most important of these reserved to Her Majesty "the control of the external relations of the said State, including the conclusion of treaties and the conduct of diplomatic intercourse with foreign Powers," and the right to march troops through the Transvaal. The boundaries of the state were defined, and to them the Transvaal was strictly to adhere.

The retrocession of the Transvaal was a terrible blow to the loyalists. The Boers, on the other hand, found themselves in better plight than they had ever been before. Their native foes Cetewayo and Secocoeni had been crushed by British forces; their liabilities were consolidated into a debt to Great Britain, to be repaid at convenience and leisure—as a matter of fact, not even interest was paid for some time. If ever a small state was well treated by a large one, the Transvaal was so in the retrocession of 1881. Unfortunately, this magnanimity was forthcoming after defeat. It appeared as though a virtue had been made of a necessity, and the Boers never could regard it in any other light.

The new régime.

The new Volksraad had scarcely been returned, and Mr Kruger elected President, before a system of Government concessions to private individuals was started. These concessions, in so far as they prejudiced the commerce and general interests of the inhabitants, consisted chiefly in the granting of monopolies. Among the first monopolies which were granted in 1882 was one for the manufacture of spirituous liquor. The system continued steadily down to 1899, by which time railways, dynamite, spirits, iron, sugar, wool, bricks, jam, paper, and a number of other things, were all of them articles of monopoly. In 1882 also began that alteration of the franchise law which subsequently developed into positive exclusion of all but the original Boer burghers of the country from the franchise. In 1881, on the retrocession, full franchise rights could be obtained after two years' residence; in 1882 the period of residence was increased to five years. Meanwhile the land-hunger of the Boers became stimulated rather than checked by the regaining of the independence of their country. On the western border intrigues were already going on with petty tribal chiefs, and the Boers drove out a portion of the Barolongs from their lands, setting up the so-called republics of Stellaland and Goshen (see BECHUANALAND). This act called forth a protest from Lord Derby, the minister chiefly responsible for the Pretoria Convention, stating that he could not recognize the right of Boer freebooters to set up governments of their own on the Transvaal borders. This protest, however, had no effect upon the freebooters, who issued one proclamation after another until in November 1883 they united the two new republics under the title of the "United States of Stellaland." Simultaneously with this "irresponsible" movement for expansion, President Kruger, having found the policy of putting pressure upon Great Britain so successful, proceeded to London to interview Lord Derby and endeavour to induce him to dispense with the suzerainty, and to withdraw other clauses in the Pretoria Convention on foreign relations and natives, which were objectionable from the Boer point of view. Moreover, Kruger significantly requested that the term "South African Republic" should be substituted for Transvaal State.

The result was the London Convention of 1884. In this document a fresh set of articles was substituted for those of the Pretoria Convention of 1881. In the articles of the new convention the boundaries were once more defined, and to them the Transvaal was bound "strictly to adhere." In what followed it must always be remembered that Lord Derby began by emphatically rejecting the first Boer draft of a treaty on the ground that no treaty was possible except between equal sovereign states. Moreover, it is undeniable that Lord Derby acted as though he was anxious to appear to be giving the Boers what they wanted. He would not formally abolish the suzerainty, but he was willing not to mention it; and though, as before stated, in substituting new articles for those of the Pretoria Convention he left the preamble untouched, he avoided anything which could commit the Boer delegates to a formal recognition of that fact. On the other hand, he was most indignant when in the House of Lords he was accused by Lord Cairns of impairing British interests and relinquishing the Queen's suzerainty. He declared that he had preserved the thing in its substance, if he had not actually used the word; and this view of the matter was always officially maintained in the Colonial Office (which, significantly enough, dealt with Transvaal affairs) whatever the political party in power. Unfortunately, the timid way in which it was done made as ineffaceable an impression on Mr Kruger even as the surrender after Majuba. Article 4 stated: "The South African Republic will conclude no treaty or engagement with any state or nation other than the Orange Free State, nor with any native tribe to the eastward or westward of the Republic, until the same has been approved by Her Majesty the Queen." The other article to which the greatest interest was subsequently attached was Article 14:—"All persons, other than natives, conforming themselves to the laws of the South African Republic (*a*) will have full liberty, with their families, to enter, travel, or reside in any part of the South African Republic; (*b*) they will be entitled to hire or possess houses, manufactories, warehouses, shops, and premises; (*c*) they may carry on their commerce either in person or by any agents whom they may think fit to employ; (*d*) they will not be subject, in respect of their persons or property, or in respect of their commerce or industry, to any taxes, whether general or local, other than those which are or may be imposed upon citizens of the said Republic."

London Convention, 1884.

Bechuanaland expedition.

As the freebooters continued their operations in Bechuanaland, Sir Hercules Robinson despatched the Rev. J. Mackenzie to adjust matters and if necessary "to order the ejectment of the persons now trespassing at Rooi Grond" (see BECHUANALAND). Mr Mackenzie met with but partial success, and Mr Rhodes was sent to succeed him, but the latter equally failed to bring about a settlement. Meanwhile President Kruger "provisionally" proclaimed and ordained, "in the interests of humanity," that the territory in dispute should be under the protection of the South African Republic. Public protests were made in Cape Town and throughout the Colony against this last act of aggression, and in October 1884 Sir Charles Warren was despatched by the British Government to "pacificate" and "hold the country" pending further instructions. Thereupon President Kruger withdrew his proclamation, and on Sir Charles Warren's arrival met him and endeavoured to persuade him from proceeding. Sir Charles Warren subsequently broke up the freebooters' two states, and occupied the country without a shot being fired. The expedition cost Great Britain a million and a half, but the attempt at farther extension westwards was foiled. At the eastern border a similar policy was followed by the Boers, and in this instance with more success. Following up the downfall of the Zulu power after the British conquest in 1879, several parties of Boers began intriguing with the petty chiefs, and in January 1883, in the presence of 10,000 Zulus, they proclaimed Dinizulu, the son of Cetewayo, to be king of Zululand (see Zululand). As a "reward" for their services to the Zulus, the Boers then took over from them a tract of country in which they established a "New Republic." Encouraged by success, the Boer claims were extended until at the end of 1885 they claimed about three-fourths of the whole Zulu territory. In 1886 the "New Republic," with limits considerably narrowed, was recognized by Great Britain, and the territory became incorporated with the Transvaal in 1888. Their eastern boundary, in the teeth of the spirit of the conventions, and with but scant observance of the latter, was by this means eventually considerably extended. A similar policy eventually brought Swazieland almost entirely under their dominion (see Swazieland).

Economic developments: Gold industry.

Meanwhile, events occurring within the state augured ill for the future of the country. In 1884 a concession to a number of Hollander and German capitalists of all rights to make railways in the state led to the formation of the Netherlands Railway Company. This company, which was not actually floated till 1887, was destined to exercise a disastrous influence upon the fortunes of the state. Gold digging, which had commenced with the discovery in 1869 of the Zoutpansberg and Lydenburg gold-fields, had hitherto enjoyed in the Transvaal but a precarious existence. In 1883 the discovery of Moodie's Reef near the Kaap Valley led to a considerable influx of diggers and prospectors from the colonies and Europe, and by 1884 the Sheba Mine had been opened up and Barberton, with a population of 5000 inhabitants, sprung into existence. In 1886 the Rand gold-fields, which had just been discovered, were proclaimed and Johannesburg was founded. From that time the gold industry made steady progress until the Rand gold mines proved the richest and most productive gold-field in the world. As the industry prospered, so did the European population increase. The revenue of the state went up by leaps and bounds. In 1882 it was £177,407; in 1889, £1,577,445; in 1896, £3,912,095. At the end of 1886 Johannesburg consisted of a few stores and some few thousand inhabitants. In October 1896 the Sanitary Board census estimated the population as 107,078, of whom 50,907 were Europeans. The wealth which was pouring into the Boer state coffers exceeded the wildest dreams of President Kruger and his followers. Land went up in value, and farms, many of them at comparatively remote distances from the actual gold-fields, were sold at enormously enhanced prices. In fact, so attractive did this sale of land become to the Boers that they eventually parted with a third of the whole land area of the country to Uitlander purchasers. Yet in spite of the wealth which the industry of the Uitlanders was bringing both to the state and to individuals, a policy of rigid political exclusion and restriction was adopted towards them.

An attempt was made in 1888, after the conference held between Cape Colony, the Orange Free State, and Natal, to induce the Transvaal to enter the Customs Union. Kruger would have none of it. His design at this time was ultimately to bring the whole of the external trade of the state, which was growing yearly as the gold industry developed, through Delagoa Bay and over the Netherlands railway (see Orange River Colony and Cape Colony).

Relations with the rest of South Africa.

His hostility towards Great Britain and even Cape Colony led him to adopt a commercial policy both narrow and prejudicial to the interests of the gold industry. In 1888 Sir John Brand, President of the Free State, who had always been an enlightened advocate of civilization and friendly relations with Great Britain, died. He was succeeded in 1889 by Mr Reitz. In the appointment of Mr Reitz, President Kruger recognized a new opportunity of endeavouring to cajole the Free State. While Brand was alive he had arranged, in the teeth of the strongest protests from Mr Kruger, that the Cape railway should extend to Bloemfontein and subsequently to the Vaal river. President Kruger now endeavoured to bind the future railway policy of the Free State, and induced the Free State to agree to a treaty whereby each state bound itself to help the other whenever the independence of either should be threatened or assailed, unless the cause of quarrel was, in the eyes of the state called in to assist, an unjust one. This was the thin end of the wedge, which in Brand's time President Kruger had never been able to insert into the affairs of the Free State.

Oligarchical restrictions.

President Kruger now turned his attention to finding a seaport, and was only prevented from doing so by the British annexation of Tongaland, which barred his progress in that direction. In 1890 a feeling of considerable irritation had grown up among the Uitlanders at the various monopolies, but particularly at the dynamite monopoly, which pressed solely and with peculiar severity upon gold-miners. Requests for some consideration in the matter of the franchise, and also for a more liberal commercial policy in the matter of railways, dynamite and customs dues, began to be made. In response Kruger resorted to the most sweeping alteration in the franchise law. He enacted that the period of qualification for the full franchise should now be raised to ten years instead of five. He at the same time instituted what was called a second chamber, the franchise qualifications for which were certainly less, but which was not endowed with any real power. During this year Kruger visited Johannesburg, and what was known as "the flag incident" occurred. He had by this time rendered himself somewhat unpopular, and in the evening the Transvaal flag, which flew over the landdrost's house, was pulled down. This incensed Kruger so much that for many years he continued to quote it as a reason why no consideration could be granted to the Uitlanders.

In 1891 the Transvaal attempted its last border raid before the war of 1899. The Banjailand trek was organized. The trekkers intended forcibly to annex a portion of the British South Africa Company's territory. The High Commissioner protested, and the President prohibited the trek, but the trekkers were not finally turned back until they were opposed by the British South Africa forces under Dr Jameson and Colonel Goold-Adams.

Uitlander grievances.

In 1892 the Uitlanders began to feel that if they were to obtain any redress for their grievances some combined constitutional action was called for, and the first reform movement began. The Transvaal National Union was formed. This consisted at the outset chiefly of mercantile and professional men and artisans. The mining men, especially the heads of the larger houses, did not care at this juncture to run the risk of political agitation. The Hon. J. Tudhope, an ex-minister in the Cape Government, was elected chairman of the Union. The objects of this body were avowed from the outset. They desired equal rights for all citizens in the state, the abolition of monoplies and abuses, together with the maintenance of the state's independence. In the furthering of this policy the Uitlander leader, Mr Tudhope, was supported by Mr Charles Leonard and his brother Mr James Leonard, who at one time had distinguished himself as attorney-general of Cape Colony.

Both the Leonards, as well as many of their followers, were South Africans by birth. They, in common with the great bulk of the Uitlanders, recognized that the state had acquired its independence, and had every right to have that independence respected. They neither sought nor desired to see it abolished. But they asserted that a narrow and retrogressive policy, such as Kruger was following, was the very thing to endanger that independence. The soundness of these views and the legitimacy of Uitlander aspirations were recognized by a few of the most enlightened men among the Boer officials at Pretoria. Some prominent burghers even spoke at Uitlander meetings in favour of the Uitlander requests. At a later date, Chief Justice Kotze when on circuit warned the Boers that in its retrogressive action the Boer Government was undermining the *grondwet* or constitution of the state. It soon became evident that one course, and one only, lay open to President Kruger if he desired to avert a catastrophe. It was to meet in a friendly spirit those men who had by their industry converted a poor pastoral country into a rich industrial one, who represented more than half the inhabitants, who paid more than three-fourths of the revenue, and who were anxious to join him as citizens, with the rights of citizenship. He chose a course diametrically opposite. In an interview accorded to seven delegates from the National Union, who visited him in 1892, with regard to reforms, he told Mr Charles Leonard to "go back and tell your people that I shall never give them anything. I shall never change my policy. And now let the storm burst."

Commandeering incident.

In 1894 there occurred an incident which not only incensed the Uitlanders to fury, but called for British intervention. A number of British subjects resident in the Transvaal, in spite of their having no political status, were commandeered for compulsory service to suppress a native rising. This led to a protest, and eventually a visit to Pretoria, from Sir Henry Loch. In the negotiations between Sir Henry Loch and President Kruger which followed, President Kruger at length agreed to extend "most favoured nation" privileges to British subjects in reference to compulsory military service, and five British subjects who had been sent as prisoners to the front were released. This result was not, however, achieved before President Kruger had done his utmost to induce Sir Henry Loch to promise some revision in favour of the Transvaal of the London Convention. Following this incident came a further alteration in the franchise law, making the franchise practically impossible to obtain.

German flirtation.

At a banquet given in honour of the German Emperor's birthday in Pretoria in January 1895, Kruger referred in glowing terms to the friendship of Germany for the Transvaal, which in the future was to be more firmly established than ever. This speech was public evidence of what was known to be going on behind the scenes. The German consul at Pretoria at this juncture was a volatile, sanguine man, with visionary ideas of the important part Germany was to play in the future as the patron and ally of the South African Republic, and of the extent to which the Bismarckian policy might go in abetting an anti-British campaign. Whether he deceived himself or not, he led President Kruger and the Boers to believe that the Kaiser was prepared to go to almost any length in support of the Transvaal if an opportunity occurred. His influence was an undoubted factor in the Kruger policy of that time.

A minor incident early in 1895 served to mark the truculent attitude which the Boer Government had come to adopt towards the Uitlander population at Johannesburg. The Netherlands railway had at length, very late in the day, completed their line from the Delagoa Portuguese frontier to Pretoria. To the official banquet in honour of the event invitations were issued to the High Commissioner and a host of minor Government officials in Pretoria. To the large commercial and mining houses in Johannesburg, to the men who had built up that very commerce which the new railway was built to carry, no invitations were sent. The Uitlanders were ignored. The Delagoa Bay railway now being completed, Kruger determined to take steps to bring the Rand traffic over it.

Drifts incident.

The Netherlands railway began by putting a prohibitive tariff on goods from the Vaal river (see CAPE COLONY). Not to be coerced in this manner, the Rand merchants proceeded to bring their goods on from the Vaal by waggon. Kruger then closed the drifts (or fords) on the river by which the waggons crossed. He only reopened them after the receipt of what was tantamount to an ultimatum on the subject from Great Britain.

Uitlander reform movement.

At this time the Uitlanders formed a majority of the population, owned half the land and nine-tenths of the property, and they were at least entitled to a hearing. When in August they forwarded one of their many petitions praying for redress of their grievances and an extension of the franchise, their petition with over thirty-five thousand signatures was rejected with jeers and insult. One member of the Raad, during a debate in the Chamber, called upon the Uitlanders to "come on and fight" for their rights if they wanted them. The words, it is true, were but the utterance of an individual Raad member, but they were only a shade less offensive than those used by President Kruger in 1892, and they too accurately described the attitude of the Boer executive. In September a combined meeting of the Chambers of Mines and Commerce was held at Johannesburg, and a letter on various matters of the greatest importance to the mining industry and community at Johannesburg was addressed to the Boer executive. It was never vouchsafed an answer. Men of any spirit among the Uitlanders were exasperated beyond measure. Their position was not merely unjust; it was humiliating. What the next step should be was freely discussed. It was easy to propound the question, impossible to answer it. Some urged an appeal to the Imperial Government; but others, especially men of colonial birth and experience, objected that they would be leaning on a broken reed. That men who had still the memory of Majuba in their hearts should have felt misgiving is not to be wondered at. At this juncture came overtures to the leading Uitlanders from Mr Rhodes and Dr Jameson, leading to the Jameson Raid.

The "Jameson Plan."

To one or two men this scheme, subsequently known as the Jameson Plan, had been revealed earlier in the year, but to the majority even of the small group of leaders it was not known till October or November 1895. The proposition came in a tempting hour. Mr Rhodes and Dr Jameson, after considerable deliberation, came to the conclusion that they might advantageously intervene between Mr Kruger and the Uitlanders. They induced Mr Alfred Beit, who was an old personal friend of Mr Rhodes, and also largely interested in the Rand gold mines, to adopt this view and to lend his co-operation. They then submitted their scheme to some of the Uitlander leaders. Between them it was arranged that Dr Jameson should gather a force of eight hundred men on the Transvaal border; that the Uitlanders should continue their agitation; and that, should no satisfactory concession be obtained from President Kruger, a combined movement of armed forces should be made against the Government. The arsenal at Pretoria was to be seized; the Uitlanders in Johannesburg were to rise and hold the town. Jameson was to make a rapid march to Johannesburg. The various movements were to be started simultaneously. Meanwhile, in order to give Mr Kruger a final chance of making concessions with a good grace, and for the purpose of stating the Uitlander case to the world, Mr Leonard, as chairman of the National Union, issued a historic manifesto, which concluded as follows:—

> We have now only two questions to consider: (*a*) What do we want? (*b*) How shall we get it? I have stated plainly what our grievances are, and I shall answer with equal directness the question, What do we want? We want: (1) the establishment of this Republic as a true Republic; (2) a *grondwet* or constitution which shall be framed by competent persons selected by representatives of the whole people and framed on lines laid down by them—a constitution which shall be safeguarded against hasty alteration; (3) an equitable franchise law, and fair representation; (4) equality of the Dutch and English languages; (5) responsibility to the heads of the great departments of the Legislature; (6) removal of religious disabilities; (7) independence of the courts of justice, with adequate and secured remuneration of the judges; (8) liberal and comprehensive education; (9) efficient Civil Service, with adequate provision for pay and pension; (10) free trade in South African products. That is what we want. There now remains the question which is to be put before you at the meeting of the 6th January, viz., How shall we get it? To this question I shall expect from you an answer in plain terms according to your deliberate judgment.

The Jameson conspiracy fared no worse and no better than the great majority of conspiracies in history. It failed in its immediate object. Dr Jameson did not obtain more than five hundred men. Johannesburg had the greatest difficulty in smuggling in and distributing the rifles with which the insurgents were to be armed. The scheme to seize the Pretoria fort had to be abandoned, as at the time fixed Pretoria was thronged with Boers. Finally, to make confusion worse confounded, Dr Jameson, becoming impatient of delay, in spite of receiving direct messages from the leaders at Johannesburg telling him on no account to move, marched into the Transvaal on the day which had been provisionally decided on.

The policy of delay in the execution of the plot which the Uitlander leaders found themselves compelled to adopt was determined by a variety of causes. Apart from the difficulty of obtaining arms, a serious question arose at the eleventh hour which filled some of the Uitlanders with mistrust. The reform leaders in the Transvaal, down to and including the Johannesburg rising, had always recognized as a cardinal principle the due observance and maintenance of the independence of the state. From Cape Town it was now hinted that the movement in which Dr Jameson was to co-operate should, in Mr Rhodes's view, be carried out under the British flag. A meeting of Uitlander leaders was hastily summoned on 25th December. Two messengers were that night despatched to interview Mr Rhodes, who then gave the assurance that he approved of the republican flag. Meanwhile, on 29th December, Dr Jameson had started, and the news of his having done so reached Johannesburg from outside sources. A number of leading citizens were at once formed into a reform committee. In the absence of Mr Charles Leonard, who had been sent as one of the delegates to Cape Town to interview Mr Rhodes, Mr Lionel Phillips, a partner in Messrs Eckstein & Co., the largest mining firm on the Rand, was elected chairman. Mr Phillips had been for three years in succession chairman of the Chamber of Mines, and he had persistently for several years endeavoured to induce President Kruger to take a reasonable view of the requirements of the industry. He was a man of marked ability and energy, and enjoyed the confidence of the great majority of the Uitlanders. Under the supervision of the reform committee, such arms as had been smuggled in were now distributed, and Colonel Frank Rhodes was given charge of the armed men. The canteens were closed in the towns and along the mines. A large body of police was enrolled, and order was maintained throughout the town. On 2nd January 1896 Dr Jameson, who found himself at Doornkop in a position surrounded by Boers, surrendered. Dr Jameson and his men were conveyed to Pretoria as prisoners, and subsequently handed over to the High Commissioner. The whole of the reform committee (with the exception of a few who fled the country) were arrested on a charge of high treason and imprisoned in Pretoria; they were then brought up for preliminary examination in the Raadzaal, and committed for trial. In April, at the trial, the four leaders—Mr Lionel Phillips, Colonel Frank Rhodes, Mr J. H. Hammond, and Mr George Farrar, who in conjunction with Mr Charles Leonard had made the arrangements with Dr Jameson—were sentenced to death, the sentence being after some months' imprisonment commuted to a fine of £25,000 each. The rest of the committee were each sentenced to two years' imprisonment, £2000 fine or another year's imprisonment, and three years' banishment. This sentence, after a month's incarceration, was also commuted. The fine was exacted, and the prisoners, with the exception of Woolls Sampson and Karri Davis, were liberated on undertaking to abstain from politics for three years in lieu of banishment. Messrs Sampson and Davis, refusing to appeal to the executive for a reconsideration of their sentence, were retained for over a year. At a later date both of them, as well as several of their reform colleagues, served gallantly in the Imperial Light Horse during the war.

Collapse of Jameson Raid and Johannesburg rising.

Sir Hercules Robinson was unfortunately in feeble health at the time, and having reached Pretoria on the 4th of January, he had to conduct negotiations under great physical disadvantage. He had no sooner learnt of the Raid in Cape Town than he issued a proclamation through Sir Jacobus de Wet, the British Resident at Pretoria, warning all British subjects in Johannesburg or elsewhere from aiding and abetting Jameson. This was freely distributed among the public of Johannesburg. While in Pretoria the High Commissioner in the first instance addressed himself to inducing Johannesburg to lay down its arms. He telegraphed to the reform committee that President Kruger had insisted "that Johannesburg must lay down arms unconditionally as a precedent to any discussions and consideration of grievances." On the following day, 7th January, Sir Hercules telegraphed again through the British Agent, who was then at Johannesburg, saying: "That if the Uitlanders do not comply with my request they will forfeit all claims to sympathy from Her Majesty's Government and from British subjects throughout the world, as the lives of Jameson and the prisoners are now practically in their hands." The two thousand odd rifles which had been distributed among the Uitlanders were then given up. With regard to the inducements to this step urged upon the reform committee by the High Commissioner, it is only necessary to say with reference to the first that the grievances never were considered, and with reference to the second it subsequently appeared that one of the conditions of the surrender of Dr Jameson's force at Doornkop was that the lives of the men should be spared. It was after the Johannesburg disarmament that President Kruger had sixty-four members of the reform committee arrested, announcing at the same time that his motto would be "Forget and forgive." Sir Hercules Robinson, in response to a message from the British Government urging him to use firm language in reference to reasonable concessions, replied that he considered the moment inopportune, and on 15th January he left for Cape Town.

In the three years which intervened between the Jameson

After the Raid.

Raid and the outbreak of the war in 1899 Kruger's administration continued to be what it had been before the war; that is to say, it was not merely bad, but it got progressively worse. His conduct immediately after Johannesburg had given up its arms, and while the reform committee were in prison, was distinctly disingenuous. Instead of discussing grievances, as before the Johannesburg disarmament he had led the High Commissioner to believe was his intention, he proceeded to request the withdrawal of the London Convention, because, among other things, "it is injurious to dignity of independent Republic." When President Kruger found that no concession was to be wrung from the British Government, he proceeded, instead of considering grievances, to add considerably to their number. The Aliens' Expulsion and Aliens' Immigration Laws, as well as the new Press Law, were passed in the latter part of 1896.

Petition to the Queen.

In 1897 a decision of Chief Justice Kotze was overruled by an Act of the Volksraad. This led to a strong protest from the judges of the High Court, and eventually led to the dismissal of the Chief Justice, who had held that office for over twenty years, and during the whole of that time had been a loyal and patriotic friend to his country. While in office Mr Kotze had protested that no honourable man could continue to sit as judge under such conditions. After dismissal he spoke out still more plainly at a public dinner in Johannesburg, and openly charged President Kruger with the tyranny of a despot. An Industrial Commission appointed during this year by President Kruger fared no better than the High Court had done. The commission was deputed to inquire into and report on certain of the grievances adversely affecting the gold industry. Its constitution for this purpose was anomalous, as it consisted almost entirely of Transvaal officials whose knowledge of the requirements of the industry was scanty. In spite of this fact, however, the commission reported in favour of reform in various directions. They urged, among other things, due enforcement of the liquor law, more police protection, the abolition of the dynamite concession, and that foodstuffs should be duty free. These recommendations made by President Kruger's own nominees were practically ignored. In January 1899 the British Colonial Secretary, Mr Chamberlain, pointed out in a despatch to President Kruger that the dynamite monopoly constituted a breach of the London Convention. In order to help the Transvaal Government out of its difficulty, and to make one more effort towards conciliation, the financial houses of Johannesburg offered to lend the Transvaal Government £600,000 wherewith to buy out the dynamite company, and so terminate the scandal and bring some relief to the industry. The offer was not accepted. In May the Uitlanders, hopeless of ever obtaining redress from President Kruger, weary of sending petitions to the Raad only to be jeered at, determined to invoke intervention if nothing else could avail, and forwarded a petition to Queen Victoria. This petition, the outcome of the second Uitlander movement for reform, was signed by 21,000 British subjects, and stated the Uitlander position at considerable length. The following extract conveys its general tenor:—

> "The condition of your Majesty's subjects in this State has become well-nigh intolerable. The acknowledged and admitted grievances, of which your Majesty's subjects complained prior to 1895, not only are not redressed, but exist to-day in an aggravated form. They are still deprived of all political rights, they are denied any voice in the government of the country, they are taxed far above the requirements of the country, the revenue of which is misapplied and devoted to objects which keep alive a continuous and well-founded feeling of irritation, without in any way advancing the general interest of the State. Maladministration and peculation of public moneys go hand in hand, without any vigorous measures being adopted to put a stop to the scandal. The education of Uitlander children is made subject to impossible conditions. The police afford no adequate protection to the lives and property of the inhabitants of Johannesburg; they are rather a source of danger to the peace and safety of the Uitlander population."

Bloemfontein conference.

In response to this appeal, which the Imperial Government felt themselves bound to deal with, Mr Chamberlain proposed a conference; and this was arranged between President Kruger and Sir Alfred Milner, who met at Bloemfontein on 31st May 1899. It no sooner opened than it was evident that Kruger had come to obtain, not to grant, concessions. He offered, it is true, a seven years' franchise law in place of the five years' franchise which Sir Alfred Milner asked for. But apart from the relief suggested being entirely inadequate, it was only to be given on certain conditions, one of which was that all future disputes which might arise between the Transvaal and the Imperial Government should be referred to a court of arbitration, of which the president should be a foreigner. No arrangement was possible on such terms. Meanwhile feeling was running high at Johannesburg and throughout South Africa. Meetings were held in all the large towns, at which resolutions were passed declaring that no solution of the Transvaal question would be acceptable which did not provide for equal political rights for all white men. Sir Alfred Milner (who in a published despatch compared the position of the Uitlanders to that of "helots") urged the Home Government strongly to insist upon a minimum of reform, and primarily the five years' franchise; and Mr Chamberlain, backed by the Cabinet, adopted the policy of the High Commissioner.

(A. P. H.)

THE CRISIS OF 1899.

A state of extreme diplomatic tension lasted all the summer. The British public, in whom there had always been the latent desire to wipe out the memory of Majuba, were at last awakened by the Ministerialist press to the necessity of vindicating British influence in South Africa, and the Government soon found that, in spite of a highly articulate Radical minority, the feeling of the country was overwhelmingly behind them. It was not then realized either by the public or the Government how seriously, and with what considerable justification, the Boers believed in their ability, if necessary, to sweep the English "into the sea." President Kruger had every expectation of large reinforcements from the Dutch in the two British colonies; he believed that, whatever happened, Europe would not allow Boer independence to be destroyed; and he had assured himself of the adhesion of the Orange Free State, though it was not till the very last moment that President Steyn formally notified Sir Alfred Milner of this fact. The Boers profoundly despised the military power of Great Britain, and there was no reason why they, any more than Germany or France, should contemplate the possibility of the Empire standing together as a whole in such a cause. In England, on the other hand, it was thought by most people that if a firm enough attitude were adopted Mr Kruger would "climb down," and the effect of this error was shown partly in the whole course of the negotiations, partly in the tone personally adopted by Mr Chamberlain. It was only later that it was seen that if Great Britain intended effectually to champion the Uitlander cause, the moment for a test of strength had inevitably arrived. Negotiations could only bring the conflict a little nearer, delay it a little longer, or supply an opportunity to either side to justify its action in the eyes of the world. The conditions of the problem were such that unless Great Britain were to accept a humiliating rebuff, any correspondence, however skilfully conducted, was bound to bring into greater prominence the standing causes of offence between the two sides. The exchange of despatches soon led to a complete *impasse*. The persistent attempt of the South African Republic to assert its full independence, culminating in a formal denial of British suzerainty, made it additionally incumbent on Great Britain to carry its point as to the Uitlander grievances, while, from Mr Kruger's point of view, the admission of the Uitlanders to real political rights meant the doom of his oligarchical régime, and appeared in the light of a direct menace to Boer supremacy. The franchise, again, was an internal affair, in which the Convention gave Great Britain no right to interfere, while if Great Britain relied on certain definite breaches of the Convention, satisfaction for which was sought in the first place in such a guarantee of amendment as the Uitlander franchise would involve, the Boer answer was an offer of arbitration, a course which Great Britain could not accept without admitting the South African Republic to the position of an equal. Here was material enough for an explosion, even if personal misunderstandings and aggravations, adding fuel to the fire, had not naturally occurred (or even been deliberately plotted) during the negotiations. But the truth was that the Boers thought they stood to gain by fighting, while the British, though not expecting war, and acting up till the last month or so on the assumption that serious military preparations were either unnecessary or sufficiently unlikely to be necessary to make them politically inexpedient, had with no less confidence committed themselves to a policy which was impracticable on peaceful terms.

After July the tactics of the Boer executive were simply directed towards putting off a crisis till the beginning of October, when the grass would be growing on the veldt, and meanwhile towards doing all they could in their despatches to put the blame on Great Britain. At last they drafted on 27th September an ultimatum to the British Government. But, although ready drafted, many circumstances conspired to delay its presentation. Meanwhile, the British War Office began to wake up. Certain departmental details were despatched to South Africa to form a working nucleus for military bases, and early in September the Cabinet sanctioned the despatch to Natal from India of a mixed force, 5600 strong, while two battalions were ordered to South Africa from the Mediterranean. Sir George White was nominated to the chief command of the forces in Natal, and sailed on 16th September, while active preparations were set on foot in England to prepare against the necessity of despatching an army corps to Cape Town, in which case the chief command was to be vested in Sir Redvers Buller. Fortunately, although the draft of the ultimatum was lying in the State Secretary's office in Pretoria, the Boers, unprepared in departmental arrangements which are necessary in large military operations, were unable to take the field with the promptitude that the situation demanded. They consequently forfeited many of the advantages of the initiative. Thus it happened that, while the ultimatum remained undelivered in Pretoria, the British Government were able, if not to render their line of resistance secure, at least to prop it with sufficient reinforcements to enable it to defeat the crowning object of the Boer invasion of Natal—the capture of Pietermaritzburg and Durban.

The military strength of the two republics was practically an unknown quantity. It was certain that, since the troublous times of 1896, the Transvaal had greatly increased its armaments; but at their best, except by a very few, the Boers were looked upon by English military experts as a disorganized rabble, which, while containing many individual first-class marksmen, would be incapable of maintaining a prolonged resistance against a disciplined army. As was to be subsequently shown, the hostilities were not confined to opposition from the fighting strength of the two little republics alone; the British had to face Dutch opposition in their own colonies, and it was only the apathy and caution of the South African Dutch, taken as a whole, which saved the Empire from disaster. The total fighting strength of the Boer republics was probably never more than 60,000 men, and of these it is doubtful if at any period of the war there were more than 36,000 in the field at the same time. But the fact that it was to a large extent a struggle with a nation in arms doubled the numbers of the force that the Transvaal executive was able to draw upon, while to this may be added the not insignificant total of 10,000 Uitlanders and foreigners, and 15,000 Kaffirs, employed in menial duties attendant upon military operations. Of this force only a microscopic proportion was permanent and disciplined. At the outbreak of war the disciplined forces in the Transvaal were the South African Republic Police, about 1400 strong, with 20 officers; the Swazieland Police, 400 strong; and the Staats Artillerie, which, when the reservists were called up in mobilization for war, numbered about 800 men. The permanent forces of the Orange Free State simply consisted of an artillery corps, at the most 400 strong. For the rest, the bulk of the Dutch levies were organized on the burgher system—that is, each district was furnished with a commandant, who had under him field-cornets and assistant field-cornets, who administered the fighting capacity of the district. Each field-cornet, who, with the commandant, was a paid official of the state, was responsible for the arms, equipment, and attendance of his commando—the commando being the tactical as well as the administrative unit; any number of commandoes might be grouped under one commandant. Vecht, or fighting generals, again, exercised an authority above the commandants, while the supreme military control was vested in the Commandant-General.

The plan of campaign which found favour with the Boers, when they determined to put their differences with Great Britain to the test by the ordeal of the sword, was to attack all the principal British towns adjacent to their own borders; at the same time to despatch a field army of the necessary dimensions to invade and reduce Natal, where the largest British garrison existed. It is not too much to suppose that the executive in Pretoria had calculated that the occupation of Durban would inspire the entire Dutch nation with a spirit of unanimity which would eventually wrest South Africa from the British. On paper the scheme had everything to recommend it, as the expedient most likely to bring about the desired end. But the departmental executive could not push off the Natal invading force as early as had been anticipated, and it was not until 9th October that the ultimatum was presented to Mr Cunyngham Green, the British agent at Pretoria. This ultimatum proved to be an arrogant document, in which the situation was reviewed in a manner which showed clearly that the Boer Government had determined long before to put their differences to the final test of arms, and that the later negotiations had but served to cover the warlike preparations which were in hand. The scheduled demands were as follows:—

"(*a*) That all points of mutual difference shall be regulated by the friendly course of arbitration, or by whatever amicable way may be agreed upon by the Government with Her Majesty's Government.

The ultimatum.

"(*b*) That the troops on the borders of this Republic shall be instantly withdrawn.

"(*c*) That all reinforcements of troops which have arrived in South Africa since the 1st of June 1899 shall be removed from South Africa within a reasonable time, to be agreed upon with this Government, and with a mutual assurance and guarantee on the part of this Government that no attack upon or hostilities against any portion of the possessions of the British Government shall be made by the Republic during further negotiations within a period of time to be subsequently agreed upon between the Governments, and this Government will, on compliance therewith, be prepared to withdraw the armed burghers of this Republic from the borders.

"(*d*) That Her Majesty's troops now on the high seas shall not be landed in any part of South Africa."

To these demands the Transvaal Government required an answer within 48 hours.

There could be only one reply, and on Wednesday, 11th October 1899, at five o'clock P.M., a state of war existed between the British Government and the two Boer republics. On the following day the Boer attack on an armoured train at Kraaipan, on the western frontier of the Transvaal, witnessed the first hostile shot of a bloody war, destined to plunge South Africa into strife for two years and a half.

THE WAR OF 1899–1902.

Stages of the war.

For the purposes of history the South African campaign may be conveniently divided into five distinct periods. The first of these would be the successful Boer invasion of British territory, terminating with the relief of Ladysmith on 28th February; the second, the period of Boer organized resistance, which may be said to have finished with Lord Roberts's formal annexation of the Transvaal on 25th October 1900, and the flight of ex-President Kruger to Holland. The next period, the most unsatisfactory of the whole war, may be characterized as a period of transition; it marks the opening of earnest guerilla resistance on the part of the enemy, and uncertain casting about on the part of the British for a definite system with which to grapple with an unforeseen development. This phase may rightly be said to have continued until the abortive Middelburg negotiations were broken off on 16th March 1901. The next stage was that which saw the slow building up of the blockhouse system and the institution of small punitive columns, and may be considered to have extended until the close of 1901. The fifth, and last, period—which, after all other expedients had failed, finally brought the residue of uncaptured and unsurrendered burghers to submission—was the final development of the blockhouse system, wedded to the institution of systematic "driving" of given areas, which operations were in force until 31st May 1902, the date upon which a peace was ratified at Pretoria between Lord Kitchener and the representative Boer leaders.

Sir George White's operations in Natal.

The Ladysmith "entanglement."

The first of these periods saw the severest fighting of the campaign. It opened with the investment of Mafeking by a Transvaal force under A. P. Cronje, the envelopment of Kimberley by Free State commandoes under General Wessels, and on 1st November the complete isolation of the bulk of the Natal Field Force in Ladysmith by the main Federal army under Commandant-General Piet Joubert. The Natal Field Force, however, did not submit to investment without a struggle; and before the enemy finally cut the communication with the south, portions of Sir George White's force had fought four considerable actions with the invading army. The first two of these were of the nature of British successes. On 20th October the detached brigade at Talana drove back the Boer left under Lucas Meyer. But this superiority was bought at a price which nullified many of the results of victory. General Sir W. Penn Symons, the British officer in command, was mortally wounded, and after losing half its mounted men as prisoners and 226 officers and men killed and wounded, the brigade only escaped being enveloped by beating a masterly retreat upon Ladysmith, where it arrived in a very exhausted state on 26th October. In the meantime Sir George White had taken the aggressive, and hearing on 20th October that an advance guard under General Kock had occupied Elandslaagte, and placed itself athwart the direct communications of General Symons's force, he detached a force of all arms under Major-General French, and defeated Kock after a sanguinary engagement on 21st October (British losses, 258 all ranks killed and wounded). Three days later Sir George White fought a second engagement against the enemy advancing from the north at Tintwa Inyoni, in order to cover the retirement of the Dundee force. It was an inconsequent action, which cost the Natal Field Force 118 casualties, the majority of which occurred in the Gloucestershire Regiment. By 29th October Joubert's army had practically enveloped Ladysmith, and Sir George White determined to strike a blow in force which should be decisive in effect. The result of this decision was the battle of Lombard's Kop, outside Ladysmith, in which the whole of Sir George White's available garrison was engaged. The engagement was disastrous to the British, who had undertaken far too comprehensive an attack, and the Natal Field Force was obliged to fall back upon Ladysmith, with the loss of 1500 men in casualties, including the headquarters of the Gloucestershire and Royal Irish Fusiliers, which surrendered to the Free Staters and Johannesburg zarps at Nicholson's Nek. From that day the rôle of the Natal Field Force was changed from that of a hostile field army into the defence of a standard on a hill, and two days later it was completely isolated, but not before General French had succeeded in escaping south by train, and the naval authorities had been induced by Sir George White's urgent appeals to send into the town a Naval Brigade with a few guns of sufficient range and calibre to cope with the heavy position artillery which Joubert was now able to bring into action against the town.

Sir R. Buller's arrival.

General Sir Redvers Buller, who had been given the supreme command in South Africa as soon as it was perceived that war was the only solution to the South African trouble—his force being an army corps in three divisions, the divisional generals being Lord Methuen, Sir W. Gatacre, and Sir W. Clery—arrived in Cape Town, ahead of his troops, on the day following the final bid of Sir George White's army. The situation which presented itself was delicate in the extreme. In Natal practically the whole of the available defence force was swallowed up by the steady success of the invasion; on the western frontier two important British towns were isolated and besieged; and Federal commandoes were on the point of invading Cape Colony, which, as far as its Dutch population was concerned, seemed in peril of rebellion. The army corps, which had been mobilized for war, was about to arrive in South Africa; but it was evident that the exigencies of the situation, and the widely divided areas of invasion, would for the time being place in abeyance the original plan which had been formulated for an invasion of the Orange Free State from Cape Colony on three parallel lines. The first duty was to effect the relief of the British forces which had been rendered immobile, and to do this Sir Redvers Buller had no choice but to disintegrate the army corps. Hildyard's and Barton's brigades were sent to Natal; Sir William Gatacre, with a brigade instead of a division, was despatched to Queenstown, Cape Colony; while Lord Methuen, with a division, was sent off at breathless pace to relieve Kimberley. As November wore on, the situation did not improve. Cape Colony was invaded in earnest; while in Natal a flying column of Boers, pushing down from the Tugela, not only captured an armoured train, but for a short time isolated Hildyard's forces concentrating at Estcourt. The situation in Natal seemed so serious that on 22nd November Sir Redvers Buller suddenly disappeared from Cape Town, to arrive in Natal three days later. In the meantime Lord Methuen, with characteristic energy, had commenced his march to the relief of Kimberley. He encountered resistance at Belmont on 23rd. This he brushed aside by direct tactics, and two days later won another step on the stair to Kimberley at Enslin. Still persevering, he moved on to the Modder, where he was seriously opposed by De la Rey and P. A. Cronje, the latter having posted down from Mafeking with 2000 men and arrived on the previous night. The Boers, who held a river line, kept the British attack at bay all night, but eventually fell back, relinquishing the position after dark, as their right had been turned by General Pole-Carew's brigade. It was a long and sanguinary fight, in which the British lost 485 killed and wounded, and what was more serious, Lord Methuen (himself wounded) found that his force had exhausted its forward momentum, and that other than heroic tactics would have to be employed to raise the siege of Kimberley. The extent of the operations and the gravity of the situation now began to be felt in England, every available man was called up from the reserves, and the War Office made what at the time appeared to be adequate provision for the waste which it was seen would occur in a war under modern conditions. On 30th November the mobilization of a sixth division was ordered, offers of Colonial aid were accepted, and every facility provided for local recruiting in the South African ports. All through the early weeks of December confidence was considerably restored. Buller was arranging for the relief of Ladysmith, which had already shown its spirit by two successful sorties to the besiegers' batteries. In every theatre the British strength was consolidating. But the full significance of British incapacity to cope with the situation presented by these two small nations in arms had not yet been appreciated. The confidence restored by the lull during the early part of December was destined to be roughly shattered. On 10th December Gatacre essayed a night march and attack upon the rebel position at Stormberg, and was himself surprised and beaten (719 killed, wounded, and missing). On the following day Lord Methuen delivered an attack upon the Spytfontein kopjes (Magersfontein), and failed hopelessly, losing General A. Wauchope and over 950 officers and men. But even this could be suffered with equanimity, since Buller was about to bring his own force into play, and Buller, it was confidently supposed, would not fail. He had collected at Chievely in Natal a brigade of mounted men, four brigades of infantry (Generals Lyttelton, Hart, Barton, and Hildyard), and two brigade divisions of artillery, and he carried with him the trust alike of the army and the nation.

Failures of Lord Methuen and Gen. Gatacre.

Buller's failure: Lord Roberts appointed to the command.

On 16th December the whole Empire was prostrated with the news that Buller had made his effort and failed; that he had essayed an assault upon the positions fortified north of the Tugela by the Boers, under their newly found general Louis Botha, and that he had been repulsed with the loss of 1100 men and 10 guns. The full nature of the failure was not realized by the British public, nor the spirit in which the general had received the finding of fortune. How he had lost heart, and actually suggested the surrender of Ladysmith, was only known to them later, but the Cabinet knew, and in the face of the serious situation thus created the Cabinet took strong action. They appointed Field-Marshal Lord Roberts, V.C., to the supreme command in South Africa, with Lord Kitchener as his Chief of the Staff. A wave of military enthusiasm shook the Empire, and as the final requisition for mobilizing a seventh division practically drained the mother-country of trained men, a scheme for the employment of amateur soldiers was formulated, resulting in the Imperial Yeomanry and Volunteer movement, which proved one of the most striking features of the South African campaign. Pending the arrival of Lord Roberts and reinforcements, the situation in South Africa remained at a deadlock: the three besieged towns—Mafeking, Kimberley, Ladysmith—still held their own, but no headway was made by the relief columns; all they could do was to stand on the defensive. The only bright spot, as far as the British were concerned, was to be found in northern Cape Colony, where General French, with two cavalry brigades and a scratch force, was able, by a magnificent display of strategy, to keep at arm's length a superior force of the enemy, over a front of thirty miles in the vicinity of Colesberg. General French's achievement during this phase of the war was the more noteworthy since he had pitted against him the military skill of both De la Rey and De Wet, two of the three men of military genius produced by the war on the Boer side. On 6th January the Boers in Natal made a desperate attempt to reduce Ladysmith by storm. The garrison, already weakened by privation and sickness, made a stubborn resistance, and after one of the most sanguinary engagements of the war, at Cæsar's Camp and Wagon Hill, the garrison repulsed the attack with severe loss to the enemy, itself having 500 casualties, including Lord Ava, the eldest son of the Marquis of Dufferin.

Spion Kop.

When Lord Roberts arrived in Cape Town on 10th January 1900, three garrison towns were still invested, and the relieving forces were still maintaining their rôle of passive resistance. The Commander-in-Chief's first duty was to create out of the tangle of units in Cape Colony a field army capable of advancing into the enemy's country *viâ* the Orange Free State. In the meantime Sir Redvers Buller, who had been reinforced by Sir Charles Warren and a division, essayed a second attempt to cross the Tugela, by turning the Boer left. But the movement, sound in its conception, was indifferently carried out, with the result that the disastrous action at Spion Kop (24th January) was fought, and the British were obliged to retire again across the Tugela. (British losses, 1700.) By 1st February Lord Roberts had begun to feel his way, and on 3rd February he ordered a demonstration against the right of the Boer position at Spytfontein to Koodoosberg to cover the withdrawal of General French and the cavalry from before Colesberg, and the concentration of his army at Modder River. In spite of another set-back in Natal to Sir Redvers Buller, who has essayed a third attempt to relieve Ladysmith on 5th February, and failed to make good the purchase which he secured across the Tugela, Lord Roberts matured his plans, and, arriving at Modder River

Roberts's advance.

on 9th February, he set his operations in motion two days later by detaching French to the relief of Kimberley. On the 15th February, French at the head of his cavalry galloped into Kimberley, spreading dismay through the ranks of the burghers under Cronje, who vacated the Spytfontein positions on the night of the 15th, and retreated along the line of the Modder, crossing the front of the infantry division which was pushing up into the gap made by the cavalry advance. Lord Kitchener, who was with the infantry, at once sent the mounted infantry in pursuit and changed the direction of the infantry, sending word to French to bring his cavalry across to Koodoosrand Drift. French, with that unfailing energy which is the true attribute of a cavalry leader, conformed to Kitchener's urgent appeal, and on the 17th seized the hills above Paardeberg just in front of Cronje's advance-guard. **Paardeberg.** Thus checked, the pursuing infantry crashed into him on the 18th. Kitchener, who as chief of the staff issued orders, attempted to reduce Cronje, now in the river bed, by a *coup de main*, which, though costing over 1000 casualties, compressed Cronje into the confined area from which he was only to leave as a prisoner of war with 4000 of his men on 27th February, the anniversary of Majuba. Lord Roberts's bold plunge into the Free State had automatically relieved the pressure in front of Buller, who after desperate fighting was able to turn the left flank of Botha's position at Colenso, and after ten days' fighting to relieve Ladysmith on the 28th February. **Relief of Ladysmith.** Ladysmith had fared worst of all the beleaguered garrisons, and its 22,000 inhabitants were almost at their last gasp when relief came. The casualties from shell fire had only been 66, but those from sickness were many times as heavy as those by the chances of war. The relief had not been without a strain: Buller's operations had cost at Colenso 1200 men, at Spion Kop 1700 men, at Vaalkranz 400, and now in the last long-drawn effort 1600 more—over 5000 in all. But the tide of war had changed. The Natal invaders fell back to the mountains which enclose the north of the colony; Olivier and Schoeman retired from Cape Colony before Gatacre and Clements; and the Presidents of the Republics, realizing that the British Empire was capable of more resistance than they had calculated upon, put forward feelers aiming at the restoration of the *status quo* before the war. These proposals were rejected by Lord Salisbury: there could be no end now but a complete destruction of the Boer power.

The surrender of Cronje and the relief of Ladysmith for the time being paralysed the Boer resistance. Two half-hearted attempts were made on 7th and 10th May, at Poplar Grove and Driefontein, to stem Lord Roberts's advance upon Bloemfontein, President Kruger himself arriving on the scene to give confidence to his burghers; but the demoralization was so great that neither the military genius of the few nor the personal influence of the President could bolster up an adequate resistance, and on 13th March 1900 Lord Roberts's army marched into the Free State capital. **Capture of Bloemfontein.** This great move of the Field-Marshal's, accomplished in spite of the loss of a convoy which cut down his reserve supplies by two-thirds, and only possible by reducing the ration of the fighting man to a minimum and by undertaking the almost unprecedented risks of changing the line of communication three times, was followed by a period of reaction. It was not until 29th March that the new railway communication recommenced to feed the army. In the meantime rebellion had broken out in the Prieska district of Cape Colony, which was promptly quelled by Lord Kitchener. The halt at Bloemfontein was marked by the publication of proclamations, offering protection to the burghers, which, however, the invaders had not yet the power to fulfil. The enforced halt was unfortunate; it not only resulted in a bad outbreak of enteric, but it gave the Boers time to recuperate, and by the beginning of April they again took the initiative. The death of their commandant-general, Piet Joubert, on 28th March, seemed to mark a change in the fortunes of the Republican army. Commandant De Wet, who had first come into prominence as the capturer of Lord Roberts's convoy at Waterval, now added to his laurels by ambushing Broadwood's mounted brigade at Sannah's Post, just outside Bloemfontein, on 31st March, while four days later he reduced a detachment of Irish Rifles at Reddersburg, and then went south and invested Colonel Dalgety and a mixed force at Wepener, which was relieved after ten days by General Hunter's division, brought round to Aliwal North from Natal.

These successes were not able to retard Lord Roberts's progress. It took the Field-Marshal six weeks to reconstruct his plan of operations, and on 1st May the grand army moved northwards upon the Transvaal capital. The main advance was taken with one cavalry and three infantry divisions (the cavalry commanded by French, and the infantry divisions by Generals Tucker, Pole-Carew, and Ian Hamilton). Rundle's division took the right of the advance; Methuen and Hunter, moving from Kimberley, formed the left. Kelly Kenny, Colvile, and Chermside held the communications based on Bloemfontein. **Relief of Mafeking.** A flying column detached from Hunter, under Mahon, in conjunction with Plumer from the north, relieved Mafeking (where Baden-Powell aroused world-wide enthusiasm by his resistance) on 17th May, the same day that the Natal field force under Buller moved up into the Biggarsberg and occupied Dundee. On 10th May Lord Roberts had crossed the Zand River; on 12th May he entered Kroonstad. After a halt of eight days at Kroonstad, the grand army again moved forward and marched triumphantly, meeting but small resistance, without a halt into Johannesburg, which was occupied on 31st May, the Orange Free State having been formally annexed by proclamation three days earlier. On 30th May President Kruger fled his capital with the State archives, taking up his residence at Waterval Boven on the Komati Poort line. But while the gold mines were now in the possession of the British, attacks were made on their line of communications by De Wet, who from this period organized a guerilla resistance which he maintained until the end of the war. **Capture of Pretoria.** On 5th June Lord Roberts's army occupied the capital of the Transvaal practically without resistance, setting free about 3000 British prisoners of war detained there.

It had been anticipated that the occupation of both the capitals would have brought the hostilities to a close, but this was not the case, and though after 5th June regular resistance was at an end, the occupation was met with two years of almost unparalleled and unprecedented partisan warfare. On 8th June Sir Redvers Buller forced his way over Alleman's Nek, and on the following day occupied Lang's Nek, while the Field-Marshal fought a more or less decisive action against Botha, De la Rey, and Kemp at Diamond Hill, 20 miles east of Pretoria. The pressure on the main communications was now so serious that a force was thrown back into the Orange River Colony under Hunter, which in co-operation with Rundle's division accomplished the surrender of Prinsloo with 3000 Free Staters in the Brandwater basin (29th July). **Prinsloo's surrender.** A week before this satisfactory result the Field-Marshal had initiated a movement from Pretoria to sweep down to Komati Poort on the Portuguese frontier,

Flight of Mr Kruger.

in which Buller, advancing from the south, was to co-operate. On August 26–27 the combined forces engaged and defeated Botha at Dalmanutha and Bergendal, with the result that the enemy dispersed into the bush-veld north of the Middelburg railway. On 30th August the remainder of the British prisoners were released at Nooitgedacht. On 6th September Buller occupied Lydenburg in the bush-veld, and five days later the aged President of the Republic, fleeing his country, took refuge in Lorenzo Marques. On 13th September Barberton was occupied, and on the 25th the Guards Brigade occupied Komati Poort. In October the military operations were confined to attempts to reduce guerilla commandoes which had taken the field. Mr Kruger, deserting his countrymen, left for Europe in a Dutch man-of-war, and General Buller sailed for Europe. On the 25th of this month Lord Roberts formally annexed the Transvaal as an integral portion of the British Empire.

Lord Kitchener takes command.

In November there seemed to be evidences that the back of the trouble was broken, and the Field-Marshal, who had been appointed Commander-in-Chief at home, left South Africa, handing over the command of the army of occupation to Lord Kitchener. Then followed a long period of groping for a means to cope with the development of guerilla tactics, which for the next six months were at their zenith. The railway communications were constantly damaged, isolated posts and convoys captured, and the armed guerilla bands always seemed able to avoid contact with the regular columns sent in pursuit. Before the close of 1900 they scored several signal successes. De Wet captured Dewetsdorp, Kemp defeated Clements in the Hekpoort Valley, and disaffection broke out in Cape Colony to an alarming degree, while, as forerunners of the promised invasion, scattered bodies of Free Staters crossed south of the Orange river to swell the rebellion. Against this the British scored one success, namely, the severe handling of De Wet's commando at Bothaville, when the gallant Le Gallais lost his life. The year closed badly, as the commandoes, under the direct influence of Louis Botha, attacked the whole of the railway posts on the Middelburg railway and captured Helvetia, with its 4·7 gun, though two attempts at invasion of Cape Colony in force had been frustrated by the watchfulness of Charles Knox's columns. Lord Kitchener called for more men, and on 22nd December the War Office announced that 30,000 more mounted men would be despatched to the seat of war.

Concentration policy.

With the opening of 1901 Lord Kitchener tried new schemes. He withdrew all his detached garrisons except in the most important centres, and set himself to make his railway communications perfectly secure. He determined to make the area of operations a waste, and instituted the concentration camps, into which he intended to bring the whole of the non-combatant inhabitants of the two republics. He despatched French with a large force to clear the south-eastern districts of the Transvaal; and for the rest maintained a force to watch De Wet, and organized a defence force in Cape Colony, while using the residue of his mounted men to sweep the country of stock, forage, and inhabitants. Although there were no great disasters, the new policy was not prolific in success. The enemy invariably dispersed before superior forces; and the removal of the women and children from the farms did not have the effect of disheartening the burghers as had been anticipated—it rather mended their vitality by relieving them of responsibility for their families' welfare. On 10th February De Wet, with five guns and 3000 men, carried out his promised invasion of Cape Colony. This invasion was a fiasco; by judicious use of the railway Kitchener concentrated sufficient troops in the Colony to cope with the attempt, and, after being hunted from pillar to post for eighteen days, De Wet escaped back into the Orange River Colony with the loss of all his guns, munitions of war, and half his force. On 3rd March De la Rey, the lion of the western Transvaal, essayed an attack upon Lichtenburg, in which he was heavily repulsed. Signs of weakness were now apparent, and as a result Louis Botha, acting with the authority of Schalk Burger, the representative of President Kruger, opened negotiations with Kitchener. A meeting took place at Middelburg, Transvaal, on 28th February. These negotiations, however, broke down, mainly over the treatment to be awarded to Cape rebels.

Blockhouse policy.

Guerilla warfare.

The hostilities now entered upon a new phase. The establishment of a line of defensive posts between Bloemfontein and Ladybrand had given Kitchener an idea, and he resolved upon the scheme of partition of the theatre of war by chains of blockhouses. In the meantime, while these posts were under construction, the harrying of the guerillas by mobile columns was continued. In March Babington captured three guns and six maxims from De la Rey near Ventersdorp. In April Plumer occupied Pietersburg, the last remaining seat of government open to the enemy. Rawlinson captured a laager and guns at Klerksdorp. In May matters had so far improved that municipal government was given to Johannesburg, and a certain number of mines were allowed to recommence operations. De la Rey was defeated by Dixon at Vlakfontein, after a desperate encounter. June brought little of moment, though the Boers scored two minor successes, Kritzinger capturing the village of Jamestown in Cape Colony, and Hindon reducing the camp of the Victorian M.I. at Wilmansrust. In July there were further evidences of weakness on the part of the Boers, and Botha applied for permission to communicate with ex-President Kruger. This was allowed, but, as Mr Kruger advised a continuance of the struggle, the slow course of the war continued. In the meantime, the concentration camps were becoming filled to overflowing, and a steady stream of captures and surrenders were reducing the hostile power of the republics. On 13th July President Steyn only escaped capture by Broadwood at Reitz by a few minutes; and on 20th July the aged wife of the ex-President died in Pretoria. August was an important month, as in it Kitchener promulgated a proclamation, formally threatening the Boer leaders who should not surrender with permanent banishment from South Africa: this proclamation, though supported by the home Government, unfortunately had very little effect. Kitchener also received letters from the Boer leaders, showing that they were still determined to keep the field. September showed some slight improvement in the situation in Cape Colony, when General (now Sir John) French was in supreme command. On the 5th, Scobell captured Lotter, who was subsequently executed for murder; though this was rather balanced a few days later by Smut's attack on the 17th Lancers. Botha made a desperate effort to reinvade Natal, but his plans were rendered abortive by his failure to reduce the posts of Mount Prospect and Fort Itala, which he attacked on 26th September. De la Rey was also defeated in the west, in an attack upon Colonel Kekewich's camp at Moedville. Desultory fighting continued till the close of the year, the balance of success being with the British, though on 30th October Colonel Benson's column had been defeated by Botha, at Brakenlaagte, in the south-eastern Transvaal. Affairs again took an unsatisfactory turn in Cape Colony, and on 8th October the whole colony was placed under martial law. But in December matters improved, and

General Bruce Hamilton's column, by a series of night marches, practically blotted out the resistance in the eastern Transvaal. The corps of National Scouts (burghers who had come over) was inaugurated, and matters so far mended in Johannesburg that the Stock Exchange reopened. By the end of the year the blockhouse system was complete, but this phase of the war was destined to close badly, as De Wet on Christmas Eve captured the whole of Colonel Firman's Yeomanry camp at Tweefontein, Orange River Colony.

The "drives."

With 1902 the last phase of this protracted struggle commenced. The blockhouse system was practically finished, and Kitchener determined upon a new means of harassing the enemy, who still had a total of about 25,000 men in the field. But the blockhouses had already begun to serve the purpose for which they were designed. In the past the mobile columns, of which there were over sixty in the field, had always been bound to the railway for supply; now convoys could be pushed out to them along whatever blockhouse line they touched. In January Bruce Hamilton continued his successful night marches, and late in the month General Ben Viljoen was captured in the Lydenburg district. The only set-back was the descent which Beyers made upon Pietersburg, breaking into the concentration camp and carrying off a number of able-bodied refugees. Early in February Lord Kitchener commenced his first drive at Wolvehoek, and it was so successful that it was evident that the key to the situation had been found. As a mark of its success it drove the enemy still in the field to desperation, and for the rest of the winter were chronicled alternate successes and disasters. A British convoy was captured in the Colony; the 28th Mounted Infantry were overwhelmed at Klip Drift; the Scots Greys were roughly handled; De la Rey captured von Donop's convoy. But against this could be set off the capture of a whole commando by Colonel Park, A.D.C., the capture of Hans Grobler's commando by Colonel Colin Mackenzie, and a successful drive in the north-east of the Orange River Colony which resulted in 600 prisoners. March was perhaps the most important month in the last stage of the war. It opened with another success to De la Rey, who captured Paris's column and Lord Methuen; but for the rest, the great drive in the western Transvaal proved to the Boers the futility of any attempt to prolong the struggle. On 23rd March the representatives of the Boer Government came into Pretoria, six weeks were spent in negotiation, and then a monster meeting of delegates, under the presidency of General Kemp, was held at Vereeniging.

As a result of this conference a peace was ratified at Pretoria on 31st May, and the South African war was a history of the past. The terms of peace may be condensed into the following points: (1) Surrender of all burghers in the field, with all arms and munitions of war; (2) all burghers duly declaring themselves subjects of King Edward VII. to be repatriated; (3) no burghers who should surrender to be deprived of either their liberty or property; (4) no proceedings to be taken against burghers for any legitimate acts of war during the period of hostilities; (5) the Dutch language to be taught in public schools on the request of parents, and to be allowed in courts of law; (6) sporting rifles to be allowed upon the taking out of licences; (7) the military administration to be superseded by civil administration as soon as possible, the civil administration to lead up to self-government; (8) the question of the native franchise not to be considered until after the introduction of self-government; (9) landed property not to be subjected to any special tax to defray the cost of the war; (10) a commission to be formed to facilitate the repatriation of the burghers. A grant of £3,000,000 to be given as compensation for the destruction of farms. These terms were signed on behalf of the British Government by Lord Milner and Lord Kitchener; on behalf of the Orange Free State by Messrs J. Brebner, C. R. de Wet, C. Olivier, and Judge J. B. M. Hertzog; on behalf of the Transvaal Government by Messrs S. W. Burger, F. W. Reitz, Louis Botha, J. H. De la Rey, Lucas Meyer, and Krogh.

In the whole war the British lost 5774 killed and 22,829 wounded, while the Boers lost about 4000 killed. The number of Boer prisoners in the hands of the British at the end of the war was about 40,000.

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Trapani, a seaport town and episcopal see of Sicily Italy, on the west coast, 47 miles west by south of Palermo (121 miles by rail). It is a place of some trade, exporting salt, wine, fish, &c., to the annual value of about £100,000 (£116,500 in 1899), and importing wheat, timber, and coals to the value of £350,000 (£359,300 in 1899) annually. The port is the safest and largest on the west coast of Sicily, and gives a depth of 24 feet alongside the quays. It was in 1899 entered by 115 vessels of 84,640 tons. The people engage in tunny and sponge fishing, in the preparation of salt (the salt-pans, 45 in number, stretch from Tripani to Marsala, and produce about 200,000 tons every year), in the manufacture of ice and olive oil, and in alabaster work. The port is constantly dredged, and a second breakwater was built in 1899–1900. There are statues to Garibaldi (1890) and Victor Emmanuel (1882). Population (1881), 33,514; (1901), 60,257.

Trasimeno, or LAKE OF PERUGIA, a lake of central Italy, 12 miles W. from Perugia. Area of lake, 59 square miles. Having no natural outlet, it was subject to sudden and serious rises of the surface, which occasioned inundations, and these in turn malaria. Through the exertions of Cav. G. Pompili an artificial outlet, consisting of alternate canals and tunnels, has been made from the S.E. corner of the lake to the Caina, a small tributary of the Tiber. The work, which is about 4 miles long, cost only about £26,000, and was completed in 1898. It is estimated to leave about 2500 acres of land dry, and to convert another 2800 acres of marshy soil into cultivable land.

Tras-os-Montes, a former province of Portugal, situated in the extreme N.E. of the country, and washed on the S. by the river Douro. It corresponds to the districts of Bragança and Villa Real. In addition to port wine, it produces olive-oil, corn, and vegetables. Cattle and sheep breeding are considerable industries. Area, 4291 square miles. Population (1900), 429,170.

Traú (Serbo-Croatian, *Trogir;* Latin, *Tragurium*), a coast town of the Austrian crownland of Dalmatia, a few miles west of Spalato. It is situated on a small island in the Canale di Traú, and is connected with the mainland and the adjoining island of Bua by two bridges. It has a number of interesting architectural and historical remains, including the ruins of a Venetian fortification and a loggia, said to be "a perfect example of a public court of justice of the Venetian period," together with a beautiful 13th-century basilica, &c. The town is a steamship station (indifferent harbour), and has some trade in wine, figs, olives, and other fruit, the port being entered and cleared by 400,000 to 500,000 tons annually. In 1890 the population of the town was 3392, and of the commune 15,809 (1900, 17,064), chiefly Croatians.

Traunstein, a town and summer resort of Bavaria, Germany, district of Upper Bavaria, 73 miles by rail east-south-east of Munich. It is one of the Bavarian towns which distil salt from the brine of Riechenhall, whence (22 miles distant) it is brought in pipes. It has a historical museum, a couple of fine fountains (1526 and 1894), and monuments of the war of 1870–71 and to King Maximilian II. There are saline baths, whey cure, and breweries. In the vicinity are Empfing, with baths of all kinds, and Pastor Kneipp's cold-water cure establishment. Population (1885), 4909; (1900), 7516.

Trautenau (Czech, *Trutňov*), the chief town of a government district in Bohemia, situated on the Aupa, a tributary of the Elbe, at the foot of the Riesengebirge, in the frontier district adjoining Prussian Silesia. It is the centre of the Bohemian linen industry, and has a yarn exchange. In addition to its spinning and weaving establishments, it has factories for the manufacture of paper and for the utilization of the waste products of the other mills. Trautenau was founded by German colonists invited to settle there by King Otto II. of Bohemia, and received a charter as a town in 1340. It was the scene of two battles between the Prussians and Austrians on 27th and 28th June 1866, which are now commemorated by public monuments. Population (1890), 13,290; (1900), 14,777.

Travancore, a state of southern India, in connexion with Madras. Area, 6370 square miles; population (1881), 2,401,158; (1891), 2,557,736, showing an increase of 7 per cent., which has been continuous since 1875; average density, 380 persons per square mile. In 1901 the population was 2,951,038, showing a further increase of 15 per cent.

The gross revenue is Rs.88,55,000; tribute, Rs.8,10,652; military force, 1360 infantry, 61 cavalry, and 30 artillery with 6 guns; number of police, 1632, under a European officer; number of schools (1897–98), 3274, with 160,368 pupils, of whom 36,562 were girls; proportion of pupils to population of school-going age, 40 per cent. (being 64 per cent. for boys and 19 per cent. for girls), compared with 15·5 per cent. for the Madras Presidency; registered death-rate (1897), 15 per 1000. The Maharaja of Travancore claims descent from Cheraman Perumal, the last Hindu monarch of united Malabar in the 14th century. Though he is a Kshatriya, the succession follows the local custom of inheritance through females; consequently his *sanad* of adoption authorizes him to adopt sisters' sons. For two or three generations the rulers have been men of education and character, and the state is conspicuous for good administration and prosperity. The two dominant sections of the population are the Namburi Brahmans and the Nairs or military caste. Native Christians, chiefly of the Syrian rite, form just one-fifth of the whole, being more numerous than in any Madras district. In 1897–98 the chief items of gross revenue were: land, Rs.22,71,000; salt, Rs.19,00,000; tobacco, Rs.10,49,000; customs, Rs.6,42,000; excise, Rs.6,35,000; forests, Rs.4,37,000; and stamps, Rs.3,56,000. The expenditure included Rs.22,95,000 on public works and Rs.3,17,000 on education. The value of the sea-borne trade in that year, mainly of a coasting character, was Rs.2,47,98,100, of which Rs.1,46,93,752 represented exports, chiefly cocoanut products, timber, pepper, cardamoms, coffee, and tea. The principal ports are Alleppi, Quilon, and Paravur; but there is no real harbour. Proposals have been considered for constructing a railway over the hills into British territory (including a line from Quilon to Tinnevelly). The Periyar project conducts water across the range in a tunnel to irrigate Tinnevelly district, for which compensation of Rs.40,000 is annually paid to Travancore. The capital is Trivandrum.

Traverse City, a city and lake port of Michigan, U.S.A., capital of Grand Traverse county, at the head of the west arm of Grand Traverse Bay, on the north-western coast of the Lower Peninsula, at an altitude of 605 feet. The harbour is good, and there is regular steamer communication during the open season with Chicago and other lake ports. The surrounding region is forested with pine, and the industries are chiefly connected with lumber, there being saw, planing, and shingle mills. Population (1880), 1897; (1890), 4833; (1900), 9407, of whom 2068 were foreign-born.

Treaties.—Since the publication of the article on TREATIES in vol. xxiii. of this Encyclopædia, treaty-making has entered more largely than ever into the life of nations. In the earlier article the different kinds of treaties were classified as (1) political; (2) commercial; (3) relating to social intercourse; (4) to extradition; (5) to copyright, trade-marks, &c.; (6) to the conduct of war. To these we may now add a seventh class, relating to international arbitration.

1. Among the treaties belonging to the first class, concluded since 1888, two recent ones stand out as of first importance. The Hay-Pauncefote Treaty, signed at Washington 18th November 1901, and ratified by the American Senate 16th December 1901, to facilitate the construction of a ship canal through the Central American isthmus, and to remove any objection arising from the Convention of 19th April 1850, known as the Clayton-Bulwer Treaty, adopted as the basis for its neutralization the form of the International Convention of 29th October 1888 for the free navigation of the Suez Canal. On 30th January of 1902 an Anglo-Japanese Treaty was signed in London, having for its object the maintenance of the "*status quo* and general peace in the extreme East," and more especially "the independence and territorial integrity of the empire of China and the empire of Corea," and to secure "equal opportunities in those countries for the commerce and industry of all nations." It provides that, if either Great Britain or Japan should become involved in war with another Power through the defence of its interests in the countries concerned, the other will maintain a strict neutrality, and, if any further Power or Powers should join in the hostilities against either ally, the other contracting party will come to its assistance. A great number of conventions and arrangements of less importance dealing with the delimitation of frontiers and spheres of influence in Africa and elsewhere have also been concluded between Great Britain and different European Governments (see Hertslet's *Treaties*, vols. xviii., xix., xx., and xxi., and the "Treaty Series" published by the British Government), as well as with many native states in Africa, on the Persian Gulf, and in the Malay Peninsula. By a declaration signed at London 5th August 1890, France recognized the British protectorate over Zanzibar and Pemba, and Great Britain recognized the French protectorate over Madagascar; the appointment of a commission to settle the details of their respective spheres of influence in Africa set out in the declaration was also agreed to. By the declaration signed at London 15th January 1896, Great Britain and France settled their respective territorial policies on the Petcha Bouri, Meiklong, Menam, and Bang Pa Kong rivers. By this declaration also the two Governments agreed that all advantages in the Chinese provinces of Yunnan and Szechuen obtained by either Government

should be enjoyed by both in common; the appointment of a commission to delimit the French and British possessions to the west of the Lower Niger was agreed upon; and arrangements were made for the conclusion of a convention with regard to commercial matters in Tunis (see *infra*). By an agreement dated 1st July 1890 Great Britain ceded to Germany the island of Heligoland. By this same agreement spheres of influence of the two countries in Africa were fixed (details to be ascertained by a mixed commission, whose proposals were embodied in an Anglo-German agreement signed at Berlin 23rd February 1901), and Germany recognized a British protectorate over Zanzibar and Pemba. The Samoan Islands were divided up under a "convention and declaration between Great Britain and Germany" signed at London 14th November 1899, which was completed by a tripartite convention between Great Britain, Germany, and the United States, signed at Washington 2nd December 1899.

2. British commercial treaties since 1888, in chronological order, include a general treaty of commerce and navigation with Mexico (27th November 1888); with Egypt (29th October 1889); with Greece (28th March 1890); with Muskat (19th March 1891); with Portugal, spheres of influence in Africa, transit dues, &c. (11th June 1891); with Servia (10th July 1893); with Japan (16th July 1894); with France, commercial relations between France and Canada (4th October 1895); with Abyssinia (14th May 1897); with Bulgaria (24th July 1897); with France in connexion with Tunis (18th September 1897); with Belgium—a provisional *modus vivendi*, with subsequent extensions to British Colonies (27th July 1898); with Uruguay (15th July 1899); and others of less importance. By an exchange of Notes on 28th April 1899 Russia and England determined the territorial limits of their respective railway interests in China; and by an agreement and exchange of Notes on 16th October 1900 Great Britain and Germany declared their intention to observe an open-door commercial policy in China, while respecting its territorial integrity. A new commercial treaty with China was signed 5th September 1902. For the Sugar Convention, see SUGAR.

3. There have been a great number of minor accessions to existing postal and telegraphic conventions.

4. Extradition treaties are dealt with under EXTRADITION.

5. The international protection of copyright and industrial property (patents, trade marks, &c.) has undergone considerable extension (see *infra*).

6. To treaties relating to the conduct of warfare a great addition has been made by the two international conventions adopted at The Hague on 29th July 1899. By the first the principles of the Geneva Convention of 22nd August 1864 were adapted to maritime warfare. By the other the laws and customs of war by land in a great many cases were formulated, and it was provided that "until a more complete code of the laws of war" was issued "populations and belligerents" should remain "under the protection and empire of International Law" (see WAR).

7. There have been several important treaties relating to arbitration (see ARBITRATION, INTERNATIONAL), the most recent being the references of the Waïma and "Sergent Malamine" incidents by Great Britain and France to the decision of Baron Lambermont (3rd April 1901), and that of the difficulties arising out of the determination of the boundary between Brazil and British Guiana to the king of Italy (6th November 1901). A new departure in treaty-making in this connexion is that of treaties specifically and exclusively devoted to providing for arbitration generally as between the contracting states. The first of these treaties was the Italo-Argentine Convention (23rd July 1898). The Anglo-American Convention for the same purpose was signed (12th January 1897), but was not ratified by the American Senate.[1] For The Hague Convention, creating a special court, see ARBITRATION, INTERNATIONAL. A Chile-Argentine Convention, providing like the Italo-Argentine Convention for compulsory arbitration, was signed on the 12th August 1902.

Among new and interesting developments which have arisen, we may also place the international unions, or open international arrangements, which all states can join on subscribing to certain conditions. These international unions date from the formation of the Union Postale Universelle in 1874.[2] It has been followed by others relating to industrial property (patents, trade marks, &c.), copyright, railway traffic, the protection of submarine cables, suppression of African slavery, and Suez Canal quarantine (19th March 1897). The union relating to the protection of industrial property, to which the Governments of Belgium, Brazil, Spain, France, Guatemala, Holland, Portugal, Salvador, Servia, and Switzerland subscribed, was concluded at Paris on 20th March 1893, and since that date Great Britain (with New Zealand and Queensland), Sweden, Denmark, Norway, Italy, Japan, the United States, and Tunis have acceded to its terms and joined the union. Turkey and Salvador have since withdrawn from it.[3] The subjects or citizens of each of the contracting states enjoy, in all other states of the union, as regards patents, designs, models, trade marks, and trade names, all the advantages their respective laws grant to their own subjects or citizens, and consequently have the same protection as the latter and the same legal remedy against any infringement of their rights, provided they observe the formalities and conditions imposed on subjects or citizens by the internal legislation of each state. They have also a right of priority in respect of registration in the respective states. The International Copyright Union was created by the Berne Convention of 9th September 1886. Both unions maintain official bureaus at Berne, and issue periodical publications. The Railway Traffic Union applies to European continental goods traffic only (14th October 1890). Under a convention, signed 5th July 1890, thirty states, including Great Britain and most British colonies, are associated for the prompt publication at an office, established at Brussels, and at their joint expense, of the customs tariffs of the world and all modifications thereof. The General Act for dealing with the suppression of African slavery (signed at Brussels on 2nd July 1890) maintains offices at Brussels and Zanzibar for the centralization of all information and measures connected with the matters dealt with in the General Act.

Further subjects which have been suggested for universal international regulation are anarchist conspiracies, the control of floating pauper populations, the white slave traffic, &c. One of the most remarkable instances of the tendency which states have at the present day to assimilate their intercourse to that between individuals is the conclusion of arrangements for the granting to each other of *leases*. As between European states and Oriental states some such arrangements were made in the form of concessions granted to European settlements; but as between European peoples such a case as that of the grant by Great Britain of leases to France of stations on the Niger (14th June 1898) is novel. Great Britain has taken similar leases of Wei-hai-Wei (1st July 1898) and of territory described as "Hong-Kong extension" (9th June 1898).

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[1] The majority of forty-two to twenty-six in its favour did not amount to the two-thirds required by the United States Constitution in such cases.

[2] Before this a Double Standard Monetary Union (23rd December 1865) had been created as between France, Italy, Belgium, and Switzerland (Greece only joined the Union in 1868), and a Single Standard Union (1873) between Sweden, Norway, and Denmark. These earlier unions were limited in their area.

[3] Similar arrangements for the mutual protection of inventions, designs, and trade marks have been made between Great Britain on the one side and each of the following states and colonies on the other: Ecuador (designs and trade marks only); Greece (designs and trade marks only); Honduras; Mexico; Paraguay; Rumania (designs and trade marks only); Tasmania; Uruguay; Western Australia.

(T. BA.)

Trebizond.—(1) A viláyet of Asiatic Turkey, situated on the south coast of the Black Sea, between 36° and 41½° E. It has an area of 12,387 square miles, and is divided into four sanjaks—Janik (Samsún), Trebizond, Lazistán, and Gümush-khaneh. The viláyet consists of a long irregular strip of coast country, the eastern half of which is deeply indented and mountainous. The mineral wealth is great and the soil extremely fertile. There are extensive forests of pine, fir, oak, elm, and chestnut. Large quantities of walnuts are grown. In 1900 the exports amounted to £1,302,640 and the imports to £1,795,760. The population consists of 932,800 Moslems and 231,200 Christians, of whom 181,100 are Greeks. The people are Laz, Georgian, Greek, and Armenian, with a few Kurds, Tatars, Persians, and Europeans. (2) The chief town of the viláyet (the Greek *Trapezus*), and a military station, situated on the south coast of the Black Sea, and connected with Constantinople and Batum by sea and with Erzerum by a *chaussée* which forms part of the caravan route to Persia. The only harbour is the bay on the east, which is exposed to north and north-east winds, and is unsafe during their prevalence. In winter there are heavy gales from the north-east with sleet and snow, but the snow rarely lies. In 1900, including the Persian transit trade (£629,800), which is decreasing annually, the exports—cattle, hazel-nuts, tobacco, carpets, tumbeki, &c.—were valued at £760,670 (as compared with £565,200 in 1876), and the imports—cotton and woollen goods, petroleum, &c.—at £1,323,850 (£1,329,400 in 1876). Trebizond is the seat of British and other consuls. The population comprises 22,000 Moslems and 18,000 Christians. In October 1895 there was a massacre of Armenians, in which the police and soldiers took part.

Tredegar, an urban district (1894) and railway station in the Western parliamentary division of Monmouthshire, England, 7 miles east-north-east of Merthyr Tydfil by rail, on the river Sirhowy. The church of St James was erected in 1890, and the town hall in 1893. There is a large export trade in coal. Population (1891), 17,341; (1901), 18,574.

Treitschke, Heinrich von (1834–1896), German historian and political writer, was born at Dresden on the 15th of September 1834. He was the son of an officer in the Saxon army who afterwards rose to be governor of Königstein and military governor of Dresden. Young Treitschke was prevented by deafness from entering the public service. After studying at Leipzig and Bonn, where he was a pupil of Dahlmann, he established himself as a *privat-docent* at Leipzig, lecturing on history and politics. He at once became very popular with the students, who were attracted by his great oratorical power; but his political opinions, which he brought even into the lecture-room, made it impossible for the Saxon Government to appoint him to a professorship. He was at that time a strong Liberal; he hoped to see Germany united into a single state with a parliamentary government, and that all the smaller states would be swept away. In 1863 he was appointed professor at Freiburg; in 1866, at the outbreak of war, his sympathies with Prussia were so strong that he went to Berlin, became a Prussian subject, was appointed editor of the *Preussische Jahrbücher*, and from that time was one of the ablest advocates of Prussia on the German press. A violent article, in which he demanded the annexation of Hanover and Saxony, and attacked with great bitterness the Saxon royal house, led to an estrangement from his father, who enjoyed the warm friendship of the king. It was only equalled in its ill-humour by his attacks on Bavaria in 1870; his admiration for Prussia made it impossible for him to be just to those Germans who had not, like himself, voluntarily become Prussians. After holding appointments at Kiel and Heidelberg, he was in 1874 made professor at Berlin; he had already in 1871 become a member of the Reichstag, and from that time till his death in 1896 he was one of the most prominent figures in the city. On Sybel's death he succeeded him as editor of the *Historische Zeitschrift.* Among the students he enjoyed great popularity. His ardent patriotism communicated itself to his hearers. He had outgrown his early Liberalism, and become the chief panegyrist of the house of Hohenzollern. He did more than any one to mould the minds of the rising generation, and he carried them with him even in his violent attacks on all opinions and all parties which appeared in any way to be injurious to the rising power of Germany. He supported the Government in its attempts to subdue by legislation the Socialists, Poles, and Catholics; and he was one of the few men of eminence who gave the sanction of his name to the attacks on the Jews which began in 1878. As a strong advocate of colonial expansion he was also a bitter enemy of Great Britain, and he was to a large extent responsible for the anti-British feeling into which so much of German Chauvinism was directed during the last years of the 19th century. In the Reichstag he had originally been a member of the National Liberal party, but in 1879 he was the first to accept the new commercial policy of Bismarck, and in his later years he joined the Moderate Conservatives, but his deafness prevented him from taking a prominent part in debate. He died at Berlin on the 28th of April 1896.

As a historian Treitschke holds a very high place. His work, indeed, lies entirely in the history of the last two centuries. He approached history as a politician; he had none of the passion for research for its own sake, and confined himself to those periods and characters in which great political problems were being worked out: above all, he was a patriotic historian, and he never wandered far from Prussia. His great achievement was the *History of Germany in the Nineteenth Century.* The first volume was published in 1879, and during the next sixteen years four more volumes appeared, but at his death he had only advanced to the year 1847. It will remain a fragment, and it is much to be regretted that he did not live to complete the account of the Revolution, in which he would have had a subject worthy of his peculiar powers. The work shows extreme diligence, scrupulous care in the use of authorities, and in the years he covered he has left little for future historians to discover. It is too discursive and is badly arranged, but it is marked by a power of style, a vigour of narrative, and a skill in delineation of character which give life to the most unattractive period of German history; notwithstanding the extreme spirit of partisanship and some faults of taste, it will remain a remarkable monument of literary ability. Besides this he wrote a number of biographical and historical essays, as well as numerous articles and papers on questions arising out of contemporary politics, of which some are valuable contributions to political thought, while others are political controversy not always of the best kind.

The most important of the essays have been collected under the title *Historische und politische Aufsätze*, in four volumes, Leipzig, 1896; a selection from his more controversial writings was made under the title *Zehn Jahre deutscher Kämpfe;* in 1896 a new volume appeared, called *Deutsche Kämpfe, Neue Folge.* After his death his lectures on political subjects were published under the title *Politik.* He brought out also in 1856 a short volume of poems called *Vaterländische Gedichte,* and another volume in the following year. The only works translated into English are two pamphlets on the war of 1870, *What we demand from France* (London, 1870), and *The Fire-test of the North German Confederation* (1870).

See SCHIEMANN. *Heinrich v. Treitschke's Lehr- und Wanderjahre, 1836–66.* Munich, 1896. *Gustav Freitag und Heinrich v. Treitschke im Briefwechsel.* Leipzig, 1900. *Deutsche Rundschau,* October 1896; and article by J. W. HEADLAM, *Historical Review,* December 1897. (J. W. HE.)

Trencsén, a corporate town of Hungary, capital of the county of the same name, beautifully situated on the Vág, 70 miles north-east of Pressburg. Near it are the romantic ruins of the fort of Trencsén, which once played an important part in Hungarian history. Trencsén is one of the most considerable towns of upper Hungary, having a gymnasium with interesting collections, a State high school for girls, a public hospital, large barracks, a beautiful park, and several manufactories. The inhabitants of the town and of its vicinity are Slovaks, partly peddlers, who stroll through all parts of Europe with their merchandise. Not far from this town are the hot baths of Trencsén-Teplicz. Population (1891), 6075; (1901), 7011.

Trĕnggânu. See MALAY PENINSULA.

Trent, the chief town of that portion of Tirol, Austria, inhabited by the Italian element, on the left bank of the Adige, 44 miles north by east of Verona. The extensive fortifications are intended for the defence of the Adige valley and the one railway line leading directly from Italy into Tirol. Some of them occupy the isolated rocky height of Doss Trento, which rises about 230 feet above the town. Other outlying forts and batteries command separate ravines, valleys, and positions in the vicinity giving access to Trent from the west (Sarco Thal) and from the east (Val Sugana). Trent has now, in addition to the archiepiscopal seminary with complete theological faculty, an Italian upper gymnasium, an episcopal private gymnasium, a training college for female teachers, a school of commerce, &c. The manufactures comprise, in addition to the silk and textile industry, the preparation of salami, a strongly-spiced Italian sausage, sweetmeats and preserves, spirits, playing-cards, earthenware and furniture. Viticulture and the quarrying of marble and gypsum are also important resources of the inhabitants. A large monument to Dante, designed by Zocchi, was erected in 1896. Population (1890), 21,486; (1900), 24,908, including garrison of 2231 men.

Trente et Quarante, like roulette, is a purely gambling game, for no ingenuity or calculation on the part of the player can enable him to win. No game could possibly be more one of chance. The diagram illustrates one half of the table, the other half precisely corresponding to it. Two croupiers sit on each side of the table, one of them being the dealer; behind the two on the side opposite to the dealer a supervisor of the game has his seat. Six packs of fifty-two cards each are used; these are well shuffled, and the croupier asks any of the players to cut, handing him a blank card with which to divide the mixed packs. There are only four chances at trente et quarante: *rouge* or *noir,* known as the *grand tableau, couleur* or *inverse,* known as the *petit tableau.* The stakes are placed on the divisions indicated on the table, the maximum being 12,000 francs and the minimum 20 francs. The dealer, who has placed all the cards before him, separates a few with the blank card, takes them in his left hand and invites the players to stake with the formula, "Messieurs, faites votre jeu!" After a pause he exclaims "Le jeu est fait, rien ne va plus!" after which no stake can be made. He then deals the cards in a row until the aggregate number is something more than thirty, upon which he deals a second row, and that which comes nearest to thirty wins, the top row being always distinguished as *noir,* and the lower as *rouge.* In announcing the result the word *trente* is always omitted, the dealer merely announcing *un, trois, quatre,* as the case may be, though when forty is turned up it is described as *quarante.* The words *noir* and *inverse* are also never used, the announcement being *rouge gagne* or *rouge perd, couleur gagne* or *couleur perd.* Gain or loss over *couleur* and *inverse* depends upon the colour of the first card dealt. If this should be also the colour of the winning row, the player wins. Assuming, for example, that the first card dealt is red, and that the lower row of the cards dealt is nearest to thirty-one, the dealer will announce "Rouge gagne et le couleur." If the first card dealt is red, but the black or top row of cards is nearest to thirty-one, the dealer announces "Rouge perd et le couleur." It frequently happens that both rows of cards when added together give the same number. Should they both, for instance, add up to thirty-three, the dealer will announce "Trois après," and the deal goes for nothing except in the event of their adding up to thirty-one. *Un après* is known as a *refait;* the stakes are put in prison to be left for the decision of the next deal, or if the player prefers it he can withdraw half his stake, leaving the other half for the bank. Assurance against a *refait* can be made by paying one per cent. on the value of the stake with a minimum of five francs. When thus insured against a *refait* the player is at liberty to withdraw his whole stake. It has been calculated that on an average a *refait* occurs once in thirty-eight coups. After each deal the cards are pushed into a metal bowl let into the table in front of the

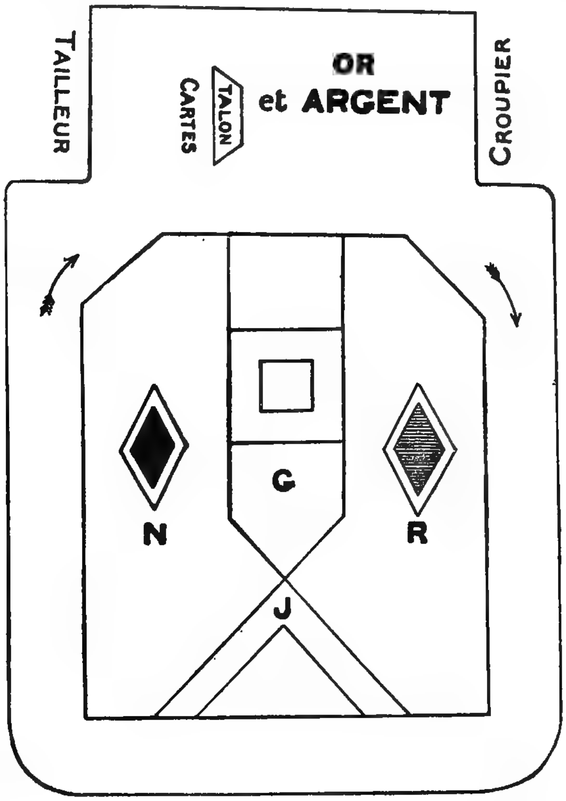

DIAGRAM OF HALF OF TRENTE ET QUARANTE TABLE.
N, *noir;* R, *rouge;* G, *grand tableau;* J, *inverse.*

dealer. When he has not enough left to complete the two rows, he remarks "Les cartes passent"; they are taken from the bowl, re-shuffled, and another deal begins.

(A. E. T. W.)

Trenton, a city of Missouri, U.S.A., capital of Grundy county, on the Grand river, and the Chicago, Rock Island and Pacific, and the Omaha, Kansas City, and Eastern railways, in the northern part of the state, at an altitude of 812 feet. It is in a farming region, for which it serves as a trading centre. It was founded in 1841, incorporated as a town in 1857, and received a city charter in 1893. Population (1890), 5039; (1900), 5396, 192 being foreign-born and 200 negroes

Trenton, a city of New Jersey, U.S.A., capital of Mercer county and of the state, on the Delaware river, at the falls and head of navigation, on the west boundary of the state. The plan of the city is irregular; it is divided into fourteen wards, has good water-supply and sewerage systems, and is well paved, mainly with brick and asphalt. Among the finer buildings are the state capitol, the public library, the court-house, and the United States building. Trenton is on the main line of the Pennsylvania railroad from New York to Philadelphia, and on a branch of the Philadelphia and Reading. It is a manufacturing city of great importance. In 1900 there were 570 establishments, with a total capital of $26,174,895. They employed 14,457 hands, and the product had a value of $31,645,695. The chief industries comprised iron and steel, $13,260,787; clay and pottery products, $4,785,142; rubber and elastic goods, $1,689,893; and foundry and machine-shop products, $894,239. For its pottery Trenton has long been famous, and also for the great wire works of the Roeblings. The assessed valuation of real and personal property was in 1900 $33,959,823, the net debt of the city was $2,613,990, and the rate of taxation was $21.50 per $1000. The total receipts, exclusive of loans, were $1,112,963, and the expenditure for maintenance and operation $698,450. At Trenton occurred one of the most celebrated military operations of the American Revolution. On Christmas night, 1776, Washington crossed the Delaware river into New Jersey, and the following day surprised and captured a British force of Hessian mercenaries. Population (1890), 57,458, a great increase since 1880, due in part to the extension of the charter limits; (1900), 73,307, of whom 16,793 were foreign-born and 2096 negroes.

Tréport, Le, a maritime town in the arrondissement of Dieppe, department of Seine-Inférieure, France, 45 miles in direct line N.N.E. of Rouen, on the railway from Beauvais, and at the mouth of the Bresle in the English Channel. It is a sea-bathing station, and a favourite resort of the Parisians. The principal buildings are the hôtel de ville, a tower and the church of St Jacques, both of the 16th century, the latter with fine modern glass, and an ancient timbered house. A casino, surrounded by gardens, was erected at the east end of the beach in 1896–97. The fisheries and oyster parks with their dependent industries and shipbuilding furnish the chief occupations of the inhabitants. The plateau of Mont Huon, rising above the town and reached by an ascent of 380 steps, affords a good view. Three miles east of Tréport is the little bathing town of Mers. Once a mere village, it now provides accommodation for the increasing number of visitors to Tréport. The port comprises a tidal harbour of 14 acres, with 1300 feet of quayage, depth alongside, high spring tide, 20 feet, and a new dock between the tidal harbour and the canal of 7 acres with 900 feet of quayage, depth alongside, 24 feet. The canal from Tréport to Eu has a length of 3 miles, and is navigable by vessels drawing 16 feet. The number of vessels entered in 1900 was 313 of 91,161 tons (from England 306 of 89,006 tons); cleared 354 of 97,471 tons (to England 347 of 96,379 tons). The total port traffic, including coasting trade, amounted to 193,331 tons. Large quantities of sugar, both raw and refined, are exported, chiefly to England, amounting in 1900 to 51,722 tons. Population (1891), 4297; (1901), 4949.

Trevelyan, Sir George Otto, Bart. (1838–——), British author and statesman, only son of Sir Charles Trevelyan, was born on 20th July 1838 at Rothley Temple, Leicestershire. His mother was Lord Macaulay's sister. He was educated at Harrow and at Trinity College, Cambridge, where he was second in the classical tripos. In 1861 he wrote his *Horace at the University of Athens.* The following year he went out as a civil servant to India, where he spent several years. During his stay he contributed *Letters of a Competition Wallah* to *Macmillan's Magazine* (republished 1864). *Cawnpore*, an account of that terrible tragedy, was published in 1865. During the same year he was elected to Parliament for Tynemouth in the Liberal interest. At the general election of 1868 he was returned for the Hawick Burghs, which he continued to represent until 1886. When the first Gladstone Ministry was formed, in December 1868, Mr Trevelyan was appointed Civil Lord of the Admiralty, but resigned in July 1870 on a point of conscience connected with the Government Education Bill. He advocated a sweeping reform of the army, including the abolition of the purchase of commissions, and both in and out of Parliament he was the foremost supporter for many years of the extension of the county franchise. In 1869 he wrote *The Ladies in Parliament*, a humorous political brochure in verse. In the session of 1874 Mr Trevelyan brought forward his Household Franchise (Counties) Bill, which was lost on the second reading; it was not till ten years later that the agricultural labourer was enfranchised. Among other causes which he warmly supported were women's suffrage, a thorough reform of metropolitan local government, and the drastic reform or abolition of the House of Lords. He was also in favour of the direct veto and other temperance legislation. In 1876 he published *The Life and Letters of Lord Macaulay*, one of the most admirable and most delightful of modern biographies; and in 1880 he published *The Early History of Charles James Fox.* In the latter year he was appointed Parliamentary Secretary to the Admiralty. This office he held until May 1882, when, after the assassination of Lord Frederick Cavendish, he became for two years Chief Secretary for Ireland. From November 1884 to June 1885 he was Chancellor of the Duchy of Lancaster. In February 1886 he became Secretary for Scotland, but resigned on 26th March on account of his disagreement with some of Mr Gladstone's Irish Home Rule proposals. The same year he succeeded his father in the baronetcy. At the general election of 1886 Sir George Trevelyan lost his seat for Hawick. As a representative of the Unionist party he took part in the Round Table Conference, and being satisfied with the modifications made by Mr Gladstone in his Home Rule scheme, he formally rejoined the Liberal party. In August 1887 he re-entered the House of Commons as member for the Bridgeton division of Glasgow; and from 1892 to 1895 he was Secretary for Scotland. Early in 1897 he resigned his seat in Parliament and retired into private life. In 1899 he published the first volume of a *History of the American Revolution*, coming down to 1776.

Treves (German, *Trier*), a town and episcopal see of Prussia, in the Rhine province, on the right bank of the Moselle, 69 miles by rail south-west of Coblenz. The most noteworthy of the modern public buildings is the provincial museum, built of red sandstone in 1885–89, and containing antiquities (many of them Roman), pictures, and objects of industrial art. There are also a bronze monument of the Emperor William I. (1893) and a fountain (1897) in commemoration of Archbishop Baldwin. Population (1885), 33,019; (1900), 43,324.

Treviglio, a town of the province of Bergamo, Lombardy, Italy, 15 miles by rail south by west of Bergamo. It has a fine church, an old castle, a technical school, important silk manufactures, wool-spinning, and manufacture of artificial manure, sulphuric acid, and glue. Population (1881), 9854; (1900), 10,000.

Treviso, a town, episcopal see, and capital of the province of Treviso, Venetia, Italy, on the plain between the Gulf of Venice and the Alps, 18 miles by rail north of Venice. In 1890 a monument to Dante (having regard to *Paradiso*, ix. 49) was erected on the bridge at the confluence of the Sile with the Botteniga. Treviso is the seat of various industries—ironworks, majolica and pottery, macaroni, cotton-spinning and rice-husking, paper, printing, brushes, brick-yards, flour-mills—and has a school of the industrial arts and sciences. Population (1900), 34,004.

Triberg, a town and health resort of Germany, grand-duchy of Baden, on the Black Forest railway, 35 miles south-east of Offenburg, a centre of the Black Forest clock trade. Straw-plaiting, saw-milling, and the manufacture of wooden wares are also carried on. It has a fine waterfall (500 feet), an industrial hall, a nerve-cure establishment, and a couple of technical schools. Altitude, 2251 feet. Triberg is what in Germany is called a "Luft-kurort," to which convalescents resort after a course of baths elsewhere. Population (1900), 3368.

Trichinopoly, a city and district of British India, in the Madras Presidency. The city is on the right bank of the river Cauvery, which here forms an island at the head of its delta, about 56 miles from the sea. It is an important junction on the South Indian railway, 219 miles south-west of Madras. Population (1891), 90,669; (1901), 104,690, being the largest town in the province after Madras; municipal income (1897–98), Rs.1,58,070. There is still a military cantonment. It has a large Roman Catholic population and several Protestant missions. The well-known Trichinopoly cigars are largely made from tobacco grown outside the district at Dindigul: there are fifteen cigar factories. It has, besides, specialities of goldsmith's work and of modelling in pith. The two colleges (Catholic and S.P.G.) had 335 students in 1896–97; the three high schools, 2604 pupils. There are seven printing-presses, one of which issues a Catholic periodical in Tamil, a reading-room and library. Bishop Heber died here in 1826.

The district of TRICHINOPOLY has an area of 3631 square miles. Population (1881), 1,215,033; (1891), 1,372,717, showing an increase of 13 per cent. after the famine of 1876–78; average density, 378 persons per square mile. Native Christians, mostly Catholics, numbered 69,410, or 5 per cent. In 1901 the population was 1,445,118, showing a further increase of 5 per cent. The land revenue and rates in 1897–98 were Rs.24,06,479, the incidence of assessment being R.1.13.4 per acre; cultivated area, 934,833 acres, of which 206,947 were irrigated, including 104,657 from Government canals; number of police, 729; boys at school (1896–97), 29,022, being 29·2 per cent. of the male population of school-going age; registered death-rate (1897), 21 per 1000. The principal crops are millet, rice, other food grains, and oil-seeds, with a little cotton, sugar-cane, indigo, and tobacco. The South Indian railway traverses the district for 93 miles.

Tricoupi, Charilaos (1832–1896), Greek statesman, was born at Nauplia in 1832. After studying law and literature in Athens and in Paris, he was sent to London in 1852 as an attaché of the Greek Legation. By 1863 he had risen to be chargé d'affaires, but he aimed rather at a political than a diplomatic career. In 1865, therefore, after he had concluded the negotiations for the cession by Great Britain to Greece of the Ionian Islands, he entered the Greek Chamber of Deputies, and in the following year was made Foreign Minister, at the early age of thirty-four. In 1875 he became Prime Minister for a few months, but had no opportunity even to begin carrying out the policy which he had in mind. This policy was to develop the resources of his country so as to create an army and a fleet, and thus to give Greece the power to acquire a leading place among the nations of south-eastern Europe. It was not until 1882 that he was able to take measures to this end. In that year he became Prime Minister for the third time (his second period of office, two years earlier, had lasted only for a few months), and at once set about the task of putting Greek finance upon a firmer basis, and of increasing the prosperity of the country by making roads, railways, and harbours. He was defeated at the general election in 1885, but in the following year he resumed office, and again took up the labour of economic and financial reform. His difficulties were now increased by the large expenditure which had been incurred for military preparations while he had been out of office, as the result of the union effected between Bulgaria and eastern Rumelia. The Greeks had demanded from Turkey compensation for this shifting of the balance of power, and had prepared to enforce their demand by an appeal to arms. The Great Powers, however, had interfered, and by blockading the Piræus had compelled Greece to remain quiet. Tricoupi, nevertheless, believed that he could in a few years raise the value of Greek paper currency to par, and upon that assumption all his calculations were based. Unfortunately for himself and for his country, he was not able to make his belief good. His dexterity in finance called forth general admiration, and his schemes for the construction of roads and railways met with a certain amount of success. But at last he was obliged to recognize that the warnings offered to him had been sound. Greece could not meet her obligations. Tricoupi tried to make terms with the creditors of his nation, but he failed in this also. The first taxation which he proposed aroused great hostility, and in January 1895 he resigned. At the general election, four months later, he and his party were defeated. He at once retired from public life, and soon afterwards the disease declared itself which eventually proved fatal He died at Cannes on 11th April 1896. The faults of excessive ambition and of a far too sanguine optimism, which marked Tricoupi's character, could not prevent him from being regarded, even during his lifetime, as the foremost Greek statesman of his time. He was not a favourite with the populace, nor was he beloved so much as respected by his followers. By nature he was reserved—his nickname was "the Englishman"—and he had no sympathy with the arts of the demagogue. But, both in the ranks of his own party and by the nation at large, his abilities and his force of character were unquestioned. It was his misfortune that the circumstances of the time did not allow his wide schemes for the benefit of his country to be carried into effect. (H. H. F.)

Trieste (German, *Triest;* Slovene, *Trst*), the principal seaport of the Austro-Hungarian monarchy, at the north-east extremity of the Adriatic Sea, constituting, with its adjoining territory, a separate Austrian crownland, and forming the seat of the administration for the Küstenland or littoral; total area, 36 square miles.

The population of the town and district, including 22 suburbs and villages and garrison of 1995 men, was in 1890, 157,466, or 437 per square mile (the population of town and suburbs was 146,556). Of this total 81,973 were female and 75,493 male (a reversal of the relations in the Küstenland as a whole, where the proportion of females to males is 976 to 1000); 77 per cent. Italian, 18 per cent. Slovene, and 5 per cent. German; 95 per cent. Roman Catholic, 3 per cent. Jews, and the Greek Orthodox and Protestant religions, 1 per cent. each. The population, which increases more slowly than the average of Austrian cities, was in 1900, including garrison, 178,672. In 1896 the marriage-rate was 8·15, the birth-rate, 30·92, or excluding still births, 30·16, and the death-rate, 27·73 per 1000. Of the births, 17·83 per cent. were illegitimate. The marriage-, birth-, and death-rates are declining.

Trieste sends 5 members to the Reichsrath, all Italian. The provincial diet, which at the same time performs the functions of municipal council, is composed of 48 Italians and 6 Slovenes. (For education, communications, &c., see Küstenland.)

In 1888 a monument was erected in commemoration of the 500th anniversary of the connexion of the town with Austria. Trieste, which had been a free port since 1719, and owed its previous prosperity to the release thus granted from hampering legislation, was deprived of that privilege in July 1891. It lost this advantage at a moment when it had to contend with various and increasing difficulties arising from a diversion of traffic towards the Italian and German coasts, the loss of part of the Levant trade through the development of the Orient railway system, and the growing rivalry of the neighbouring Hungarian port of Fiume, whose interests were vigorously promoted by the Transleithan Government. In 1901, however, the efforts to secure a second line of railway connecting Trieste with the interior were at length crowned with success through the adoption by the Reichsrath of the railway programme of the Körber Ministry. This had been recognized by successive Governments as of vital importance for the future of the Austrian export trade, and an important factor in the commercial rivalry between Austria and Germany, the Adriatic and the North Sea. The Government scheme provided for the realization of the two principal competing projects. The first was a line across the Karawanken range (Trieste-Klagenfurt, with a branch to Villach, to be opened in 1905), forming a direct connexion with Bohemia and the northern industrial districts of Austria, calculated to counteract the gravitation of traffic towards the German ports. The second was the Tauern scheme (from Möllbrücken in Carinthia to Schwarzach in Salzburg, through the Gastein valley, to be completed in 1908), the shortest and cheapest route to the Austrian interior, as well as to south Germany, which was expected to raise Trieste to the rank of a first-class harbour. An objection to this line was formerly raised by a section of the Italian element in the town. It would, they contended, bring the Germans to Trieste, and experience had shown that where they once set foot commercially they finished by establishing their political predominance. Another suggestion for reinvigorating Trieste is the construction of a canal connecting it with the Danube.

The total net tonnage of vessels entering and departing in 1871 was 1,900,000. In 1896 it amounted to 3,500,000 tons, the lowest increase of any large European port. In 1890, while still a free port, the total value of the exports and imports was £58,333,000. There was a reduction of £6,416,600 in the following year, but in 1892 trade had begun to recover, the total being £54,583,300, to fall again in 1895 to £52,390,000. Of the entire trade of Trieste, 55 per cent. is with the Levant and the Far East. In 1892 its mercantile fleet consisted of 1267 ships of an aggregate burden of 105,504 tons. These included 110 steamers, of which three-fourths belonged to the Austrian Lloyd, which receives subventions from the state. Fifty-one vessels (5 of them steamers) with a total tonnage of 1660 were built in the docks of the Austrian Lloyd and the Stabilimento Tecnico Triestino, which employ over 3000 hands. Other important industries include the construction of marine steam engines, brewing, tanning, the manufacture of anchors, cables, silk and cotton stuffs, soap, wax, wine, liqueurs, furniture and clothing. The most important natural products are fruit, corn, and oil.

Authorities.—Neumann-Spallart. *Oesterreichs maritime Entwickelung und die Hebung von Trieste* (Stuttgart, 1882).—Soussa. *Storia cronografica di Trieste* (Trieste, 1885–86).—Ireno della Croce. *Storia di Trieste* (Trieste, 1879).

(Æ. O'N.)

Trifail (Slovene, *Trbovlje*), a commune in the government district of Cilli, in Styria, Austria, near the left bank of the Save and 28 miles east by north of Laibach. It is the centre of an extensive lignite deposit, which yields about 300,000 tons annually. There are also large cement works, and manufactures of chemicals and glass. Population (1890), 8464; (1900), 10,851.

Trikkala (the ancient *Trika*), a town of Greece, capital of the province of Trikkala, 38 miles west of Larissa, and after that town the largest in Thessaly. It has the appearance of a Mussulman town, on account of its mosques (only one of which, however, is in actual use), and it is a centre of trade in wheat, maize, and tobacco. Population (1889), 14,820; (1896), 21,149.

Trincomali, a town and naval station on the north-east coast of Ceylon, 100 miles north-east by north of Kandy. It is no longer the principal capital, having been superseded by Batticaloa, but with its magnificent harbour—one of the five or six greatest natural harbours in the world—it continues to be the headquarters of the admiral commanding on the East Indian station, and there is a garrison of infantry and British artillery. A steamer from Colombo calls weekly with and for passengers and cargo. Average annual rainfall, 62¾ inches; average temperature, 81·2°. Some tobacco, rice, and palms are grown in the district. Population (1900), about 13,000; of district, 28,500.

Tring, a market town and urban district (1894), Hertfordshire, England, in the Watford parliamentary division of the county, 7 miles south-east of Aylesbury. The Rothschild Museum, erected in 1889, contains a very extensive natural history collection, and in a paddock and cages a short distance from the building live animals are kept. Population (1891), 4525; (1901), 4368.

Trinidad, the most southerly, and with the exception of Jamaica the largest, of the British West Indian Islands. Area, 1754 square miles, or nearly 1,123,000 acres. In 1889 Tobago was annexed to Trinidad to form one colony, and since 1899 that island has been incorporated as a ward of the united colony of Trinidad and Tobago. The soil of Trinidad is varied and extremely fertile. Population (1891), 200,028; (1901), 253,250. Of the population a third are East Indians. Of the other two-thirds, the upper classes are mainly of pure or mixed British, French, Corsican, or Spanish blood, while the lower classes are of pure or mixed negro origin. Immigration from India is conducted under Government control, £48,809 being expended for this purpose during 1898. The immigrants numbered 1940 in 1893, 3087 in 1896, and 1292 in 1898. Port-of-Spain, the capital, has a fine harbour, with 7 miles of tramway and 500 miles of telephones; its population in 1900 was 55,000. A system of underground drainage has been constructed. Two other boroughs of importance are San Fernando (7641) and Arima (3653).

The climate is both hot and damp: annual death-rate about 26 per 1000; average rainfall annually about 62 inches at the Botanic Garden. The wet season begins in June and lasts till December, with a short cessation in September. The mean annual temperature is about 80°. In Port-of-Spain, in May, June, September, and October, the shade temperature often reaches 90°; in December and March it often falls below 70° at night.

The principal industries are the cultivation of cacao, sugar-cane-growing, and the manufacture of sugar, rum, and bitters; the growing of coffee, tobacco, cocoanuts, oranges, bananas, and timber (such as mahogany and cedar), dye-woods (logwood and fustic), and balata, rubber-trees; stock-farming, &c. The area under cacao cultivation is nearly twice that of sugar. Cane-farms, as opposed to sugar estates, are on the increase. Large quantities of asphalt are annually exported from the Pitch Lake in La Brea, 90 acres in extent, by a British company which has the exclusive right of digging from the lake, in return for an annual sum (£10,000) and a royalty to the Government, which together in 1898 produced £34,056. The value of the imports in 1900 was £2,500,258; exports, £2,593,475. The trade is principally with the United Kingdom, the United States, France, and Venezuela. The transport trade (almost entirely with Venezuela) represents a quarter of the commerce of the colony. The values of the principal native products and manufactures exported in 1900 were: sugar, with molasses and rum, £552,158; cacao, £978,632; asphalt, £177,460. Large quantities of Tonga beans, the produce of the mainland, are cured in Port-of-Spain, in bond; and as much as £30,000 worth has been shipped in a single year. Out of a total area of 1,123,000 acres, 450,926 acres are unalienated Crown lands. About 205,000 acres are under cultivation.

The revenue in 1900 was £698,939; expenditure, £659,079; public debt, £918,472. About thirty-four steamers call at Trinidad per month. Port-of-Spain is in direct communication with Southampton. The shipping entered and cleared in 1900 had a total tonnage of 1,178,494, of which 591,102 was British. The island is not well furnished with roads, the total mileage being 193. There are 90 miles of railway, besides several miles of steam, electric, and mule tramways; and 166 miles of internal telegraphs.

Places of worship are owned as follows:—Roman Catholic, 60; Anglican, 51; Baptist, 16; Wesleyan, 13; Presbyterian, 8 (and 59 chapels). The bishopric of Trinidad forms part of the West Indian Province of the Church of England. The 239 elementary schools are of two kinds: (1) 56 Government schools, which are secular; (2) 183 denominational schools, aided by grants. In 1898 there were 9810 children on the rolls of the former and 18,056 on those of the latter. Fees are paid. More than a quarter of the assisted schools are managed by a Canadian mission. Agriculture is a compulsory subject. For higher education there are the Queen's Royal College (secular), and its affiliated institutions, St Mary's College (Roman Catholic), and a school managed by the Canadian mission. Attached to these are four exhibitions of the value of £150 a year, tenable for three years at an English university, granted annually. There are also many private schools. English is generally spoken in the towns, and in some of the districts. In the country parts of the north, and generally in the cacao-growing districts, the common language is a French patois. Over some small areas Spanish is still spoken. There are good hospitals at Port-of-Spain (320 beds) and San Fernando (120 beds), 8 district hospitals, a segregation hospital, and a lunatic asylum. There is no poor law. There is no regular military force in the colony. There are three volunteer corps—light horse, garrison artillery, and light infantry—making a total force of 697 men. The police force numbers 555 officers and men. There is a Legislative Council consisting of the governor with 9 official and 11 unofficial members all appointed by the Crown.

(F. CU.)

Trinidad, an uninhabited island in the South Atlantic, 680 miles east of the coast of Espirito Santo, Brazil, in 20° 30′ S. and 29° 30′ W., 4 miles long by 2 broad. It is of volcanic formation, and has fertile springs of fresh water. As a possible coaling and telegraph station in mid-ocean, it has formed a subject of contention between Brazil and Great Britain. The dispute was settled in favour of Brazil, which claimed on the ground of its discovery by Tristan da Cunha early in the 16th century, while Great Britain relied on its occupation by the astronomer Halley in the name of England in the year 1700. About 30 miles farther east are the three islets of Martin Vaz, so named from the Portuguese mariner who discovered them about 1510.

Trinidad, a city of Colorado, U.S.A., capital of Las Animas county, on the Purgatory river, at the foot of the Raton Mesa, in the southern part of the state. It has a hilly site, on which it is regularly laid out, and has a good water-supply. It is on three railways—the Denver and Rio Grande, the Colorado and Southern, and the Atchison, Topeka, and Santa Fé. It is in a stock-raising region, and near the rich coal-fields of southern Colorado. It has railway works and coking ovens, and handles large quantities of coal. Population (1895), 5982; (1900), 5345, of whom 659 were foreign-born and 125 negroes.

Trinidad, a town near the southern coast of Cuba, about 35 miles south-east of Cienfuegos, and 3 miles from its seaport, Casilda, which lies due south. It is one of the original seven cities of Cuba founded by Lieutenant-Governor Diego Velasquez in 1513. Sugar and honey are exported. The town, which is surrounded by high mountains, is mediæval in aspect, but contains some fine buildings. The scenery, which is unexcelled, and the climate, which is considered to be the healthiest in Cuba, make the place a favourite resort for natives and foreigners. Population (1899), 11,120.

Tripoli, a Turkish vilayet (regency) of North Africa, extending from the Mediterranean to the Sahara Desert in 23½° N. Much fresh light has been thrown on its physical, ethnical, and economic relations by Haimann, Fournel, Cowper, Borsari, and other observers. Tripoli does not form a geographical unit, but comprises at least five distinct regions—Tripoli proper, the Barca plateau (*Cyrenaica*), the Aujila oases, Fezzan, and the oases of Ghadames and Ghat—which with the intervening sandy and stony wastes occupy the whole space between Tunisia and Egypt, extend from the Mediterranean southwards to the Tropic of Cancer, and have a collective area of about 400,000 square miles, with a population variously estimated at from 1,200,000 to 1,600,000. The regency has remained almost untouched by the political changes by which the map of Africa has been so profoundly modified since the early 'eighties. Towards the south and east the frontiers still remain undefined. But on the west side, where the country is conterminous with Tunisia, the conventional line laid down by agreement with France in 1886 was more accurately determined in 1892, when the terminal point on the Mediterranean was shifted from Borj-el-Biban to the Ras Ajir headland, 18 miles to the south-east, in 33° 12′ N. and 12° E. From this point the line runs southwards along the Wed Magla and across the El Erg dunes in such a way as to leave Ghadames to Turkey. Beyond that oasis the line has not been traced, because the southern region as far as Ghat, which is recognized as belonging to the vilayet, is held by the still independent Azjar (Tuareg) nomads.

Physical features.

For some distance east of Tunis the seaboard is low and sandy, and is often regarded as a part of the Sahara, which, however, begins only some 80 miles farther south, beyond the Jebels Nefusi, Yefren, and Ghurian (Gharian). The "Jebel," as this system is locally called, terminates eastwards in the Tarhona heights of the Homs (Khoms) coast district, has a mean altitude of about 2000 feet, and culminates in the Takut volcano (2800 feet), nearly due south of the capital. It is not, however, a true mountain range, but rather the steep scarp of the Saharan plateau, which encloses southwards the Jefara coast plains, and probably represents the original coast-line. The Ghurian section is scored in places by the beds of intermittent coast streams, and on its lower slopes is clothed with a rich sub-tropical vegetation. South of these escarpments, which Cowper calls the "Tripoli chain," the vast Hammada el-Homra, the "Red Hammada," an interminable stony tableland covering some 40,000 square miles, occupies the whole space between Tripoli proper and the Fezzan depression. The now uninhabited and waterless Hammada formerly drained through several large rivers, such as the Wadys

Targelat (Uani, Kseia), Terrgurt, Sofejin, Zemzem, and Bel, north-eastwards to the Gulf of Sidra (*Syrtis major*). Southwards the tableland is skirted by the Jebel Welad Hassan, the Jebel es-Suda, the Jebel Morai-Yeh, and other detached ranges, which have a normal west to east trend in the direction of the Aujila oases, rising little above the level of the plateau, but falling precipitously towards Fezzan. The Jebel es-Suda ("Black Mountains"), most conspicuous of these ranges, with a mean altitude of 2800 feet, takes its name from the blackened aspect of its limestone and sandstone rocks, which have been subjected to volcanic action, giving them the appearance of basalt. Eastwards this range ramifies into the two crescent-shaped chains of the Harúj el-Aswad and Harúj el-Abiad ("Black" and "White" Harúj), which rise some 700 feet above the Red Hammada, and enclose an extensive Cretaceous plateau, which has never been visited since it was crossed by Hornemann in 1798. Beyond the barren Ghadama district in the extreme north, the dreary aspect of the wilderness is broken by several productive tracts under grass, corn, and date-palms, and even containing some permanent reservoirs in the beds of the Wadys Sofejin and Zemzem, where the plateau falls from a mean height of 2000 feet to 1000 and 530 feet respectively. But it again rises rapidly southwards to a somewhat uniform level of 1600 or 1700 feet, and here the main caravan route from Tripoli to Murzuk and Lake Chad traverses for a distance of fully 130 miles a monotonous region of sandstone, underlying clays, marls, gypsum, and fossiliferous silicious deposits. In its northern section this part of the Hammada, as it is locally called in a pre-eminent sense, is relieved here and there by a few patches of herbage, scrub, and brushwood, with even a little water left in the rocky cavities by the heavy showers which occasionally occur in this almost rainless desert.

The Aujila depression.

North-eastwards the Neddik pass over the Jebel Morai-Yeh leads down to the remarkable chain of low-lying oases, which, from the chief member of the group, is commonly called the Aujila depression. Collectively the oases present the aspect of a long winding valley, which is enclosed on the north side by the southern escarpments of the Barca plateau, expands at intervals into patches of perennial verdure and shallow saline basins, and extends from the Wady el-Fareg, near the Gulf of Sidra, through the Bir Rassam, Aujila, Jalo, Faredgha, and Siwah oases, to the Natron lakes and the now dried-up branch of the Nile delta known as the Bahr bilá-Má ("waterless river"). The whole region presents the aspect of a silted-up marine inlet, which perhaps in Pliocene times penetrated some 300 miles south-eastwards in the direction of the Nile. Nearly all the fossil shells found in its sands belong to the fauna now living in the Mediterranean, and Siwah is still actually 98 feet below sea-level. This is true also of its eastern extensions, Sittra (80) and the Birket el-Kerun in the Fayum (141). But Aujila and Jalo stand, on the contrary, 130 and 296 feet respectively above sea-level, so that the idea at one time entertained by Rohlfs of transforming the chain of oases into a marine gulf, and thus converting the Barca plateau into an island or peninsula in the midst of the Mediterranean waters, and in fact flooding the Libyan desert, must share the fate of Rudaire's equally visionary scheme in respect of the Algerian Sahara.

The Barca plateau.

The Barca plateau, which falls in terraces down to the Aujila depression, and presents an unbroken rampart of steep cliffs towards the Mediterranean, is by far the most favoured region of the viláyet. Its many natural advantages of climate, soil, and vegetation had already in remote times attracted numerous Egyptian settlers to *Barke* (later Ptolemais) and other points. But these were afterwards replaced by Greek colonies, the oldest and most famous of which was the Dorian settlement of *Cyrene*, dating from about 630 B.C. From this place the whole region took the name of Cyrenaica, and was also known as *Pentapolis*, from its "five cities" of Cyrene, Apollonia, Arsinoe, Berenice, and Barke. The elevated plateau of Cyrenaica, which encloses the Gulf of Sidra on the west, is separated southwards by the Aujila depression from the Libyan desert, and projects northwards far into the Mediterranean, might seem, like the Atlas region in the extreme west, to belong geologically rather to the European than to the African mainland. It has a mean altitude of considerably over 2000 feet, and in the Jebel Akhdar ("Green Mountains") attains a height of nearly 3500 feet. Eastwards the Barca uplands merge gradually in the less elevated Marmarica plateau, which nowhere rises more than 1800 feet above sea-level, and disappears altogether in the direction of the Nile delta.

The Kufra oases.

South of the Aujila depression the land rises steadily to a height of nearly 1200 feet in the *Kufra* oases, which lie to the north of the Tropic of Cancer and due east of Fezzan, of which they may be regarded as a geographical dependency. The group consists of five distinct oases in the heart of the Libyan desert—Taizerbo, Zighen, Bu-Zeima, Erbena, and Kebabo—which extend for a distance of 200 miles north-west and south-east, and have a collective area of 7000 square miles and a present population of 6000 or 7000 Arabo-Berber nomads. Good water is obtained in abundance from the underground reservoirs, which lie everywhere within a few feet of the surface, and suffice to support over a million date-palms. Kufra, that is, "Infidels" (in reference to the now extinct pagan Tibu aborigines), is a great stronghold of the Senúsiya brotherhood, whose *zawya* (convent) at Jof, in Kebabo, ranks next in importance to that of Jarabub, their chief station in the Sahara. This circumstance, together with the great fertility of the group and its position midway on the caravan route between Cyrenaica and Wadai, imparts exceptional political and commercial importance to these oases.

Fezzan.

Fezzan, the ancient *Phazania*, appears to have been the chief centre of the Garamantes, whose empire was overthrown by the Romans in the reign of Augustus. A stone monument near their capital *Garama* (now Jerma) marks the southernmost limit of the Roman dominion in the interior of the continent. The Romans were succeeded in the 7th century by the Arabs, who maintained their independence till the 16th century, when Fezzan was attached to the Turkish viláyet of Tripoli. The Hofra ("ditch"), as it is called, does not form a continuous fertile tract, as might be supposed from the large space on most maps coloured green and labelled "Fezzan," but rather consists of a monotonous sandy expanse somewhat more thickly studded with verdant isles than the surrounding wastes. The oases are numerous, especially in the district of the capital, Murzuk, and farther north, in the Wady Lajâl, a long narrow valley which trends north-east in the direction of the White Harúj, and the western section of which—the Wady Gharbi—is the most fertile tract in the whole of Fezzan. Here are several perennial springs, and even lacustrine basins with cornfields and date-groves, enlivened by flocks of doves and hoopoes. One of these basins, the saline Bahr el-Dud ("Sea of Worms"), has an extent of no less than 600 square miles, with a depth, according to Vogel, of at least 26 feet. Here stood *Old Jerma* (Garama), capital of the Garamantes and of the Roman province, later replaced by *New Jerma*, a little farther north. Murzuk, the present capital, dating from about the 12th century, is less favourably situated, lying farther east near the Wady Sherkiya wells, where the Hofra falls to its lowest level, about 600 feet above the sea. It has a mixed population of about 7000 Arabs, Tuaregs, and Negroes, who are almost entirely dependent on the caravan trade between Sudan and Tripoli.

From Murzuk a beaten track leads across a stony waste, west by south, to the oasis of Ghat; and it was at the Sharaba wells, on this route, that Miss Tinné was murdered by the Tuaregs in 1869. East of Murzuk follow the oases of Traghen, Zuila, and Temissa, and far to the south-east Wau el-Kebir, discovered by Beurmann in 1862. Southwards the Hofra again rises to a height of 2000 feet, and in this direction lies the oasis of Gatron, followed by Tejerri on the verge of the desert, which marks the southern limit of the date and the northern of the dum palm. Beyond Tejerri the Saharan plateau rises continuously to the Tibesti highlands, from which it seems evident that Fezzan is a true depression, like Lake Chad an old lacustrine basin without seaward outflow, and flooded at a time when the Sahara enjoyed a moister climate than at present.

Ghat.

Ghat stands 2400 feet above the sea, on the Wady Aghelad in the Igharghar basin, and consequently belongs, not to the Fezzan depression, but to the Saharan plateau. The Aghelad, or "Passage," trends north to the Iasawan valley along the east foot of the Tasili plateau, that is, the divide between the waters which formerly flowed north to the Mediterranean, west to the Atlantic, and south to the Niger and Chad basins. Ghat, which is skirted eastwards by the Akakus range, forms a sandy plain dotted over with clumps or groves of date-palms. In the centre is an open space where is held a great annual fair, and to this, combined with its position on one of the caravan routes across the desert, the oasis owes all its importance. There is a collective population of perhaps 10,000, nearly all Ihajenen Tuaregs, about half of whom are concentrated in the town of Ghat, which appears to be a relatively modern place, successor to *Rapsa*, a great commercial centre and military station under the Roman empire.

Ghadames.

Ghadames, on the contrary, is a very old place, being the *Cydamus* of the Garamantes, the capture of which by Cornelius Balbus led to the overthrow of their empire. The oasis, which stands on the Cretaceous Tinghert plateau, 300 miles south-west of Tripoli, and 1200 feet above the sea, is enclosed by a circular rampart over three miles in circumference. The town, which occupies the south-west corner of the enclosure, has a population of about 7000, forming distinct ethnical and even hostile groups of Arabs, Berbers, and Negro freedmen, all following their own customs and speaking their own language, but using Berber as the medium of general intercourse. Owing to some perennial springs and artesian wells, the oasis is very productive, yielding an abundance of dates, figs, apricots, and vegetables, besides some wheat, barley, and millet. It occupies a highly advantageous position at the converging-point of several caravan routes, and has extensive trading relations with the markets of Tripoli, Tunis, and Sudan. The Turkish authority is little more than nominal, and the French masters of Tunis are looking forward to the peaceful occupation of Ghadames in the near future.

Inhabitants past and present.

The explorations of Duveyrier, Largeau, Von Bary, and Cowper have shown that Tripoli was not only inhabited by primitive man, but was the seat of a flourishing Neolithic culture, comparable to and in many respects resembling that of Iberia, Brittany, and the British Isles. As in other parts of Mauritania, many now arid and uninhabitable wastes are strewn with monolithic and other remains, which occur in great variety of form and in vast numbers, as many as 10,000, chiefly of the menhir type, having been enumerated in the Mejana steppe alone. All kinds of megalithic structures are found—dolmens and circles like Stonehenge, cairns, underground cells excavated in the live rock, barrows topped with huge slabs, cup stones, mounds in the form of step pyramids, and sacrificial altars. Most remarkable are the "Senams," or trilithons of the Jebel Msïd and other districts, some still standing, some in ruins, the purpose of which has not been determined. They occur either singly or in rows, and consist of two square uprights 10 feet high standing on a common pedestal and supporting a huge transverse beam. In the Terrgurt valley "there had been originally no less than eighteen or twenty megalithic trilithons in a line, each with its massive altar placed before it" (Cowper). There is reason to believe that the builders of these prehistoric monuments are represented by the Hamitic Berber people who still form the substratum, and in some places the bulk, of the inhabitants of Tripoli proper. But even here the Berbers have for the most part been driven to the Ghurian and Tarhona uplands by the Arab nomads, who now occupy the Jefara flats about the capital, and are in almost exclusive possession of Cyrenaica, Marmarica, and the Aujila oases. In Fezzan the Saharan Berbers (Tinylkum Tuaregs) are still dominant, but are here largely intermingled with Negro or Negroid intruders from Sudan. But even in the uplands many of the Berbers have been Arabized, and Cowper describes those of the Tarhona heights as even "pure-bred Arabs." Other early intruders are the Jews, some of whom arrived from Egypt in the time of the Ptolemies, and are still found leading the life of troglodytes in the limestone caves of the Ghurian escarpments. They are also numerous in the large towns, where the population is further diversified by the presence of Turkish officials and garrison troops, of Maltese, Italian, and other South European traders and artizans.

Towns and trade.

On the other hand, no trace can now be detected either of the Greeks who colonized Cyrenaica in the 7th century B.C., or of the Phœnicians who at a still earlier date founded the three great cities of Œa, Sabrata, and Leptis Magna, from which the western region projecting seawards between the two Syrtes took the name of Tripolitana. Later, when Œa, which stood between the two others, was made the capital of the province, it was called Tripolis, the "Three Cities," as it were, rolled into one, and this name it has retained since Roman times, being now distinguished from the Tripolis of Syria as West Tripolis, the *Tarabulus el-Gharb* of the Turks and Arabs. TRIPOLI, still the capital of the province, is thus one of the oldest places in the world, and no doubt owes its stability in large measure to its position over against Sicily at the northern terminus of three great historic caravan routes, one of which runs due south to Lake Chad through Fezzan and Bilma, that is, across the narrowest part of the Sahara; another runs south-west through Ghadames to Timbuktu, and the third south by east through Sokna to Wadai and Darfur. The city, which has a population (1900) of 30,000 within its crumbling walls, besides an equal number of semi-nomad Arabs and Negro freedmen in the Meshiya district round about the ramparts, occupies the south-west side of a crescent-shaped bay partly sheltered by a chain of low reefs from the northern winds. The harbour or roadstead has a depth of about 20 feet, but owing to a dangerous bar is inaccessible to vessels drawing over 14 feet. In 1899 the port was visited by over 600 ships of 200,000 tons, of which 70, of 51,000 tons, were British. In Barca the only important centre of population is *Benghazi*, the ancient *Berenice*, at the southern extremity of a headland which formerly enclosed a spacious natural haven on the north-east side of the Gulf of Sidra. But the harbour has been partly filled up by the ruins of a large fortress, and is now inaccessible to vessels drawing over 6 or 7 feet. Benghazi has a mixed population of about 15,000 Arabs, Berbers, Jews, and Negroes. East of Benghazi is the exposed roadstead of *Derna*, which was occupied by the Americans in 1815. Nothing has been done to complete the harbour works begun by them; but it is now proposed to restore the port of *Marsa-Susa*, the ancient *Apollonia*, which lies under the Ras Sem headland, and was formerly much frequented as the emporium of the neighbouring city of Cyrene (Grenna). The Government has displayed much activity in this fertile and healthy district, to which have been removed many of the Turkish inhabitants of Crete dissatisfied with the present relations in that island. Nearly the whole of the foreign exchanges pass through the ports of Tripoli and Benghazi, where the total imports were valued in 1900 at £499,500, and the exports at £418,500. Of the imports, chiefly cottons, silks, sugar, and flour, £123,000 were British; while the exports to Great Britain, chiefly alfa-grass, sponges, ostrich feathers, wool, skins, and ivory, were valued at £158,000. The caravan trade across the Sahara with Sudan has suffered a severe blow by the opening of new routes to the Atlantic through British and French territories (Niger, Benue, and Senegal routes). Nevertheless the total exchanges rose from £143,000 in 1897 to nearly £200,000 in 1898. The convoys bound for the interior of the continent are laden chiefly with English cottons, Venetian beads, Bohemian glass, silks, paper, tea, and sugar, and return with ostrich feathers, dressed goat-skins, and ivory. Some of these wares reach the capital from Wadai by the Benghazi route. (For climate, natural history, administration, and other details, see TRIPOLI in the ninth edition of this work.)

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(A. H. K.)

Tripoli, now *Tarábulus*, the chief town of a sanjak of the same name in the Beirut viláyet in Syria, situated about 2 miles inland from its port, el-Mina. The population, including el-Mina, amounts to 30,000 (Moslems 24,000, Christians 6000). In 1900 the exports were valued at £607,700 and the imports at £311,800, the principal exports being silk thread, cereals, lemons and oranges, wool, sponges, and soap.

Tristan da Cunha, a group of three islands belonging to Great Britain, situated in the South Atlantic, 1500 miles south-west of St Helena. Annexed in 1816, the garrison was removed in the next year. Three men, of whom one was married and had ten children, remained behind, and from these, together with settlers from whaling ships, the present population is derived. It consisted in 1897 of 64 persons, against 109 in 1880. In spite of healthy surroundings and of naturally fine physique, the race appears to be deteriorating from want of infusion of fresh blood. What government there is is carried on under a patriarchal system. The question of education presents great difficulties. It has been proposed that the children should be sent to Cape Colony to receive their education. The climate, though very windy and rainy, is healthy, averaging from 68° in summer to 55° in winter. Tristan da Cunha is visited once a year by a British war-vessel.

Trivandrum, or TREVANDRUM, a town of southern India, capital of the state of Travancore, situated about 2 miles from the sea-coast. Population (1891), 27,887. The best houses and chief public buildings stand on hilly terraces above. There is a cantonment for the Nair brigade. The town contains the

Maharaja's college, a Sanskrit college, a high school, a school for girls, and an industrial school of arts, a hospital and medical school, an observatory and museum. There is little trade, but it makes a speciality of wood-carving.

Trochu, Louis Jules (1815–1896), French general, was born at Palais, near Belleisle, Morbihan, on 12th March 1815. Educated at St Cyr, and at the Staff Corps Practical School, he received a commission in the army in 1837, was promoted lieutenant in 1840, and captain in 1843. He served as a captain in Algeria under Marshal Bugeaud, who, in recognition of his gallantry in the battles of Sidi Yussuf and Isly, made him his adjutant and entrusted him with important commissions. He was promoted major in 1845, and lieutenant-colonel in 1853. He served with distinction throughout the Crimean campaign, first as colonel and aide-de-camp to Marshal St Arnaud, and then as general of brigade (Commander, Legion of Honour, and general of division). He again distinguished himself in command of a division in the Lombardy campaign of 1859 (Grand Cross, Legion of Honour). In 1866 he was employed at the Ministry of War in the preparation of army reorganization schemes, and he published anonymously in the following year *L'Armée Française en 1867*, a work inspired with Orleanist sentiment, which ran through ten editions in a few months and reached a twentieth in 1870. This brochure brought him into bad odour at Court, and he left the War Office on half-pay, but was afterwards selected to command the Toulouse division. After the disasters in the war with Germany in 1870, he was appointed (17th August) governor of Paris and commander-in-chief of all the forces destined for the defence of the capital, including some 120,000 regular troops, 80,000 mobiles, and 330,000 National Guards. He worked energetically to put Paris in a state of defence. At the revolution of the 4th September, he became president of the Government of National Defence in addition to his other offices. His "plan" for defending the city raised expectations doomed to disappointment; the successive sorties made on the besieging Germans were unsuccessful, and having declared in one of his proclamations that the governor of Paris would never capitulate, when capitulation became inevitable he resigned the governorship of Paris on 22nd January 1871 to General Vinoy, retaining the presidency of the Government until after the armistice in February. He was elected to the National Assembly by eight departments, and sat for Morbihan. In October he was elected president of the Council General for Morbihan. In July 1872 he retired from political life, and in 1873 from the army. He published, in 1873, *Pour la Vérité et pour la Justice*, in justification of the Government of National Defence, and in 1879 *L'Armée Française en 1879, par un officier en retraite.* He died at Tours on 7th October 1896. (R. H. V.)

Troitskosavsk, a district town of Russia, in the province of Transbaikalia, 2¼ miles from Kyakhta and 2½ miles from the Chinese frontier. When the main trade was transferred to Kyakhta, the town fell into decay for a period, but it has already begun to revive, and was made the chief town of a district in 1901. Population (1897), 9213.

Trombetas. See Amazon.

Tromsö, a seaport town of Norway, capital of the county of Tromsö, in 69° 38′ N. It has a trade, valued at £130,000 to £170,000 per annum, in the export of whale and seal oil (£34,500), and fish (£37,000); and in the import of coal (£25,250), textiles, salt, grain, and flour. Mean temperature of year 36·4° Fahr.; February, 25°; July, 51·8°. Population (1875), 5409; (1900), 6955.

Trondhjem, a seaport town and bishop's see of Norway, on the west coast, and south side of Trondjhem Fjord, 349 miles by rail north of Christiania, and 531 by rail north-west of Stockholm *viâ* Östersund. The restoration of the choir of the cathedral was finished in 1890; that of the north and south transepts in 1900. The bishop's palace has been converted into barracks and arsenal, and there are a new fisheries museum and industrial art museum. The city's commerce has grown with the prosperity of the Röros and Sulitelma mines, and with the opening of the railway from Östersund, increasing from £747,000 in 1882 to £1,226,500 in 1892 and £1,903,000 in 1899. Of this about three-fifths is for imports—coal, grain and flour, groceries, salt, and machinery; the remainder being for exports—timber, wood-pulp, fish, butter, copper, iron, and pyrites. The bulk of the imports comes from Great Britain, and a large portion of the exports passes overland by rail into Sweden. In 1900 the port was entered by 484 vessels of 277,743 tons, as compared with 230 vessels of 111,100 tons in 1886. The industries embrace saw-mills, wood-pulp factories, fish curing factories, machine shops, and a shipbuilding yard. Population (1891), 29,162; (1900), 38,156.

Troon, a police burgh (1896), seaport, railway station, and watering-place of Ayrshire, Scotland, 6 miles north by west of Ayr. It has the best natural harbour in the county, with over a mile of quayage, a breakwater 3000 feet long, and two graving docks. In 1888, 2500 vessels of 251,514 tons entered; in 1898, 1573 of 252,150 tons. The principal article of import is iron ore, and coal and pig-iron are the chief exports, 449,767 tons of the former having been shipped in 1898. Shipbuilding is the principal industry. The municipality is very progressive, and controls waterworks (1895) and gasworks, both of which are being largely extended. Two golf-courses attract many visitors. Population (1891), 3315; (1901), 4696.

Troppau (Polish, *Oppava;* Czech, *Opava*), the capital of Austrian Silesia, situated on the Oppa river, close to the Prussian frontier, 37 miles north-east of Olmütz. The industries comprise the manufacture of hats and fezzes, jute fabrics, tiles, &c., beer, spirits, and liqueurs. Population (1890), 22,867; (1900), 26,725, including a garrison of 2154 men.

Trossachs, The, a characteristic Highland district in the south-west of Perthshire, Scotland. Strictly speaking, it is a narrow, beautiful-wooded glen or defile in the upper valley of the Teith, extending from Loch Katrine on the west to Lock Achray on the east, a distance of only about a mile. On the south-west the pass is shut in by the steep green slopes of Ben Venue (2393 feet), and on the north-east by the bolder and more precipitous Ben A'an (1750 feet), backed by two hills of much greater altitude—Ben Vorlich (3224 feet) and Ben Ledi (2875 feet). The region, which is one of great natural charm, owing to its blending of wood, water, rock, and hill, was made famous by Scott's poem *The Lady of the Lake* (1810). From the lovely Ellen's Isle, near the east end of Loch Katrine, all the way to Callander, every mile recalls associations of the stirring poem—Brig of Turk, Glen Finglas, Lanrick Mead, Coilantogle Ford, Bochastle, Pass of Leny, Strathyre, St Bride's. And the publication, seven years later, of *Rob Roy* awakened equally romantic, though less poetic, associations of another kind—namely, those which cluster about the "broken" clan of the MacGregors, as the Braes of Balquhidder, Rob Roy's cave, Portnellan, Glengyle, Glenfalloch, Aberfoyle, Killearn, Glen Fruin, Inversnaid, and so forth. In the wider usage of the term, the Trossachs embraces about a dozen lakes altogether, each as a rule lying amid grassy heath-clad hills 1000 to 3000 feet and more in altitude. The names of these lakes and other particulars regarding them are contained in the annexed table:—

Loch.	Alt. in feet above sea-level.	Length in miles.	Max. breadth in miles.	Max.'depth in feet.	Mean depth in feet.	Area of loch in acres.	Area of drainage basin in sq. miles.
Lubnaig .	405	4	⅖	146	42¾	614	35
Voil . .	414	3½	⅓	98	41	561	35⅓
Doine . .	414	1	¼	65	33	138	
Vennachar	270	4	¾	111	42½	1030	28½
Drunkie .	416	1	¼	97	36	138	2⅕
Achray .	276	1¼	⅓	97	36	207	7
Katrine .	364	8	1	495	199	3059	37½
Ard. . .	105	2¼	¾	...	...	...	...
Chon . .	290	1¾	⅜	...	...	...	...
Arklet . .	455	1	½	67	24	210	5⅓
Lomond .	23	22	4½	630	66–120	17,420	...

Except for the lower (eastern) extremity of Loch Vennachar, all these lakes lie just within the Highland line, that is, immediately west of the great geological fault which stretches in a north-east to south-west direction right across Scotland, from the coast of Kincardineshire to the Firth of Clyde, and in a region which is seamed with secondary faults that branch off from the main fault at various angles. The district as a whole is built up of the crystalline schists which characterize the Highlands, the rock formations being mostly hard conglomerates and pebbly grits. Indeed, it was the hard coarse grits of Ben Ledi which originally dammed up the east end of Loch Katrine, and made the lovely pass of the Trossachs which links that lake with Loch Achray. As the table above clearly indicates, every one of these lakes is long and narrow, and relatively of no great depth, though the two largest do indeed go down below sea-level, namely, Loch Lomond to the extent of over 600 feet, and Loch Katrine 500 feet. From these circumstances, coupled with the general indications of their physical surroundings, it is pretty certain that they owe their origin, or at any rate their present shape and extent, to glacial action. In most cases each loch consists of but a single basin, which is scooped out to its greatest depth in a narrow trough along the middle; but in Lochs Vennachar and Katrine the maximum depth is found in each case towards the east, and in Loch Voil, quite exceptionally, at the western end. The lake last named and its neighbour, Loch Doine, were at no very distant period connected, and obviously formed one sheet of water. Two of the lakes, however, namely, Loch Lubnaig and Loch Drunkie, have each two distinct basins, all more than 50 feet in depth throughout. Loch Lomond, which is not only the largest of the Trossachs lakes—in fact, it is the largest lake in Scotland—but is also esteemed the most beautiful, is divided into three distinct basins, separated by two sublacustrine barriers—one, at Rowardennan, coming to within 6 feet of the surface, and the other, at the island of Eilean Vow, not far from the head of the loch, only 48 feet below the surface. The greatest depth occurs in the middle basin between Tarbet and Inversnaid, namely, 630 feet. The lake is, however, widest at its southern end, where its charm is greatly enhanced by about thirty green islets, the whole framed in a setting of soft green hills, which, in Smollett's words (*Humphrey Clinker*), "display a sweet variety of woodland, cornfield, and pasture . . . while the prospect terminates in huge mountains covered with heath." At its northern end the lake narrows to a mile and even less in width, and the enclosing hills not only wear a barer aspect, but draw together closer about the loch. About midway up, the chain of hills which fence in the lake on the east reach their culminating point in Ben Lomond (3192 feet). This, together with its sister hills on the north and south, forms the watershed of the middle belt of Scotland; on the east the Forth and its affluent, the Teith (which flows out of Loch Katrine and through Lochs Achray and Vennachar), convey the drainage to the North Sea, and on the west the Leven carries the surplus water of Loch Lomond into the Clyde, and so into the Atlantic. Nearly opposite Ben Lomond, on the west side of the lake, a low narrow neck of land between Arrochar and Tarbet is all that separates Loch Lomond from the sea-fjord of Loch Long, and a subsidence of less than 40 feet would convert the former into what it no doubt was in prehistoric times, namely, an actual arm of the sea. Loch Lomond is well stocked with fish—sea-trout, lake-trout, pike, perch, and occasionally salmon, and formerly it also yielded flounders, eels, and the fresh-water herring (*powan*). There are also numbers of trout in Lochs Katrine, Vennachar, Lubnaig, and most of the smaller lakes, besides salmon, char, perch, and pike. The annual rainfall throughout the Trossachs region ranges from 53·7 inches on the west face (1800 feet) of Ben Ledi to 115·1 inches at Ardlui (50 feet) at the head of Loch Lomond. This matter has acquired special importance since 1855, and in an even much greater measure since 1884, owing to the city of Glasgow's schemes for drawing its water-supply from Loch Katrine. In consequence of the execution of these schemes the level of Loch Katrine has been raised 4 feet above its normal summer level, and may be raised yet another 5 feet; while the level of Loch Vennachar may be raised 5¾ feet and Loch Drunkie as much as 25 feet. Further authorization has been obtained to tap Loch Arklet, and convert it into a larger gathering basin by raising its level 25 feet; and in case still greater supplies shall be necessary, it would probably be found feasible to draw upon Lochs Voil and Doine, which lie 50 feet above Loch Katrine, and upon Loch Lubnaig, which lies 41 feet above the latter, the water being in both cases conducted by means of aqueducts bored through the intervening hills. (See further under GLASGOW.)

The Trossachs are approached by coach from Callander station on the Stirling–Oban branch of the Caledonian railway, and by coach from Aberfoyle station on the North British railway, by steamer up Loch Lomond, and since 1894 by the West Highland railway, which runs along the west side of Loch Lomond from Tarbet. In summer steamers ply on Loch Katrine, communicating with the rail at Balloch (southern end) and with rail or coach at Ardlui (northern end), and calling at Luss, Balmaha, Rowardennan, Tarbet, and Inversnaid.

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(J. T. BE.)

Trouville-sur-Mer, a town, arrondissement of Pont l'Évêque, department of Calvados, France, 24 miles in direct line north-east of Caen, with terminal station (Trouville–Deauville) on railways from Caen and Pont l'Évêque. Besides trawl-fishing and the provisioning of ships, in which Deauville is also engaged, Trouville has boat-building, rope, and briquette works. The port, shared with Deauville, comprises in addition to the commercial harbour and the fishing quay (2132 feet long) a half-tide dock 230 feet long with 750 feet of quayage, connected with the railway. A reservoir, excavated in the bed of the river above the floating basin, is connected with the latter by siphons. The London and South-Western Railway Company have a daily steamboat service to Trouville in connexion with their Southampton and Havre boats. Passengers arriving from Havre by steamer in 1900 numbered 110,850, and the departures 110,977. The number of vessels entered, 1900, was 143 of 48,718 tons (from England, 129 of 42,717 tons), cleared, 139 of 49,947 tons (to England, 134 of 46,480 tons). Including coasting, the total port traffic amounted to 133,228 tons. The fisheries employed in the same year 100 ships with 385 men. Population (1891), 5627; (1901), 6137. Deauville (1901), 2857.

Trowbridge, a market town in the Westbury parliamentary division of Wiltshire, England, 8 miles south-east of Bath, on the Great Western railway. Modern erections include a town hall and a high school. Population (1891), 11,901; (1901), 11,526.

Troy, represented now by important ruins on and about the mound of Hissarlik, situated in the north-west angle of Asia Minor, about 3½ miles both from the Dardanelles and from Yeni Koi, which lies on the Ægean coast north of Besika Bay. The famous academic dispute concerning the precise site, which began about A.D. 160 with Demetrius of Skepsis, and was still being maintained in the ninth edition of this Encyclopædia (*s.v.* TROAD), may now be regarded as settled. After the full demonstration, made in 1893, that remains of a fortress, contemporary with the great period of Mycenæ, and larger than the earlier acropolis town, first identified by Schliemann with Ilios, exist on the mound of Hissarlik, no reasonable person has continued to doubt that this last site is the local habitation of the Homeric story. The rival ruins on the Bali Dagh have been shown to be those of a small hill fort which, with another on an opposite crag, commanded the upper Menderé gorge. It is inconceivable that this fort should have been chosen by poets, generally familiar with the locality, as the scene of the great siege, while in the plain between it and the sea there had lain from time immemorial, and lay still in the Mycenæan age, a much more important settlement with massive fortified citadel.

No site in the Troad can be brought into complete accordance with all the topographical data to be ingeniously derived from the text of Homer. Indeed, it would be little short of miraculous if consistent accuracy in every small detail of the locality were preserved in poems composed and combined as were the cantos of the *Iliad*. The hot and cold springs that lay just without the gate of "Troy" (*Il.* xxii. 147) are no more to be identified with Bunarbashi, which wells out more than a mile from the Bali Dagh ruins, than with the choked conduits, opened by Schliemann in 1882, to the south of Hissarlik. But the broader facts of geography ought to be, nay are, recognizable in the modern plain of the Menderé. The old bed of that river is the Scamander, and its little tributary, the Dumbrek Su, is the Simois. In their fork lies Hissarlik or Troy. In sight of it are, on the one side, the peak of Samothrace (xiii. 11–14); on the other, the mass of the Kaz Dagh *Ida* (viii. 52). Hissarlik lies in the plain (xx. 216) less than 4 miles both from the Hellespontine and the Ægean coasts, easily reached day by day by foes from the shore, and possible to be left and regained in a single night by a Trojan visiting the camp of the Greeks (vii. 381–421). It is far less reasonable to demand a closer correspondence between the poem and geographical facts than to be astonished that the actual correspondence is so close.

In summarizing what has been found to exist on the mound of Hissarlik, in the excavations undertaken there since 1870, it is not advisable to observe the order of the finding, since Schliemann's want of experience and method caused much confusion and error in the earlier revelations. No certainty as to the distinction of strata or their relative ages was possible till Wilhelm Dörpfeld obtained entire control in 1891, after the original explorer's death. There are in all nine strata of ancient settlement.

(1) On the virgin soil of the hillock, forming the core of the mound, scanty remains appear of a small village of the late Ægean Neolithic period, at the dawn of the Bronze Age. This includes what were originally supposed by Schliemann to be two successive primitive settlements. Thin walls of rough stones, bonded with mud, are preserved mainly in the west centre of the mound. No ground plan of a house is recoverable, and there is no sign of an outer fortress wall. In this stratum were found implements in obsidian and other stones, clay whorls, a little worked ivory, and much dark monochrome pottery, either of a rough grey surface or (in the finer examples) treated with resin, highly hand-polished, and showing simple geometric decoration, which was incised and often filled in with a white substance.

(2) Superposed on these remains, where they still exist, but comprehending a much larger area, lies a better-constructed and better-preserved settlement. This has been twice rebuilt, and it was enclosed by a massive fortress wall of rudely squared Cyclopean character, showing different restorations, and now destroyed except on the south side of the mound. Double gates at the south-east and south-west are well preserved. The most complete and most important structures within the citadel lie towards the north. These are two rectangular blocks lying north-west to south-east, side by side, of which the southern and larger shows a *megaron* and vestibule of the type familiar in "Mycenæan" palaces, while the smaller seems a pendant to the larger, like the "women's quarters" at Tiryns and Phylakopi (see MYCENÆAN CIVILIZATION). Other blocks, whose plans are difficult to bring into inter-relation in their present state of ruin, are scattered over the area, but mainly in the south-west. This is the fortress proclaimed by Schliemann in 1873 to be the Pergamos of Troy. But we now know that, while his identifications of Homeric topographical details in these ruins were fanciful, a much larger fortress succeeded to this long before the period treated of in the *Iliad.* The settlement in the second stratum belongs in fact to a primitive stage of that Ægean civilization which preceded the Mycenæan; and it is this latter that is recalled by the Homeric poems. The pottery of the second stratum at Hissarlik shows the first introduction of paint, and of the "slip" and somewhat fantastic forms parallel to those of the pre-Mycenæan style in the Cyclades. The beaked vases, known as *schnabelkannen*, are characteristic, and rude reproductions of human features are common in this ware, which seems all to be of native fabrication. Bronze had come into use for implements, weapons, and utensils; and gold and silver make up a hoarded treasure found in the calcined ruins of the fortification wall near one of the gates. But the forms are primitive and singular, and the workmanship is very rude, the pendants of the great diadems being cut out of very thin plate gold. Discs, bracelets, and pendants, showing advanced spiraliform ornament, found mainly in 1878, and then ascribed to this same stratum, belong undoubtedly to a higher one, the sixth or "Mycenæan." Rough fiddle-shaped idols, whorls, a little worked ivory, and some lead make up a find of whose early period comparison of objects found elsewhere leaves no sort of doubt. This treasure is now deposited in Berlin and in Constantinople, but the larger part in the former city.

(3, 4, 5) This primitive "Troy" suffered cataclysmal ruin (traces of conflagration are everywhere present), and Hissarlik ceased for a time to have any considerable population. Three small village settlements, not much more than farms, were successively erected on the site, and have left their traces superposed one on another, but they yielded no finds of importance.

(6) The mound, however, stood in too important a relation to the plain and the sea to remain desolate, and in due time it was covered again by a great fortress, while a city spread out below. The latter has never yet been explored, but is a principal object of Dr W. Dörpfeld's future plans. The remains of this stratum on the acropolis, however, have now been examined. A portion of

them was first distinguished clearly by Dörpfeld in 1882, but owing to the confusion caused by Schliemann's drastic methods of trenching, the pottery and metal objects, really belonging to this stratum, had come to be confused with those of lower strata; and some grey monochrome ware, obviously of Anatolian make, was alone referred to the higher stratum. To this ware Schliemann gave the name "Lydian,". and the stratum was spoken of in his *Troja* (1884) as the "Lydian city."

In 1893, however, excavations were carried out on the south of the mound in the hitherto undisturbed ground outside the limits of the earlier fortress; and here appeared a second curtain wall of massive ashlar masonry showing architectural features which characterize the "Mycenæan" fortification walls of Mycenæ itself, and at Phylakopi in Melos. With this wall was associated not only the grey ware, but a mass of painted potsherds of unmistakably "Mycenæan" character; and further search in the same stratum to west and east showed that such sherds always lay on its floor level. The inevitable inference is that here we have a city, contemporary with the mass of the remains of Mycenæ, which imported "Mycenæan" ware to supplement its own ruder products. The area of its citadel is larger than the citadel of the second stratum; its buildings, of which a large *megaron* on the south-west and several houses on the east remain, are of much finer construction than those which lie lower. This was the most important city yet built on the mound of Hissarlik. It belonged to the "Mycenæan" Age, which precedes the composition of the Homeric poems, and is reflected by them. Therefore this is Homer's Troy.

Its remains, however, having been obliterated on the crown of Hissarlik, almost escaped recognition. When some centuries later a third important city, the Hellenistic Ilios, was built, all the accumulation on the top of the mound was cut away and a terrace made. In this process the then uppermost strata of ruins wholly vanished, their stones being taken to build the new city. The Mycenæan town, however, which had been piled stage upon stage to the summit, descended on the south side a little down the face of the mound; and the remains of its fortifications and houses at that point, lying below the level cut down to by the Hellenistic terracemakers, were covered by the depositing of rubbish from the crown and again built over. Thus we find them now on the southern slope of the mound only, but have no difficulty in estimating their original extent. Many tombs and a large lower city of this era will doubtless be explored ere long.

(7) To "Mycenæan" Troy succeeded a small unfortified settlement, which maintained itself all through the Hellenic age till the Homeric enthusiasm of Alexander the Great called a city again into being on Hissarlik.

(8) The Hellenistic Ilios, however, has left comparatively little trace, having been almost completely destroyed in 85 B.C. by Fimbria. Portions of fortifications erected by Lysimachus are visible both on the acropolis (west face chiefly) and round the lower city in the plain. A small Doric temple belongs to the foundation of this city, and a larger one, probably dedicated to Athena, seems to be of the Pergamene Age. Of its metopes, representing Helios and a gigantomachia, important fragments have been recovered. Coins of this city are not rare, showing Athena on both faces, and some inscriptions have been recovered proving that Hellenistic Ilios was an important municipality.

(9) Lastly, about the Christian era, arose a Græco-Roman city, to which belong the theatre on the south-east slope of the hill and the ornate gateway in the same quarter, as well as a large building on the south-west and extensive remains to north-east.

(D. G. H.)

Troy, a city of New York, U.S.A., capital of Rensselaer county. It is on the Hudson river at the mouth of the Mohawk, and near Albany, in the eastern part of the state. It is regularly laid out, has a water-supply by the Holly system, is sewered, and is well paved with granite blocks, bricks, and asphalt. It has three railways—the Delaware and Hudson, the New York Central and Hudson River, and the Fitchburg (Boston and Maine), which, with the Erie canal and boats on the Hudson, give it a large traffic. In 1900 there were 662 manufacturing establishments, with a total capital of $23,531,622. They employed 21,564 hands, and their total output was valued at $28,209,259. The most important products were furnishing goods, with a value of $8,685,676; foundry and machine-shop products, $1,777,543; malt liquors, $1,438,869; and shirts, $4,774,520. Troy is the largest shirt-manufacturing place in the United States. Rensselaer Polytechnic Institute, situated here, in 1898 had 15 professors, and was attended by 138 students. In 1900 the assessed valuation of real and personal property was $49,147,550, the net debt was $1,506,056, and the rate of taxation was $19.71 per $1000. Population (1890), 60,956; (1900), 60,651, of whom 14,384 were foreign-born and 400 negroes. Of 17,038 males 21 years of age and over, 895 were illiterate (unable to write).

Troy, a city of Ohio, U.S.A., capital of Miami county, on the Miami river, the Miami and Erie canal, and at the intersection of the Cleveland, Cincinnati, Chicago, and St Louis, and the Cincinnati, Hamilton, and Dayton railways, in the western part of the state. Population (1890), 4494; (1900), 5881, of whom 234 were foreign-born and 391 negroes.

Troyes, chief town of the department of Aube, France, 104 miles east-south-east of Paris, on the railway from Paris to Mulhouse. Many of the old timbered houses have been destroyed, and of modern structures the principal is the Monument des Enfants d'Aube, erected in 1890 in commemoration of the war of 1870–71. The library, now containing 110,000 volumes, has been installed in a new building, and a school of hosiery has been added to the educational establishments of the town (1888). Population (1891), 47,551; (1901), 51,195.

Troyon, Constant (1810–1865), French painter, was born on the 28th of August 1810 at Sèvres, near Paris, where his father was connected with the famous manufactory of china. Troyon was an animal painter of the first rank, and was closely associated with the artists who painted around Barbizon. The technical qualities of his methods of painting are most masterly; his drawing is excellent, and his composition always interesting. It was only comparatively late in life that Troyon found his *métier*, but when he realized his power of painting animals he produced a fairly large number of good pictures in a few years. Troyon entered the *ateliers* very young as a decorator, and until he was twenty he laboured assiduously at the minute details of porcelain ornamentation; and this kind of work he mastered so thoroughly that it was many years before he overcame its limitations. By the time he reached twenty-one he was travelling the country as an artist, and painting landscapes so long as his finances lasted. Then when pressed for money he made friends with the first china manufacturer he met, and worked steadily at his old business of decorator until he had accumulated enough funds to permit him to start again on his wanderings.

Troyon was a favourite with Roqueplan, an artist of distinction eight years his senior, and he became one of his pupils after having received certain tuition from a painter, now quite unknown, named Riocreux. Roqueplan introduced Troyon to Rousseau, Jules Dupré, and the other Barbizon painters, and in his pictures between 1840 and 1847 he seemed to endeavour to follow in their footsteps. But as a landscapist Troyon would never have been recognized as a thorough master, although his work of the period is marked with much sincerity and met with a certain success. It may be pointed out, however, that in one or two pure landscapes of the end of his life he achieved qualities of the highest artistic kind; but this was after lengthy experience as a cattle painter, by which his talents had become thoroughly developed.

In 1846 Troyon went to the Netherlands, and at The Hague saw Paul Potter's famous "Young Bull." From the studies he made of this picture, of Cuyp's sunny landscapes, and Rembrandt's noble masterpieces he soon evolved a new method of painting, and it is only in works produced after this time that Troyon's true individuality is revealed. When he became conscious of his power as an animal painter he developed with rapidity and success, until his works became recognized as masterpieces in Great Britain and America, as well as in all countries of the Continent. Success, however, came too late, for Troyon never quite believed in it himself, and even when he could command the market of several countries he still grumbled loudly at the way the world treated him. Yet he was decorated with the Legion of Honour, and five times received medals at the Paris Salon, while Napoleon III. was one of his patrons; and it is certain he was at least as financially successful as his Barbizon colleagues.

Troyon died, unmarried, at Paris on 21st February 1865, after a term of clouded intellect. All his famous pictures are of date between 1850 and 1864, his earlier work being of comparatively little value. His mother, who survived him, instituted the Troyon Prize for animal pictures at the École des Beaux Arts. Troyon's work is fairly well known to the public through a number of large engravings from his pictures.

In the Wallace Gallery in London are "Watering Cattle" and "Cattle in Stormy Weather"; in the Glasgow Corporation Gallery is a "Landscape with Cattle"; the Louvre contains his famous "Oxen at Work" and "Returning to the Farm" (see PLATE), while the Metropolitan Art Museum and other galleries in America contain fine examples of his pictures. His "Vallée de la Toucque, Normandy," is one of his greatest pictures; and at Christie's sale-room in 1902 the single figure of a cow in a landscape of but moderate quality fetched £7350. Émile van Marcke (1827–1891) was his best-known pupil.

AUTHORITIES.—H. DUMESNIL. *Constant Troyon: Souvenirs Intimes.* Paris, 1888.—A. HUSTIN. "Troyon," *L'Art.* Paris, 1889, pp. 77 and 85.—ALBERT WOLFF. "Constant Troyon," *La Capitale de l'Art.* Paris, 1886.—D. CROAL THOMSON. *The Barbizon School of Painters.* London, 1890; "Constant Troyon," *The Art Journal.* 1893, p. 22. (D. C. T.)

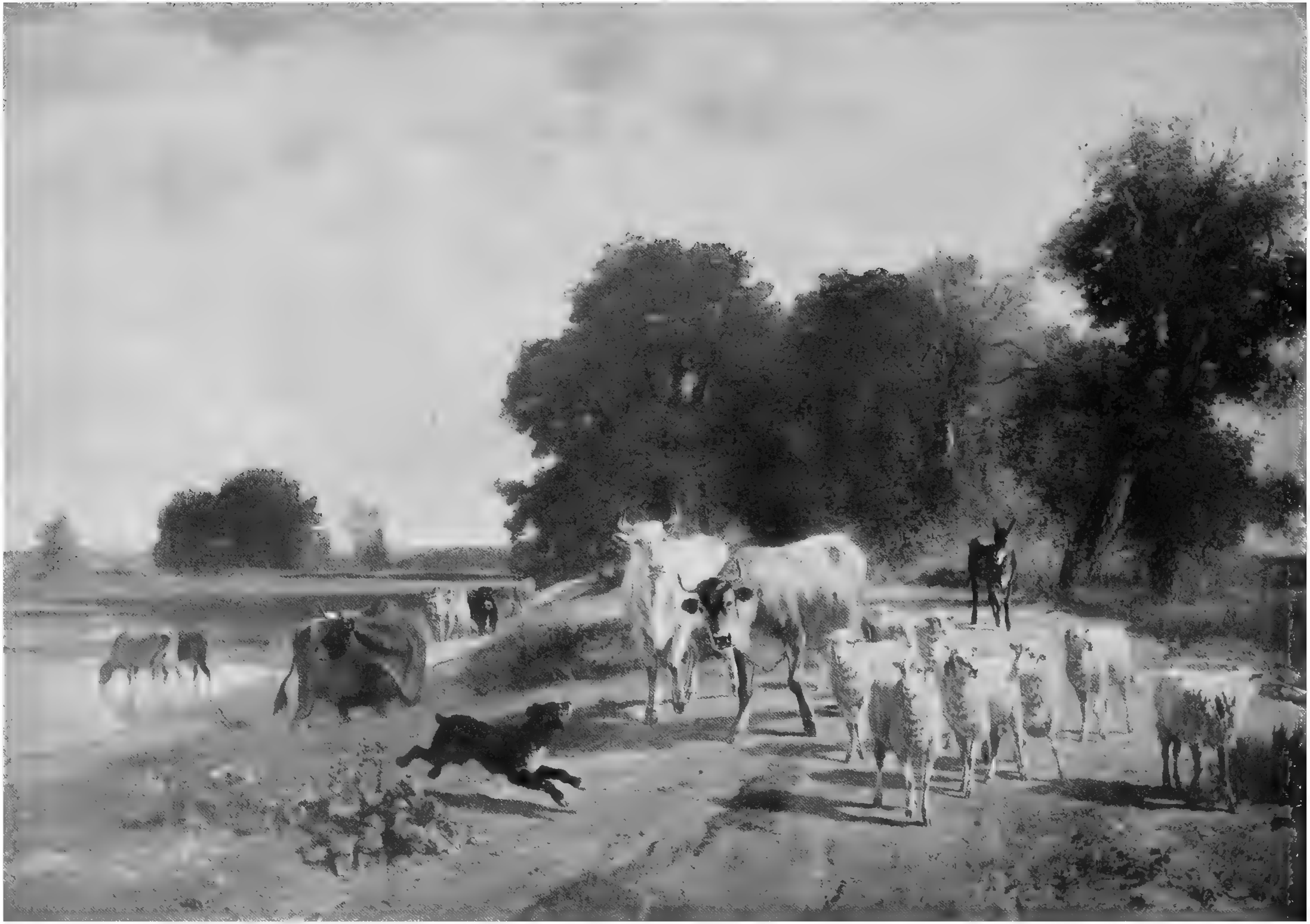
Trübau. See BÖHMISCH-TRÜBAU.

Trujillo, a town of Spain, province of Caceres, on a hill to the east of Caceres. The country around is rugged, but produces wheat, wine, oils, and fruit, besides live-stock of all sorts. Much phosphorite is found in the district, and the extraction of it has been resumed. Valuable forests are close to the town. In the oldest part of Trujillo are the remains of a Roman castle and the Julia tower, also Roman, like much of the fortifications. The streets are broad, and there are some fine squares. The principal parish church, Santa Maria, is a fine Gothic structure of the 15th century. Besides its Roman records, Trujillo was a town of importance in the Middle Ages. Pizarro, the conqueror of Peru, was born here. Population (1887), 10,773; (1897), 12,254.

Truro, episcopal city, municipal borough, and market town, in the Truro parliamentary division of Cornwall, England, at the confluence of the Allen and the Kenwyn, 11 miles north of Falmouth by rail on the Great Western railway. Truro cathedral (begun 1880, and designed by Mr Pearson) was opened in 1887. That part of it consisting of the old south aisle of the former parish church forms a small parochial church of itself, and by Act of Parliament of 1887 has all the legal rights of a parish church. A free library has been opened. There are tin-smelting works, several potteries, a boot factory, a biscuit factory, and works for jam-making and for the manufacture of shirts and clothing. Area, 1127 acres. Population (1891), 11,131; (1901), 11,562.

Truro, the chief town of Colchester county, Nova Scotia, on the Salmon river, near the head of Cobequid Bay and 61 miles from Halifax by rail. It contains 10 churches, county and school buildings, provincial normal school, a factory for condensing milk, besides other factories and mills. Victoria Park is noted for its natural beauty. Population (1891), 5102; (1901), 5993.

Trust Companies.—Trust companies, as defined in this article, are confined almost exclusively to the United States, and are the growth of the last half of the 19th century. They mainly differ from banks of deposit and discount in the following particulars:—they are incorporated only under state laws; usually they must invest their capital in first-class securities, and also deposit large amounts in United States or city bonds with the respective state superintendents of banks; they do not issue circulating notes; they do not, as a rule, discount commercial paper, although they frequently buy such paper, often when representing large amounts due from corporations which have other business relations with them; they pay interest on the deposits of customers, rarely more than 2 per cent., or perhaps a little more on moneys deposited for a stated period; they make loans on real estate, usually for large amounts, although on a conservative basis such as 50 per cent. of the appraised value; they act in fiduciary capacities, such as executors, trustees, receivers, committees, agents for corporations, fiscal agents for states, cities, or other municipalities, registrars or transfer agents for shares of capital stock, agents for the payment of coupons on the bonds issued by corporations, agents for the underwriting of new securities, depositaries of securities called for under plans of reorganization or held in escrow pending the transfer of ownership. Because of the more permanent character of their deposits, they are able to use such deposits for the general purposes enumerated above, many of which are foreign to the business of national and state banks. By reason of their special powers, the stable nature of their business, and their continued existence, trust companies have steadily grown in favour as executors or trustees of large estates. In Philadelphia, New York, and Boston this department had by 1900 assumed large proportions. In some parts of the United States, notably the Central West, the businesses of the trust company and the savings bank are combined by special charter, but as a rule, and especially in New York City, where the largest trust companies are situated, the trust company does not act as a savings bank. Some of the trust companies do not encourage the deposit of moneys subject to withdrawal on demand, preferring to restrict their deposit account to moneys held on an arrangement partaking of the nature of a trust, the latter sums being usually larger in amount, and not so liable to withdrawal as individual deposits. Because of the nature of the general business performed by trust companies, no portion of their deposits is required by law to be held as a cash reserve; as a result the deposit accounts of the trust companies with the national and state banks are among the largest which those banks carry, it being customary for the latter to pay interest upon such balances. As a rule, trust companies exist only in the larger cities, and the profits accumulated by some of the companies, particularly those concerned with syndicate operations, are often very large. In recent years it has become customary to organize trust companies with a large paid-up surplus. This is often made equal to the total of the capital stock issued, the subscription price of the stock then being made twice the amount of its par value. On 2nd January 1900 the combined capital and surplus of the forty-two trust



"Le Retour à la Ferme." By Troyon.

companies doing business in the city of New York was $126,081,123, while their deposits on that date amounted to $485,711,429. Of the 614 loan and trust companies in the United States which gave more or less complete information to the public authorities at the close of the year 1899, 612 reported a paid-up capital of $203,587,935; 506 had surplus and undivided profits of $176,925,270; 434 had in cash and due from banks the amount of $231,774,508. The deposits of 504 of such loan and trust companies amounted to $1,156,784,312, while the loans, discounts, and securities on hand reported by 497 of such companies amounted to $1,145,353,387.

(T. L. G.)

Trustees.—The chief modifications since 1887 of the English law of trust have been made by the Trustee Act, 1888, the Trustee Act, 1893, and the Judicial Trustee Act, 1896, and relate mainly to the position of trustees. It may be stated generally that the previous statute law concerning trustees was consolidated by the Trustee Act, 1893. In the article in the ninth edition of the *Encyclopædia Britannica* it was stated in regard to investments that legislation had conferred on trustees a right to invest in certain securities. The Trustee Act, 1893, has consolidated the law on this point, and now provides, as it were, a code or charter of investment authorizing trustees, unless expressly forbidden by the instrument (if any) creating the trust, to invest trust funds in various modes, of which the more important are as follows:—In any of the parliamentary stocks or public funds or Government securities of the United Kingdom; on real or heritable securities in Great Britain or Ireland; in stock of the Bank of England or the Bank of Ireland; in India 3½ per cent. stock and India 3 per cent. stock; in any securities, the interest of which is for the time being guaranteed by Parliament; in consolidated stock created by the London County Council; in the debenture or rent charge or guaranteed or preference stock of any railway company in Great Britain or Ireland incorporated by special Act of Parliament, and having during each of the ten years last past before the date of investment paid a dividend at the rate of not less than 3 per cent. on its ordinary stock; in the debenture stock of any railway company in India, the interest on which is paid or guaranteed by the secretary of state in council of India; in the "B" annuities of the Eastern Bengal, the East Indian, and the Sind, Punjab, and Delhi railways; and also in deferred annuities—comprised in the register of holders of annuity Class D, and annuities comprised in the register of annuitants Class C of the East Indian Railway Company; in the stock of any railway company in India upon which a fixed or minimum dividend in sterling is paid or guaranteed by the secretary of state in council of India, or upon the capital of which the interest is so guaranteed; in the debenture or guaranteed or preference stock of any company in Great Britain or Ireland established for the supply of water for profit, and incorporated by special Act of Parliament or by royal charter, and having during each of the ten years last past before the date of investment paid a dividend of not less than £5 per cent. per annum on its ordinary stock; in nominal or inscribed stock issued, or to be issued, by the corporation of any municipal borough having, according to the returns of the last census prior to the date of investment, a population exceeding 50,000, or by any county council under the authority of any Act of Parliament or Provisional Order; in any of the stocks, funds, or securities for the time being authorized for the investment of cash under the control or subject to the order of the High Court. Trustees may from time to time vary any such investments for others of an authorized nature. The statutory power to invest on real securities does not, of course, authorize the purchase of realty; but by § 5 of the Trustee Act, 1893, a power to invest in real securities (in the absence of express provision to the contrary) authorizes investment on mortgage of leasehold property held for an unexpired term of not less than 200 years and not subject to a greater rent than one shilling a year, or to any right of redemption or condition of re-entry except for non-payment of rent.

The Judicial Trustees Act, 1896, inaugurated a semi-official system of trusteeship which was new in England, but had been known in Scotland for upwards of 150 years. The general scope of the Act is indicated by § 1 (1), which runs as follows:—"Where application is made to the court by or on behalf of the person creating or intending to create a trust, or by or on behalf of a trustee or beneficiary, the court may, in its discretion, appoint a person (in this Act called a judicial trustee) to be a trustee of that trust, either jointly with any other person or as sole trustee, and if sufficient cause is shown, in place of all or any existing trustees." The Act and the rules made under it (the Judicial Trustees Rules, 1897) provide that judicial trustees shall be under the control and supervision of the court as officers thereof, and may be paid for their services out of the trust property. The trust accounts are to be audited annually, and a report thereon made to the court, which has power to order inquiries into transactions connected with the administration of the trust. A judicial trustee may be required to give security, and in any case has to keep the trust account with a bank approved by the court, and deposit title-deeds and other documents of title in such custody as the court directs. Communications between judicial trustees and the court with reference to their duties are permitted to be made with little or no formality, and strict proof of facts may be waived in proper cases. The Act may, in short, be described as an attempt to provide for an official check upon the administration of trusts, while avoiding the formality and expense incident to the procedure in an administration action.

The position of trustees in respect of what was frequently an undue personal responsibility for the administration of their trust has been much improved by § 8 of the Trustee Act, 1888 (not repealed by the Trustee Act, 1893), and § 3 of the Judicial Trustees Act, 1896. Subsection (1) of the former enactment (with some omissions) runs as follows:—"In any action or other proceeding against a trustee or any person claiming through him, except where the claim is founded upon any fraud or fraudulent breach of trust to which the trustee was party or privy, or is to recover trust property, or the proceeds thereof still retained by the trustee, or previously received by the trustee and converted to his use, the following provisions shall apply—(*a*) All rights and privileges conferred by any statute of limitations shall be enjoyed in the like manner and to the like extent as if the trustee or person claiming through him had not been a trustee or person claiming through him. (*b*) If the action or other proceeding is brought to recover money or other property, and is one to which no existing statute of limitations applies, the trustee or person claiming through him shall be entitled to the benefit of, and be at liberty to plead the lapse of time as a bar to such action or other proceeding in the like manner and to the like extent as if the claim had been against him in an action of debt for money had and received." The statutory period of limitation which trustees are thus permitted to plead is the six years fixed as the period of limitation for actions of debt by the Limitation Act, 1623. It has been decided on the above section that in the case of a breach of trust consisting of an improper investment of the trust funds, time begins to run in favour of the trustee from the date of the investment. Subsection (3) of the Judicial Trustees Act, 1896, provides that "If it appears to the court that a trustee, whether appointed under that Act or not, is or may be personally liable for any breach of trust, whether the transaction alleged to be a breach of trust occurred before or after the passing of that Act, but has acted honestly and reasonably, and ought fairly to be excused for the breach of trust and for omitting to obtain the directions of the court in the matter in which he committed such breach, then the court may relieve the trustee either wholly or partly from personal liability for the same." Owing to the generally reduced rate of interest obtainable for money invested on trust securities, the court has in several instances, and even as against defaulting trustees, charged them with interest at 3 per cent. per annum (instead of 4 per cent., which was formerly the recognized rate) upon sums found due from them to the trust estate.

Under the old law trustees could not safely advance on mortgage more than two-thirds of the actual value of agricultural land or one-half of the value of houses. This "two-thirds rule" is now made statutory by § 8 of the Trustee Act, 1893, which enacts that "A trustee lending money on the security of any property on which he can lawfully lend shall not be chargeable with breach of trust by reason only of the proportion borne by the amount of the loan to the value of the property at the time when the loan was made, provided that it appears to the court that in making the loan the trustee was acting upon a report as to the value of the property made by a person whom he reasonably believed to be an able practical surveyor or valuer instructed and employed independently of any owner of the property, whether such surveyor or valuer carried on business in the locality where the property is situate or elsewhere, and that the amount of the loan does not exceed two equal third parts of the value of the property as stated in the report, and that the loan was made under the advice of the surveyor or valuer expressed in the report." The same section protects trustees for not investigating the lessor's title when lending on the leasehold security, and for taking a shorter title than they might be otherwise entitled to on the purchase or mortgage of any property, if they act with prudence and caution. By § 9 (replacing § 5 of the Trustee Act, 1888), trustees who commit a breach of trust by lending more than the proper amount on any property are excused from making good any more than the excess of the actual loan over the sum which they might have properly lent in the first instance.

An inconvenience which formerly attached to dealings with trustees and trust property, in consequence partly of the rule "delegatus non potest delegare," and partly of the liability of persons dealing with trustees to see that money paid to them is properly applied, has been largely obviated by § 17 of the Trustee Act, 1893 (replacing § 2 of the Trustee Act, 1888), which in effect provides that a trustee may appoint a solicitor to be his agent to receive and give a discharge for any money or valuable consideration or property receivable by the trustee under the trust, by permitting the solicitor to have the custody of and to produce a deed having in the body thereof or endorsed thereon a receipt for the consideration money or other consideration, the deed being executed or the endorsed receipt being signed by the trustee; and a trustee is not chargeable with breach of trust by reason only of his having made or concurred in making any such appointment; and the producing of any such deed by the solicitor is a sufficient authority to the person liable to pay for his paying to the solicitor without the solicitor producing any separate or other direction or authority in that behalf from the trustee. The rule of equity by which a beneficiary who consented to a breach of trust was liable to indemnify the trustees to the extent of his interest has now taken definite statutory shape in § 45 of the Trustee Act, 1893 (replacing § 6 of the Trustee Act, 1888), which enacts that when a trustee commits a breach of trust at the instigation or request, or with the consent in writing of a beneficiary, the High Court may, if it thinks fit, and notwithstanding that the beneficiary is a married woman entitled for her separate use and restrained from anticipation, make such order as to the court seems just for impounding all or any part of the interest of the beneficiary in the trust estate by way of indemnity to the trustee.

The Intestates' Estates Act, 1884, has altered the previous law as to escheat, by which a trustee became entitled for his own benefit to real estate held upon trust for a *cestui que* trust who died intestate and without heirs, so that now equitable estates escheat in the same manner as legal estates. (E. M. Bs.)

United States.

A trustee under American law is generally entitled to compensation for his services. Charitable trusts are becoming more frequent as the wealth of the United States increases, and are regarded with more favour by the courts. The *cy pres* doctrine has been either expressly or virtually applied to uphold them in several of the states, and in some there has been legislation in the same direction. Spendthrift trusts, *i.e.*, those under which the enjoyment of income bequeathed by will in such a way as to prevent creditors of the beneficiary from reaching it before it gets into his hands, are generally supported (*Nichols* v. *Eaton*, 91 United States Reports, 713).

A "voting trust" is a concerted transfer of their shares in a corporation by a majority of the shareholders to trustees to hold and vote on them for a specified period for the purpose of securing the adoption or continuance of a certain line of corporate action. Any shareholder may recede from such an arrangement and reclaim his stock. (S. E. B.)

Trusts.—The word "trusts," as used in this article, includes all those aggregations of capital engaged in productive industry that, by virtue of their industrial strength, have or are supposed to have some monopolistic power. Legal monopolies, as such, and natural monopolies are excluded, although it is frequently true that the trusts are aided by and sometimes control natural monopolies. Trusts are here considered to be identical with the so-called "capitalistic monopolies."

While it is probably true that trusts are a product of evolution, it is desirable to analyse and explain that conception in some detail if we are to understand their industrial significance. Competition, especially among industries managed on a great scale, often makes modern business unprofitable. Commercial men have been thus compelled in some way to modify former methods of doing business. So long as most industries were run on a small scale, the differences in the ability and the facilities of the various competitors were so great that only those at the lower end of the scale of excellence were forced out of the business—this to the general advantage of industrial society. The great mass of producers remained vigorously competing with one another, some making larger, others smaller profits, but all except a few at the lower margin making at least a living. Under modern business conditions competitors are often, relatively speaking, few in number, of substantially equal ability, and controlling substantially equal facilities for managing the business economically. Consequently, in such circumstances, modern competition differs greatly from that form which was familiar to the earlier economists. Among competitors of such great resources, the struggle may last long after the business has become unprofitable to all before any will fail. Among competitors so nearly equal in strength, the entire industry may be very seriously injured by competition before enough are forced out to affect materially the severity of the competition.

The dictum of Stephenson, that "where combination is possible, competition is impossible," has a much wider application now than in the early days of railways. The modern facilities for the transportation of goods, for the rapid transmission of intelligence by fast mail, and especially for the instantaneous exchange of information by the telegraph and telephone, have made it possible to manage easily a large business, however widely separated its different plants or establishments may be. Half a century ago or thereabouts, on account of the lack of these facilities, management of such institutions would often have been impossible. Many of the advantages of combinations are entirely dependent upon these modern facilities, and on that account these facilities may be said to be an occasion, if not a cause, of the trusts.

Two kinds of trust industries.

If the product of an industry is of such a nature that its quality is substantially uniform and can be readily tested by purchasers, especially if the goods are such that they are ordinarily sold in large quantities, the competition between rival establishments must almost of necessity be a competition in price. Sugar refining, oil refining, the distilling of spirits, the manufacture of salt, are such industries. The standard quality is readily tested, and the manufacturer who can offer the standard product at the lowest price effects a sale. Industries manufacturing comparatively inexpensive articles for the retail trade, put them up in packages which become well known to customers; and those industries whose goods are sold under brands or trade-marks, or in some other form so that they are familiar to buyers, afford an example of competition of an entirely different kind. When the reputation of a certain brand of goods of this nature becomes established, consumers make no further efforts to test its quality, and the retail price often becomes a customary price. If a manufacturer of such goods finds his trade injured by a rival, his most effective means of competition will often be, not a lowering of the price, but an increase of the outlay on advertising. Soap, baking-powder, photographic cameras for general use, and of late years certain brands of coffee, patent medicines, and other goods of similar nature, are examples of this class. Those industries in which the competition becomes a matter of cutting of prices can by combination remove rivals from the field, and then put prices up to a remunerative rate. Competitors in industries of the second class by combination can save many of the costs of selling, and thus without any increase in the price of the product may save enough of the cost to make the business profitable.

Some of the advantages of combination over competition which have led to the organization of trusts may be enumerated:—

Savings from combination.

(1) The cost of selling may be greatly lessened. As has been intimated, competition in the case of industries of the second class named above leads to very expensive advertising in order to effect sales. An examination of the pages of any of the American magazines, with a thought as to the amount charged for the use of these advertising pages (from one hundred to as high as even four hundred dollars, or from £20 to £80, per page for a single insertion in some of the magazines with the largest circulation) will convince one of the cost of such competitive advertising. The expense involved in making attractive show windows in stores or shops, and in calling the attention of the public to popular wares by posters scattered about the country and by legends painted on rocks, on buildings along the lines of railways, &c., are other common examples.

(2) The salaries of commercial travellers, together with their hotel and travelling expenses, are of a similar nature. This competitive advertising in many cases does not increase to any noteworthy extent the consumption of the products in question, but merely attracts customers from one manufacturer to another. Combination among establishments that do this costly advertising saves a large part of the expense without lessening materially the quantity of goods sold.

(3) If different manufacturing establishments, scattered throughout the country, are brought under one management, it will be possible for orders for goods to be received at one central office, and then to be distributed to the federated establishments, so that goods can be despatched to customers in each case from the nearest establishment. In this way freight expenses may be very greatly lessened, cross freights over the same territory being substantially eliminated. A single establishment supplying all of its customers would often be compelled to deliver much longer distances at greatly increased expense.

(4) The entire profit of an establishment frequently depends upon the skill of the manager. When many different establishments are organized into one, it is possible to select the most skilful manager of all and to put him in charge of the combination, thus securing in many cases, if the trust includes practically all of the establishments in the entire industry, the ablest manager in the country for them all. It is of course true that as an establishment increases in size, or as a combination increases the number of its branches, especially if they are widely scattered, it becomes impossible for the manager to give his personal supervision to the details of management of each institution. An executive officer of the highest skill, however, will so select his subordinates, so direct their work, and so infuse into them his own spirit, that, under careful inspection, comparatively little will be lost from his inability to be present personally in each separate establishment. In the larger combinations frequent reports, often daily, are made from each concern, giving in detail the quantity of the output, the quality of the goods, the exact cost of the different processes of manufacture; so that it is possible to compare continually each of them with all of the others; to detect the special weakness of each, and in this way to remedy any slight defects in any one establishment, and to bring all nearly up to the highest level of productive capacity.

(5) Each business manager is likely to have some special excellence in his methods of management. One will be particularly skilful in the technique of manufacturing; another in the organization of the business; a third in selling goods, and so on. By combining many establishments into one, it is possible so to distribute this managerial skill that each superintendent will be given the department for which he is peculiarly fitted, and the whole establishment will thus get the benefit, not merely of the best executive ability at the head, but also of the best managing skill at the head of each separate department. In many cases it is probable that as much is saved in this way as is in any other.

(6) Besides this distribution of skill of the managers, it is sometimes equally beneficial to distribute the various products of the combination among the different plants. For example, in the manufacture of hoop and bar iron the products are turned out in great varieties of size, probably from seventy-five to a hundred. Wholesale dealers in sending their orders to the mills are likely to call for from ten to fifty different kinds. If these orders go to an establishment which has but one large mill, it may

be necessary, in order to execute the order, to change the rolls in the mill several times, causing thus a waste of power, of time, and of energy. If several establishments are combined, each can be equipped for certain sizes. When, in these circumstances, a large order is received, to each establishment will be sent that part of the order which it is especially equipped to fulfil, and thus, without any changes of rolls or stoppage of machinery, the separate sizes can be made. The same principle holds of course in nearly all lines of work, in some to a greater degree than in others; but in the manufacture of hoop and bar iron a saving from this source amounting to from a dollar to a dollar and a half, or from 4s. to 6s., per ton is sometimes made.

(7) The advantage of unifying in one establishment the manufacture of products somewhat allied in nature appears also in selling goods. If customers can buy all of the various kinds of related goods in one establishment, much of their time and energy will be saved. Some of the larger combinations, therefore, in order to make this saving for their customers and thus to be sure of retaining their orders, add to their plant facilities for making products which a smaller establishment could hardly manufacture. For example, the Distilling Company of America, which controls probably 90 per cent. of the entire product of corn spirits, found it to its advantage to add to its plant several rye distilleries, and to purchase a number of the leading brands of whiskies for consumption as beverages, in order that they might supply the needs along different lines of practically all dealers in spirits and whiskies, in this way saving for themselves many customers who otherwise might have been lost.

(8) The mere size of an establishment and its ability to supply at any time on short notice any order, however large, gives it also an advantage in retaining custom. A concern that controls only from 5 to 10 per cent. of the entire output of the country in any special line of goods might at times find it impossible to supply goods promptly. Large customers who might thus be embarrassed are more ready to deal regularly with an establishment controlling 75 to 90 per cent. of the output, if they can in this way be sure of having their orders attended to promptly. It is stated that the American Sugar Refining Company on this account is able to secure, with considerable regularity, one-sixteenth of a cent a pound more on its refined sugars than the independent refiners, the latter being frequently compelled to cut their prices to that extent in order to make sales.

(9) Owing to the fact that the introduction of goods into new markets, especially into foreign markets, is a matter of time, expenditure of energy, and of money, the large establishment with great capital has in this particular also a decided advantage. The Standard Oil Company, and American Tobacco Company, and other similar establishments, have thus been able to open up new markets in Europe, in Japan, China, and other portions of the Far East more readily by far than individual producers along those lines could have done. This stimulus to the foreign trade acts also beneficially to the domestic trade, inasmuch as the exportation of part of the product tends to keep prices somewhat higher at home, and as the added demand for the raw material influences its price, thus creates a demand for labour along many lines.

(10) The combination also frequently saves for its stockholders considerable sums from its wiser dealing with credits, and this in a way also that is beneficial to the entire business community. When competition is very severe among different establishments, the managers, in order to increase their sales, will not infrequently grant credit somewhat unwisely. The combination controlling a large part of the market is not so tempted, and moreover has the power to bring needed pressure to bear upon delinquent debtors more readily, so that losses from bad debts are much less frequent.

Special favours to combinations.

Besides the special savings which have been mentioned above that serve as reasons for the formation of combinations, certain special favours at times lead to their formation.

(1) The protective tariff is most frequently cited as such a favour. By the protection which a protective duty gives against foreign competition, it doubtless often furnishes the occasion for the formation of trusts. If a large amount of capital is tempted into the industry through the profits promised by the tariff, and therefore competition among the various establishments becomes fierce, it is much easier for them to form a combination with the certainty of good profits, provided the domestic competition can be overcome, if they are certain that foreign competition also is to be excluded. On the other hand, it would hardly be right to speak of the tariff as in this case the direct cause. In other industries not protected by the tariff the same fierce competition leads to the formation of combinations. The tariff is simply an encouraging condition. The removal of the tariff would not destroy the combination unless it destroyed the industry at the same time; but, on the other hand, the removal of a protective tariff might very easily prevent the abuses of exorbitant prices which might be exacted by a combination protected by the tariff.

(2) It is doubtless true that combinations have a good many times been encouraged by special discriminating rates of freight granted by the railways or other transportation agencies. There is, of course, a certain economic advantage to the railways in having goods despatched in large quantities by consigners who are able to supply their own cars, loading and unloading facilities, &c. Railways on that account often prefer to deal with large firms, and, other things being equal, are willing to give them some special rates. These concerns also are likely to have rather better credit than the smaller ones, so that dealing with them ensures prompt pay and cheaper collection of accounts. The competition among the different railways also for the freights which an important customer can furnish leads to cutting of the rates in their favour. These special rates, however, whether justified from the business point of view or not, are beyond any question from the social point of view often a very grave injury. A manufacturer who receives these special favours can build up a business substantially monopolistic in its extent, whereas his rival of equal or even of greater ability, and equally skilful as a manufacturer, would be ruined if he did not receive like rates. The injustice of such discriminations and their evil effects on the community have been recognized by legislatures and courts in America, and they are practically universally forbidden. It nevertheless remains beyond question true that they are very frequently granted even at the present time.

Promotion.

In recent years in the United States there can be little question that the formation of the great combinations has been much encouraged by the opportunities, which promoters were able to seize, of making for themselves large profits. The movement towards combination was so fully recognized and the advantages in many cases so palpable, that a well-informed and skilful promoter was often able to persuade a large proportion of the manufacturers in some special industry to combine. In preparing the plan for such combination, the promoter has in many cases seen to it that he himself first bought the properties which he could very shortly turn over to the combination at high rates of profit; or else he has been able to persuade the new corporation to issue large amounts of stock, of which considerable proportions were given to him in return for his services. It has been true in many cases that these securities have been speculative in nature, but nevertheless the promoter has often reaped in this way large rewards. The possibility of this profit has doubtless stimulated his activity in urging the combinations.

The underwriter.

Associated with the promoter in the organization of these combinations have usually been bankers or other financiers who stood ready, for an amount of stock or other promised profit sufficiently large to compensate them for their risk, to furnish to the combinations cash sufficient to start the business and to provide other needed capital. Usually the form of underwriting employed has been this: A promoter engaged in the formation of a combination and needing a certain fixed sum in cash, would make an arrangement with a bank to sell to it at a price agreed upon such portions of a named amount of stock as were not disposed of to other customers before a certain fixed date. For example, the bank might agree to furnish one million dollars in cash (£200,000) in return for say four millions of stock (£800,000), or to purchase itself at a fixed price all there mainder of the $4,000,000 stock unsold at the date agreed upon, the bank itself to become the sales agent. In those circumstances the bank would naturally use its best endeavours to sell the four millions of stock to other customers at the price agreed upon, say twenty-five dollars, or £5, per share. So far as it failed of disposing of the entire amount, it would take the remainder itself. For taking these risks, naturally the bank has almost invariably asked a very high commission, and not infrequently it has been asserted that the managers of the banks have been given a special bonus for themselves privately, in addition to the rates of profits granted the bank.

The basis of capitalization.

These large amounts of stock that are paid to the promoter and the financier for the purpose of bringing about the organization of a large trust, lead, of course, to what is called over-capitalization. What the proper basis of capitalization for a manufacturing industry should be, is a matter that cannot perhaps easily be determined by a definite principle which shall be applicable in every case. The laws that have been most strict on the subject attempt to limit the capitalization to the "actual cash value" of the business, by that being understood at times simply the cost of the plant itself with the running cash capital needed. On the other hand, most business men think that it is a wiser plan, and on the whole equally just, to capitalize a business on the basis of its earning capacity, regardless of what the plant may have cost. When, as has been frequently the case of late years, in addition to this cash value of the plant and the cash itself which may have been paid in, large sums of stock are issued also for properties which may be in themselves highly overvalued, and for the services of the promoter, the financier, and others, we can see that the capitalization must be far above what may ordinarily be considered a paying basis. On the other hand, if the element of monopoly enters into the business to any noteworthy extent, the prices of the product may be kept so high that fair dividends may be paid even on this high capitalization. That the tendency towards increasing the capital has been very strong there can be no question. It is probable that in the near future the penalty that must be paid for this somewhat reckless financiering will have to be endured. As soon as a slight depression in business comes, so that it is perfectly evident not merely that dividends cannot be paid on the common stock, but that in all probability both the deferred stock and the bonds, if any have been issued, will also have to go without interest, it will be necessary to reorganize many of these combinations and to start them anew on a much lower capitalization. According to a report of the United States Census Office, the actual value of the manufacturing capital employed by combinations which it investigated, June 1900, including 2147 works, was $1,458,522,573. This huge sum equalled only 47·3 per cent. of the securities issued, though it exceeded the amount of bonds and preferred stock. The sum does not include the value of certain forest and mining lands held by some companies.

The industrial manager.

When the person organizing the combination is himself an active business man, and has the intention of himself directing the affairs of the combination, another element besides that of personal profit very frequently enters into the problem. Most strong men like to take responsibility and to be dominant in affairs. When, owing to the advantages of combination that have been enumerated above, the prospect of a virtual monopoly seems certain, provided due skill in management is exercised, it is natural that the manager should wish to bring about the combination in order that he may himself have the satisfaction of being in substantially absolute control of the entire industry in a country, or possibly even in the world. The ambition thus to dominate in a great industry is akin to that of a statesman, and there can be little question that this pride of power and the desire to control the destinies of others has been a more or less conscious element in the formation of many of the most successful and most skilfully managed combinations.

The forms of combination.

(1) The form of combination which has ordinarily been first adopted has been some kind of agreement with reference to maintaining prices, or to paying wages, or to dividing the territory for the distribution of the product, or similar questions. Experience has shown that, generally speaking, such agreements are not likely to be kept in good faith for a long period.

(2) In order to make the combination more permanent in its nature, the form of the trust, technically so called, was adopted. Under this form of combination, the stockholders of the various constituent companies of the trust place their stock in the hands of a small board of trustees, giving to these trustees an irrevocable power of attorney to vote the stock as they see fit, or in accordance with specific instructions given at the beginning. The title to the stock itself remains in the original holder, with the right to sell or pledge or dispose of it as he sees fit, but without the power of recalling his right to vote. In return for this stock thus deposited with the trustees, the trustees have ordinarily issued trust certificates, which are in themselves negotiable, and take the place of the stock. Inasmuch as the holding of the voting power of the majority of the stock of each of the different constituent companies gave to the trustees absolute power of election of directors, and consequently the power of guiding harmoniously the affairs of all of the plant entering into the combination regardless of the will of the stockholders, the United States courts held that the corporations entering into such an agreement had gone beyond their powers, and that such a trust was illegal. Owing chiefly to these hostile decisions of the courts, this form of trust was abandoned, and new forms, which still, however, leave the power of unified direction in the hands of a few men, were adopted.

(3) After the trusts were declared illegal, it was usual, when a combination was formed, to organize a new corporation which bought all of the properties of the

constituent members of the trust. These constituent companies then dissolved, and the one great corporation owning all of the properties remained.

(4) The form that of late seems to be much in favour approaches in its general nature more closely to that of the original trust. Under this form, a corporation is organized for the special purpose of buying and owning all, or a controlling share, of the stocks of each one of the constituent companies. The separate companies are then managed technically independently, the dividends of the separate corporations are all paid to the parent corporation as the stockholder owning all of the stocks, and these dividends are the source of profits of the new corporation. The officers in this parent corporation, of course, vote the stocks of the separate companies, and thus absolutely control.

The trust and wages.

From the savings which it is possible for the combinations to make, it would seem possible for them to pay higher rates of wages to those remaining in their employment than it was possible for the constituent companies to do. In certain instances, especially when the combination has first been made, wages have been increased. On the whole, however, it is probable that as yet the wage-earners have succeeded in getting an increase of wages in circumstances substantially similar to those under which their wages would be increased by single corporations. An increase of wages comes only through pressure on their part. Under a prosperous condition of industry it is possible, without materially lowering profits, to increase the wages.

Certain classes of employés, especially superintendents and commercial travellers, are less needed by the combinations, and consequently the total sum of wages paid to these classes by the combination is less than that formerly paid by the constituent companies. On the other hand, the number of employés of these classes being less than before, the average wage has, in certain cases at least, been increased. Owing to the fact that competitive selling is in certain cases largely done away with, it has in some, perhaps in many, cases been possible for fewer travelling salesmen, of less skill and with lower wages, to do the work than before the combination, so that not merely has the total expense been lessened, but also the average salary paid to those retained in the business.

In case of disputes arising between the combination and the operatives, the position of the combination is stronger than that of an individual corporation. It is possible to close one or two works where troubles have arisen, and to transfer orders to the other works without any material injury to the business, provided the closing of the one or two establishments is not for too long a period. Such instances have occurred. On the other hand, labour organizations are also rapidly increasing in strength, and their leaders are of the opinion that within a comparatively short time they will be so thoroughly organized in all of the chief industries that a strike can be instituted and supported not merely in one or two establishments, but throughout the entire industry. Whenever this condition of affairs shall have been reached, the employés will be substantially on an equality with their employers in such cases of conflict, so that the advantage now resting with the combination will be largely removed. In certain industries this condition seems already to have been reached.

Prices.

From the sources of savings that were enumerated before, it is evident that it would be possible for a combination either to increase the prices paid for raw materials, or to lower the prices of its finished products. Experience, however, seems to show beyond question that whenever the combinations are powerful enough to secure a monopolistic control, it has usually been the policy to increase the prices above those which obtained during the period of competition preceding the formation of the combination. Inasmuch, however, as an attempt to increase prices to any great extent, so as to secure very high profits, would certainly result in tempting new capital into the field, it has been the general experience that prices have either been increased only comparatively little after the combination was formed, or else that competition entering the field has comparatively soon forced a lowering of prices to substantially the former competitive rates. It should be noted, however, that inasmuch as combinations have very frequently been formed only after a period of competition so fierce that practically all the competitors were running at a loss, it is hardly just to speak of a combination placing its prices above "competitive rates" unless one defines what is meant exactly by that expression. Whenever they have put their prices above the competitive rates existing just before the combination, it may mean that they have put their prices back to rates that will allow medium profits instead of losses, and not above rates that would be normal in the case of small competitors.

Legislative remedies.

It will have been noted from what has been said that the excellences of the combination consist largely in the savings that have already been enumerated. The evils are: (1) The losses to investors through the acts of the promoters and financiers at the time of the organization of the combinations, and through the speculation in the stocks which is at times carried on by the directors of the combinations themselves. (2) The losses to the wage-earners from the power that sometimes exists of forcing wages rather lower than it would be possible for a single corporation or manufacturer to do, and also from the discharge of certain classes of employés whose services are no longer needed, such as commercial travellers. It should be remarked of the latter case, however, that the injury is a personal one to those men that are discharged, but that it results in a saving to the community, and therefore presumably to the wage-earning class as a whole in the long run. (3) A further injury at times to the consumer arises, as has been suggested, from the increase in price. Other evils come through the power that is sometimes exercised by combinations in the corruption of legislatures; in the control over industries of such a nature that it tends to destroy the spirit of individual activity and independence on the part of many persons who would otherwise enter business independently; and evils also come through the increased force of any improper or dishonourable business practices, since this added force for evil is given to any combination by virtue of its greater influence in the community. It is not intended to convey the impression that managers of combinations are less moral than other business men, but merely that whenever they are dishonourable in their practices the influence reaches more widely.

The chief remedies for these evils enumerated would seem to be more rigid laws with reference to the methods of incorporation and to the responsibility of directors to stockholders and to the public. This can perhaps best be brought about through greater publicity in both of these directions, probably under the inspection of Government officials. The other line of remedies would seem to be the removal of special favours granted to these combinations either by the Government or by railways or other bodies so situated that they can distribute favours to the larger combinations.

The movement towards consolidation of industries in the United States began to be noticeable soon after the Civil War (1861–65), but it had not reached noteworthy proportions, excepting in connexion with the railways, until within the last twenty years of the 19th century.

The movement towards consolidation.

During the later years many consolidations were made, the largest number during the years 1898–1900. From what has been said earlier, it is evident that certain classes of industries, especially those that require the investment of fixed capital to large amounts, are especially adapted for combination. Very little tendency towards consolidation is found in the farming industry, and, relatively speaking, little in industries that require the investment of but small capital. It is perhaps, however, not too much to say that in nearly all lines of industry which from their nature are adapted for consolidation combinations more or less firm have been made during the last few years. It is probable that as time passes we shall have many of these combinations reorganized, and that in many lines of industry there will be further consolidation of present combinations.

Experience has shown that when combinations are made in industries that from their nature do not seem well suited for consolidation, failure follows. In many individual instances corporation lawyers, who have had much practice in forming combinations, advise their clients in lines of business especially fitted for competition not to enter a combination, but to remain independent, assuring them that an individual is able to compete in such lines of industry with any combination, however large. Such advice of course would not be given were the industry one which was well adapted for consolidation.

According to the United States census report of 1900, it seems a fair inference that not over one quarter of the value of the manufactured products of the United States is as yet produced by the combinations, powerful as they are in many lines.

European experience.

Great Britain.—The tendency toward consolidation has been for several years very noticeable in Great Britain, although until within the last few years the form has been rather that of a pool or ring than that of a trust or of a single large corporation. In the coal and milling industries there have been agreements; and, particularly in London and other distributing centres, these selling combinations have been able at times to control the market. This has also been true with reference to certain kinds of provisions, such as the bacon imported from Denmark.

Of late years there has been a marked tendency towards the formation of large corporations that buy up a very large proportion of competing manufacturing plant, and in this way secure at least a temporary monopoly of the market. The Salt Union was formed along these lines, but this has not proved successful, owing probably to the fact that new sources of supply were discovered. The dyeing industries in Bradford and in Yorkshire have been consolidated, so that in certain respects they have an absolute monopoly of the business, and in most directions of over 90 per cent. of it. The calico printers, the fine cotton spinners, the thread manufacturers, the bleachers, and others connected with the cotton manufacturing industries in Great Britain, have nearly all been brought together into large corporations which control from 90 per cent. upwards of the entire business. Similar combinations in cement, wall-paper, soap, and other trades have been formed. Most of these large corporations have been in existence for such a short time that one cannot yet judge accurately regarding their permanent success. Many of them seem to have been over-capitalized, and their dividends have not always met shareholders' anticipations. There has been no active popular movement against consolidation in England, and the Government has passed no laws opposed to it. Parliament, however, has passed stringent amendments to the Companies Acts, changes enforcing publicity regarding the organization of all limited liability companies and their methods of management. The amended law is expected to prevent most of the abuses of the combinations.

Germany.—Germany seems to be peculiarly the home of combinations so far as Europe is concerned. In 1897 Liefmann, writing regarding combinations in Germany, was able to mention combinations which were international in their scope in forty-one different branches of industry. Of combinations that were confined to Germany alone he mentioned 345, although many of them were in the same line of industry: for example, he found 80 combinations in different branches of the iron industry, 82 in the chemical industries, 38 in the textiles, and so on. Of that number he thought that definite information could be secured, but he was of the opinion that very many more of less importance existed, and had excluded from his reckoning all of those that were purely local, as for example those among the breweries in the different cities, as well as those among firms engaged merely in trade. The form of combination in Germany is ordinarily that merely of contracts among independent establishments regulating the amount of output for each, and in certain cases also the prices. As in Austria and in France, a central selling bureau for all the members of the combination is frequently found. The most successful combinations have been those among the coal-miners in western Germany, and the four or five in the leading branches of iron manufacture, also in western Germany. Lately two others of somewhat similar rank have been organized, one in the sugar industry, which includes both refiners and producers, and one among the manufacturers of spirits. The former, following that among the Austrian sugar manufacturers, is somewhat peculiar in that the refiners guarantee to the producers of raw sugar a fixed price for their output so far as the sugar is intended for the home market, the refiners expecting to recoup themselves from the consumers through the monopolistic power which they possess. The law does not seem to be hostile to these combinations. Contracts that are immoral in their nature are, of course, non-enforceable. But the courts have, on the whole, not taken an attitude inimical to the larger combinations, and the Government seems at times to have been inclined to favour them. In one or two cases where the Government is itself a producer, as of soda, it is a member of a combination. Comparatively lately, one of the Prussian ministers in a speech in the Landtag expressed himself favourably regarding the coal and iron combinations. The facts seem to show that the coal combination, at any rate, has used its power of fixing prices in a conservative way, and that during 1901 it has apparently held prices somewhat lower than they probably would have been had free competition existed in that industry. So long as the combinations are managed thus conservatively, and so long as the Government is able to secure a careful supervision over them, it is not to be expected that there will be much hostility in Germany on the part of the Government.

France.—The number of combinations in France is probably much less than in Great Britain or Germany. In the Penal Code there has been a provision for many years against monopoly brought about by unfair means, and in one or two rather prominent instances there seem to have been convictions under this article. Consequently, the agreements that have been made, so far as they are intended to control prices, are usually kept secret. There have been, however, notably in the case of the iron industries, agreements made among the leading manufacturers, under which the proportion of output assigned to each was fixed. A single selling bureau has also in such cases been established, which receives all orders, and fixes the prices for all of the different establishments concerned. So far this form of organization, although in certain localities it seems to have secured monopolistic power, has not been successfully attacked in the courts. For several years it has been supposed that a similar agreement existed among the sugar refiners. They themselves, however, acknowledge only an agreement regarding the amount of the output which shall be assigned to each, and deny any agreement as to prices. Of course an agreement regarding output would be likely to have a material effect upon prices. Somewhat similar combinations exist among the petroleum refiners, the porcelain makers, and some few others. The Government has taken no active steps in the matter, but popular opinion seems to be awakening somewhat.

Austria.—In Austria the development of combinations has been very marked. The most successful combination, on the whole, as well as one of the earliest, has been that of the iron industry. The sugar industry, however, including both refiners and producers of the raw sugar, and the petroleum industry, are also combinations of great power. The form of these combinations is ordinarily that of an agreement regarding both output and prices. In some instances a central selling bureau fixes the prices, in others the market is divided, while in others still other forms of agreements of many kinds which serve to secure a monopoly are found. The movement has spread very rapidly indeed, until, in the opinion of many writers in Austria, practically all branches of industry, in which agreements for the lessening of competition will prove advantageous, are now largely controlled by combinations. The courts of Austria have, on the whole, within the last few years shown themselves hostile to the movement. Contracts for the division of the market, for the assignment of fixed proportions of the entire output to different establishments, the fixing of prices, &c., are declared void, and will not be enforced by the courts. This adverse action, however, does not seem to have affected very materially the tendency towards combination, although it has perhaps tended somewhat to encourage the formation of large corporations which should purchase all of the separate plant in any one industry. This tendency, again, is checked by the fact that the corporation law requires publicity in business, and that the taxes are heavier on corporations than on private firms, both as regards the legal rate and the certainty of collection. A Government commission has recommended recognition of the combinations by law and their careful supervision and regulation by governmental authority. (J. W. J.)

Tryon, Sir George (1832–1893), British admiral, a younger son of Thomas Tryon, of Bulwick Park, Northamptonshire, was born on 4th January 1832. He entered the navy in 1848, on board Lord Dundonald's flagship on the North American station; was afterwards in the *Vengeance* with Lord Edward Russell in the Black Sea; was landed for service with the naval brigade; and was made a lieutenant in November, but dated back to 21st October 1854. From 1855 to 1858 he was in the *Royal Albert*, flagship of Sir Edmund Lyons; and from 1858 to 1860 in the royal yacht, which gave him his promotion to commander on 25th October 1860. From 1861 to 1864 he was commander of the *Warrior*, the first British sea-going ironclad; from 1864 to 1866 he commanded the *Surprise* gun-vessel in the Mediterranean; and was promoted to be captain on 11th April 1866. In 1867 he was sent out as director of transports and store ships for the Abyssinian expedition, a post which involved a great deal of hard work in a sweltering and unhealthy climate. He discharged his duties exceedingly well, but his health broke down, and he returned to England a helpless invalid. From 1871 to 1873 he was private secretary to Mr Goschen, then First Lord of the Admiralty; and from 1874 to 1877 commanded the *Raleigh* in India with the Prince of Wales, and afterwards in the Mediterranean. In the years 1878–81 he had command of the *Monarch*, one of the Mediterranean fleet under Sir Geoffrey Hornby and Sir Beauchamp Seymour, afterwards Lord Alcester. He was afterwards for two years secretary of the Admiralty; and for three years more, on his promotion in April 1884 to the rank of rear-admiral, commander-in-chief on the Australian station. On his return, in June 1887, he was made K.C.B.; afterwards he was for three years superintendent of reserves, in which capacity it fell to him to command one of the opposing fleets during the summer manœuvres, when he showed marked ability and originality of ideas. In 1889 he was promoted to be vice-admiral; and in August 1891 was appointed to command the Mediterranean fleet, which under him—following the example of his old chief, Sir Geoffrey Hornby—became very distinctly an evolutionary and, in that sense, experimental squadron. Some of his methods were afterwards said to be dangerous; but those which were most severely criticized do not appear to have had anything to do with the lamentable accident which ended Tryon's career. On the 22nd June 1893, the fleet being then off Tripoli on the coast of Syria, in two columns, Tryon made the signal to invert the course, the ships turning inwards in succession. By a fatal error, the psychological cause of which has never been explained, he ignored the patent fact that the two columns were so near each other that the manœuvre, as ordered, must entail the most serious risk, if not certainty, of collision. And in fact the two leading ships did come into collision, with the result that the *Victoria*, Tryon's flagship, was cut open and sank in a few minutes. Tryon and a lamentably large proportion of the men were drowned. A full *Life* of Tryon, by Rear-Admiral C. C. Penrose FitzGerald, has been published. He had married in 1869, and left issue. (J. K. L.)

Tsaidam. See TIBET.

Tsanpo. See BRAHMAPUTRA.

Tschaïkovsky, Peter Iliitsch (1840–1893), Russian composer, born at Votkinsk, in the province of Vyatka, on the 7th May 1840, was the son of a mining engineer, who shortly after the boy's birth removed to St Petersburg to assume the duties of director of the Technological Institute there. While studying in the School of Jurisprudence, and later, while holding office in the Ministry of Justice, Tschaïkovsky picked up a smattering of musical knowledge sufficient to qualify him as an adept amateur performer. Thus he became in demand in society. But the seriousness of his musical aspirations led him to join the classes held in connexion with the famous Musical Society, after which he entered the Conservatorium under Zaremba, and was induced by Anton Rubinstein, its principal, to take up music as a profession. He therefore resigned his post in the Ministry of Justice. On quitting the Conservatorium he was awarded a silver medal for his thesis, a cantata on Schiller's "Ode to Joy." In 1866 Tschaïkovsky became practically the first chief of the recently founded Moscow Conservatorium, since Seroff, whom he succeeded, never took up his appointment. Although in Moscow Tschaïkovsky missed the life and bustle of St Petersburg, he met many artistic people whose services were useful. Thus Ostroffsky wrote for him his first opera libretto, *The Vojevoda.* After the Russian Musical Society had rejected a concert overture written at Rubinstein's suggestion, Tschaïkovsky in 1866 was much occupied on his *Winter Day Dreams*, a symphonic poem, which proved a failure in St Petersburg but a success at Moscow. In 1867 he made an unsuccessful début as conductor. Failure still dogged his steps, for in January 1869 his *Vojevoda* disappeared off the boards after ten performances, and subsequently Tschaïkovsky destroyed the score. The *Romeo and Juliet* overture has been much altered since its production by the Russian Musical Society in 1870, in which year the composer once more attempted unsuccessfully an operatic production, St Petersburg rejecting his *Undine.* In 1871 Tschaïkovsky was busy on his cantata for the opening of the Exhibition in celebration of the bicentenary of Peter the Great, his opera *The Oprischnik*, and a text-book of harmony, which latter was adopted by the Moscow Conservatorium authorities. At Moscow in 1873 his incidental music to the *Snow Queen* failed, but some success came next year with the beautiful quartet in F. During these years Tschaïkovsky was musical critic for two journals. On the death of Seroff he competed for the best setting of Polousky's *Wakula the Smith*, and won the first two prizes. Yet on its production at St Petersburg in November 1876 this work gained only a *succès d'estime.* Since then it has been much revised, and is now known as *The Little Shoes.* Meanwhile the Second Symphony and the *Tempest* fantasia had been heard, and the pianoforte concerto in B flat minor completed. This was first played by von Bülow in Boston, U.S.A., some time later, and was entirely revised and republished in 1889. At last something like success came to Tschaïkovsky with the production of *The Oprischnik*, in which he had incorporated much of the best of *The Vojevoda.* The Third—or Polish—Symphony, four sets of songs, the E flat quartet (dedicated to the memory of Lamb), the ballet *The Swan Lake*, and the *Francesca da Rimini* fantasia all belong to the period of the late 'seventies—the last being a *rechauffé* of operatic remains. Opera still possessed Tschaïkovsky, who in 1877 first conceived the germs of *Eugen Onegin.* With the production of this opera at the Moscow Conservatorium in March 1879 real success first came to him. The story, by Pushkin, was a familiar one, and the music not so extravagant in its demands as in the earlier operas. Over part of this period of Tschaïkovsky's life a mystery still hangs. M. Kashkin, his best friend, believes that even in 1877 the composer was engaged to be married. But no word on the subject ever passed between them, and the first intimation Kashkin received was his meeting with Tschaïkovsky and his wife in the autumn of that year. From this time Tschaïkovsky was a changed man. He became taciturn to moroseness, and finally he quitted Moscow and his friends for St Petersburg. There he fell ill, and an attempt to commit suicide by standing chin-high in the river in a frost (whereby he hoped to catch his death from exposure) was only frustrated by his brother's tender care. With his brother Tschaïkovsky went to Clarens to recuperate. In 1878 he accepted (but later resigned) the post of director of the Russian musical department at the Paris Exhibition, completed his Fourth Symphony and the Italian Capriccio, and worked hard at his "1812" overture, more songs, the second pianoforte concerto, and his interesting "Liturgy of St Chrysostom." This latter nearly came to an untimely end through the officialdom which necessitated the imprimatur on all Greek Church music of the Court Chapel-Master, Bortniansky, who had been in his grave nearly half a century! The year of rest following Tschaïkovsky's domestic *débâcle* gave him a taste for freedom. Consequently he returned only for a short time to Moscow. Thence he went to Paris. In 1879 he wrote his *Maid of Orleans* (produced in 1880) and his first suite for orchestra. In 1881 Nicholas Rubinstein died—to whose memory Tschaïkovsky dedicated one of his most beautiful and characteristic works, the trio in A minor. The following five years saw him fully occupied with travels, and working at *Manfred* and *Hamlet*, the operas *Mazeppa* and *Charodaïka*, the Mozartian suite, and the fine Fifth Symphony. During a great part of the time he lived in retirement at Klin, where his generosity to the poor made him beloved. His operas *The Queen of Spades* and the one-act *Iolanthe* were feeble by comparison with his earlier works, but the *Sleeping Beauty* and *Casse-Noisette* ballets are quite charming. In 1893 Tschaïkovsky sketched his Sixth Symphony, now known as the Pathetic, a work that has done more for his fame in foreign lands than all the rest of his works. This symphony was at first thought to have aroused undue sympathy from an entirely fictitious autobiographical interest, and from its having been first conducted by the composer within ten days of his sudden death. Tschaïkovsky died from cholera at St Petersburg, 6th November 1893, barely six months after Cambridge University had conferred on him in person the honorary degree of Doctor in Music.

PETER ILIITSCH TSCHAÏKOVSKY.
(*From a photograph by Reutlinger, Paris.*)

Tschaïkovsky's work is so unequal that it would be possible, by carefully chosen examples of his music, to prove him at once one of the immortals of music and a merely mediocre composer. In dramatic affairs he lacked point precisely as Anton Rubinstein lacked point. But in the matter of invention of broad, sweeping melody Tschaïkovsky was far ahead of his compatriot, and as a composer of music saturated with what are popularly understood to be national Russian characteristics was on a plane far above the other. Among his songs and smaller pianoforte works, as in his symphonies and quartets, are passages of exquisite beauty; while, on the other hand, *bizarrerie*, and even downright uncouthness, are not always to seek. But the best of Tschaïkovsky's work commands whole-hearted admiration. It is more distinctly Russian and more beautiful than that of most of his compatriots; it is not disguised German music, as is so much by Rubinstein and Glazounow, and it is not incoherently ferocious, like so much by Balakireff. Probably time will place Tschaïkovsky somewhere after Glinka and before his own contemporaries. (R. H. L.)

Tschudi.—The historical reputation of Giles Tschudi (1505–1572) has suffered very much owing to recent researches. His inventions as to the early history of the Swiss Confederation have been described under TELL. His statements and documents relating to Roman times and the early history of Glarus and his own family had long roused suspicion. Detailed examination of late years has proved beyond the shadow of a doubt that he not merely claimed to have copied Roman inscriptions that never existed, and amended others in a most arbitrary fashion, but that he deliberately forged a number of documents with a view to pushing back the origin of his family to the 10th century, thus also entirely misrepresenting the early history of Glarus, which is that of a democratic community, and not (as he pretended) that of a preserve of several aristocratic families. Tschudi's historical credit is thus hopelessly ruined, and no document printed or historical statement made by him can henceforward be accepted without careful verification and examination. These discoveries have a painful interest and importance, since down to the 19th century all Swiss historical writers had largely based their works on his investigations and manuscripts.

For a summary of these discoveries see Professor G. v. WYSS in the *Jahrbuch* of the Historical Society of Glarus, vol. xxx. (1895), in No. 1, 1894, of the *Anzeiger f. Schweizerische Geschichte*, and in his *Geschichte d. Historiographie in d. Schweiz* (1895), pp. 201–2. The original articles by VOGELIN (Roman inscriptions) appeared in vols. xi., xiv., and xv. (1886–1890) of the *Jahrbuch f. Schweizer Geschichte*, and that by SCHULTE (Glarus) in vol. xviii. (1893) of the same periodical. For a defence see a feeble pamphlet, *Schulte u. Tschudi* (Coire, 1898), by P. C. v. PLANTA. (W. A. B. C.)

Tsêng Kuo-fan (1811–1872), Chinese statesman and general, was born in 1811 in the province of Hunan, where he took in succession the three degrees of Chinese scholarship. In 1843 he was appointed chief literary examiner in the province of Szechuen, and six years later was made junior vice-president of the Board of Rites. When holding the office of military examiner (1851) he was compelled by the death of his mother to retire to his native district for the regulation mourning. At this time the Taiping rebels were overrunning Hunan in their conquering career, and had possessed themselves of the cities and strongholds on both shores of the Yangtse-kiang. By a special decree Tsêng was ordered to assist the governor of the province in raising a volunteer force, and on his own initiative he built a fleet of war junks, with which he attacked the rebels. In his first engagement he was defeated, but, happily for him, his lieutenants were more successful. They recovered the capital, Chang-sha, and destroyed the rebel fleet. Following up these victories of his subordinates, Tsêng recaptured Wuchang and Hanyang, near Hankow, and was rewarded for his success by being appointed vice-president of the Board of War. In 1853 other triumphs led to his being made a Baturu (a Manchu order for rewarding military prowess), and to his being decorated with a yellow riding-jacket. Meanwhile, in his absence, the rebels retook Wuchang and burnt the protecting fleet. The tide quickly turned, however, and Tsêng succeeded in clearing the country round the Poyang lake, and subsequently in ridding the province of Kiangsu of the enemy. His father died in 1857, and after a brief mourning he was ordered to take supreme command in Chekiang, and to co-operate with the governor of Fuhkien in the defence of that province. Subsequently the rebels were driven westwards, and Tsêng would have started in pursuit had he not been called on to clear the province of Anhwe of rebel bands. In 1860 he was appointed viceroy of the two Kiang provinces and imperial war commissioner. At this time, and for some time previously, he had been fortunate in having the active support of Tso Tsung-t'ang, who at a later period recovered Kashgar for the emperor, and of Li Hung-Chang. Like all true leaders of men, he knew how to reward good service, and when occasion offered he appointed the former to the governorship of Chekiang and the latter to that of Kiangsu. In 1862 he was appointed assistant grand secretary of state. At this time the imperial forces, assisted by the "Ever-victorious Army," had checked the progress of the rebellion, and Tsêng was able to carry out a scheme which he had long formulated of besieging Nanking, the rebel headquarters. While Gordon, with the help of Li Hung-Chang, was clearing the cities on the lower waters of Yangtse-kiang, Tsêng drew closer his besieging lines around the doomed city. In July 1864 the city fell into his hands, and he was rewarded with the rank and title of marquis and the right to wear the double-eyed peacock's feather. After the suppression of the Taipings a rebellion, closely related to the former movement, broke out in Shantung, and Tsêng was sent to quell it. Success did not, however, always attend him on this campaign, and by imperial order he was relieved of his command by Li Hung-Chang, who in the same way succeeded him in the viceroyalty of Chihli, where, after the massacre of Tientsin (1870), Tsêng failed to carry out the wishes of his imperial master. After this rebuff he retired to his viceroyalty at Nanking, where he died in 1872. Tsêng was a voluminous writer. His papers addressed to the throne and his literary disquisitions are held in high esteem by the scholars in China, who treasure as a memorial of a great and uncorrupt statesman the edition of his collected works in 156 books, which was edited by Li Hung-Chang in 1876. (R. K. D.)

Tsetse Fly.—The tsetse fly (*Glossina morsitans*, Westwood) belongs to the dipterous family Muscidæ. It is sometimes locally called "Tsaltsaya," although it is generally known to the natives as the tsetse or tzetze fly. This pest is met with throughout Central, South, and East Africa, on the Congo, and up the Niger on the west coast. It is the active agent in spreading one of the most virulent equine diseases of South Africa, the so-called tsetse disease or *nagana*. This disease, which is caused by minute protozoa of the genus *Trypanosoma* in the blood, affects the horse chiefly, but is also found in the ox, ass, goat, dog, and such wild animals as the koodoo deer. The germs of this disease are spread by the tsetse fly, which is a blood-sucker. On obtaining the blood of a horse or other animal suffering from this complaint the fly also obtains some of these protozoal parasites, which even after two or three days' severance from their host retain their vitality. The germs which the tsetse fly has obtained are ejected into the next horse or ass which the insect attacks. At present it is not known if the fly acts in any way as an intermediate host, but it is generally assumed that it acts merely as a carrier of the hæmatozoa from beast to beast. In size the tsetse fly is about half an inch long, that is, considerably larger than the common house fly (*Musca domestica*). Its thorax is deep chestnut-brown, with four dark longitudinal lines, and with small bristles, which when denuded show small black specks; the abdomen is bristly and dull yellowish-brown in colour, with black patches on the visible segments which are interrupted in the middle; the wings are of a smoky hue. The legs are buff-coloured with some yellowish markings. The proboscis is long, about twice the length of the head, and is in the form of a sharp piercing organ. When gorged with blood the female's abdomen swells to a great size and becomes reddish-brown beneath. Its favourite habitat seems to be the borders of marshes, river sides, places where animals go to water, and in and around beds of reeds. It is very local, sometimes being confined to one side of a river in thousands, whilst on the opposite bank not one can be found. The so-called "fly-zones" make transport by horse almost impossible where the tsetse disease occurs. When on the wing *Glossina morsitans* makes a loud buzzing noise. When at rest the wings fold over one another. The female has been shown by Bruce to produce her young viviparously. The larva is yellow and nearly as large as the abdomen of the parent; it is furnished with a black hood at one end and two hooks at the other, and consists of ten segments. After living a short free existence, it crawls into some hole or crevice, and in a few hours it has turned into a jet black puparium. The pupal stage lasts six weeks. The parent requires an enormous amount of blood for the nourishment of the young, hence she is always sucking blood from the various warm-blooded animals and man. The fly is found in districts in which tsetse disease does not occur, and when this is the case the bite alone, though annoying, produces no further results than irritation; when piercing the skin the proboscis causes a sharp prick. According to Bruce, the reason why *Glossina morsitans* only carries the virus is that, being viviparous, the mother has to take constant nourishment for her developing larvæ. The bite has no effect upon man even when the fly has just left a diseased animal, except by causing irritation. When attacking a horse the fly usually settles on the legs, but also sticks on to the belly, inside the thighs, and under the tail. Their favourite feeding-time is sunset, but they also bite by moonlight. (F. V. T.)

Tsu-shima, signifying "the island of the port," an island belonging to Japan, situated about midway between Korea and the island of Iki, so that the two islands were used as places of call in former times by vessels plying between Japan and Korea. It lies a little to the east of 129° E. and a little to the north of 34° N. It has a circumference of 454 miles, an area of 262 miles, and a population of 38,636. It is almost completely divided at the waist by a deep sound (Asaji-ura), and the southern section has two mountains, Yatachi-yama and Shira-dake, 2130 feet and 1680 feet high respectively, while the northern section has Ibeshi-yama and Mi-take, whose heights are 1128 feet and 1598 feet. The chief town is Izu-ga-hara. The Mongol armada visited the island in the 13th century and committed great depredations. From Tsu-shima to Fusan, the principal Japanese settlement in Korea, the distance is 65 miles, but the nearest point of the Korean coast is only 48 miles distant.

Tuam, an episcopal city in the county of Galway, Ireland, on the Waterford, Limerick, and Western railway, 129 miles west of Dublin. A place of great antiquity, it has always had intimate ecclesiastical connexions. The Protestant archbishopric of Tuam was lowered to a bishopric in 1834, and the see joined to that of Killaloe. It is, however, a Roman Catholic archbishopric. The Protestant cathedral is also the parish church, and was to a great extent rebuilt in the third quarter of the 19th century from plans by Sir Thomas Deane, at a cost of £16,000. Only the chancel of the old church remains, but its red sandstone arch is architecturally famous as a remarkably fine example of Norman work; it dates from the middle of the 12th century. The modern Roman Catholic cathedral is perpendicular in style and cruciform in plan. The interior is elaborately decorated. The Cross of Tuam, re-erected in modern times, bears inscriptions in memory of Turlogh O'Conor, king of Ireland, and O'Hoisin, successively (1128) abbot of St Jarlath's Abbey, founded in the 6th century, and archbishop (1152) of Tuam. St Jarlath's College is a seminary for the education of priests. Population (1891), 3012; (1901), 2890.

Tuamotu, an archipelago of coral formation in the South Pacific, between 14° and 24° S. and 135° and 150° W., officially part of the French dependency of Tahiti. The largest islands are Fakarava and Ravida; the former is the administrative headquarters of the French resident. With three or four exceptions they are flat, and the vegetation which grows upon the arid limestone is scanty. The group is, however, planted with cocoa-nut, breadfruit, bananas, water-melons, yams, &c., which form the chief subsistence of the natives. The fine fisheries in the rocky and surf waters are a source of revenue, the pearls being sold in Tahiti. The best harbour of the group is that of Fakarava, which, together with Mengarewa, is open to trade. The islands were first discovered by the Spaniard Pedro Fernandez Quiros in 1606. The area of the entire group is about 330 square miles, and the population is about 7000, all of whom are natives, with the exception of a few French officials and other Europeans. The group passed under the protection of France in 1844, and was absorbed into the Republic in 1881.

Tuat, a Berber word signifying "oasis," sometimes applied generally to all the oases of the Algerian Sahara between 0° and $2\frac{1}{2}$° E., 26° and 29° N., sometimes restricted to a particular group which borders the east side of the Wad Mzaud between $26\frac{1}{2}$° and $27\frac{1}{2}$° N. According to the first-mentioned usage, it includes the oases of Gurara and Tidikelt with the important centre of Insalah. The district is comparatively fertile, being formed of recent alluvium extending along the base of the Tademait plateau (Cretaceous), and produces dates and some cereals and vegetables. It is peopled with a diversity of races, Arab, Berber, and negro being all represented, but the population is much less dense than formerly. The separate "ksur" or hamlets, of which the district is said to contain over 300, are in Tuat proper placed very closely together. The district is of importance as commanding the routes southwards to Timbuktu from both Morocco and Algeria, and it is thus a great centre of trade. Although formerly claimed by Morocco, the sovereignty of that kingdom has long been merely nominal, and the district was early in 1900 occupied by French troops as a step towards consolidating French influence over the routes to the south. Schemes have been set on foot for the extension of the Algerian railways to Tuat, the route most favoured being that *viâ* Figig and Igli (occupied later in 1900), following the course of the Wad Susfana and Wad Saura. A step in this direction has already been taken by the continuation of the Western Algerian railway beyond Ain Sefra to Jenien-bu-Rezg (opened early in 1900). It has since been carried still farther.

See works by DEPORTER, Algiers, 1890-91.—FLAMAND, in *La Géographie*, May 1900; *Annales de Géographie*, 1900, pp. 233–242.

Tuberculosis.—The word "tuberculosis," as now used, signifies invasion of the body by the tubercle bacillus, and is applied generally to all morbid conditions set up by the presence of the active parasite. The name is derived from the "tubercles" or "little lumps" which are formed in tissues invaded by the bacillus; these were observed and described long before their real nature or causation was known. (For an account of the organism, which was discovered by Koch in 1882, see PATHOLOGY: *Parasitic Diseases*). The bacillus attacks every organ and tissue of the body, but some much more frequently than others. The commonest seats of tubercular disease are the lungs, lymphatic glands, bones, serous membranes, mucous membranes, intestines, and liver. Before the discovery of the bacillus its effects in different parts of the body received separate names and were classified as distinct diseases. For instance, tuberculosis of the lung was called "consumption" or "phthisis," of the bones and lymphatic glands "struma" or "scrofula," of the skin "lupus," of the intestine "tabes mesenterica." Some of these names are still retained for convenience, but the diseases indicated by them are known to be really forms of tuberculosis. On the other hand, there are "tubercles" which are not caused by the tubercle bacillus, but by some other source of irritation, including various parasitic organisms, some of which closely resemble the tubercle bacillus. To these forms of disease, which are not as yet well understood, the term pseudo-tuberculosis has been given. Lastly, the word "tubercular" is still sometimes applied to mere lumpy eruptions of the skin, which have no connexion with tuberculosis or pseudo-tuberculosis.

Pathology.—The effects of tuberculosis on the structures attacked vary greatly, but the characteristic feature of the disease is a breaking-down and destruction of tissue. Hence the word "phthisis," which means "wasting away" or "decay," and was used by Hippocrates, accurately describes the morbid process in tuberculosis generally, as well as the constitutional effect on the patient in consumption. According to the most recent views, the presence and multiplication of the bacilli excite by irritation the growth of epithelioid cells from the normal fixed cells of the tissue affected, and so form the tubercle, which at first consists of a collection of these morbidly-grown cells. In a typical tubercle there is usually a very large or "giant" cell in the centre, surrounded by smaller epithelioid cells, and outside these again a zone of leucocytes. The bacilli are scattered among the cells. In the earliest stages the tubercle is microscopic, but as several of them are formed close together they become visible to the naked eye and constitute the condition known as miliary tubercle, from their supposed resemblance to millet seeds. In the next stage the cells forming the tubercle undergo the degenerative change known as "caseation," which merely means that they assume in the mass an appearance something like cheese. In point of fact, they die. This degeneration is believed to be directly caused by a toxin produced by the bacilli. The further progress of the disease varies greatly, probably in accordance with the resisting power of the individual. In proportion as resistance is small and progress rapid the cheesy tubercles tend to soften and break down, forming abscesses that burst when superficial and leave ulcers, which in turn coalesce, causing extensive destruction of tissue. In proportion as progress is slow the breaking down and destructive process is replaced by one in which the formation of fibrous tissue is the chief feature. It may be regarded as Nature's method of defence and repair. In tuberculosis of the lungs, for instance, we have at one end of the scale acute phthisis or "galloping consumption," in which a large part or even the whole of a lung is a mass of caseous tubercle, or is honeycombed with large ragged cavities formed by the rapid destruction of lung tissue. At the other end we have patches or knots of fibrous tissue wholly replacing the original tubercles or enclosing what remains of them. Such old encapsuled tubercles may undergo calcareous degeneration. Between these extremes come conditions which partake of the nature of both in all degrees, and exhibit a mixture of the destructive and the healing processes in the shape of cavities surrounded by fibrous tissue. Such intermediate conditions are far more common than either extreme; they occur in ordinary chronic phthisis. The term "fibroid phthisis" is applied to cases in which the process is very chronic but extensive, so that considerable cavities are formed with much fibrous tissue, the contraction of which draws in and flattens the chest-wall. Tuberculosis commonly attacks one organ or part more than another, but it may take the form of an acute general fever, resembling typhoid in its clinical features. "Acute miliary tuberculosis" is a term generally used to indicate disseminated infection of some particular organ—usually the lungs or one of the serous membranes—in which the disease is so severe and rapid that the tubercles have not time to get beyond the miliary stage before death occurs. Tuberculosis is exceedingly apt to spread from its original seat and to invade other organs. The confusing multiplicity of terms used in connexion with this disease is due to its innumerable variations, and to attempts to classify diseases according to their symptoms or anatomical appearances. Now that the cause is known, and it has become clear that different forms of disease are caused by variations in extent, acuteness, and seat of attack, the whole subject has become greatly simplified, and many old terms might be dropped with advantage.

Tuberculosis in the Lower Animals.—Most creatures, including worms and fishes, are experimentally susceptible to tuberculosis, and some contract it spontaneously. It may be called a disease of civilization. Domesticated animals are more susceptible than wild ones, and the latter are more liable in captivity than in the natural state. Captive monkeys, for instance, commonly die of it, and of birds the most susceptible are farmyard fowls. Of the domesticated animals, horses and sheep are least, and cattle most, affected; pigs, dogs, and cats occupy an intermediate position. The percentage of tuberculous animals recorded at the slaughter-houses of Berlin in 1892–93 was as follows: Cows and oxen, 15·1; swine, 1·55; calves, 0·11; sheep, 0·004. Similar records at Copenhagen in 1890–93 give the following result: Cows and oxen, 17·7; swine, 15·3; calves, 0·2; sheep, 0·0003. The order of the animals is the same, and it is confirmed by other slaughter-house statistics; but the discrepancies between the figures indicate considerable variation in frequency, and only allow general conclusions to be drawn. A striking fact is the comparatively small amount of tubercle in calves. It shows, as Nocard has pointed out, that heredity cannot play an important part in the transmission of bovine tuberculosis. The infrequency of the disease in sheep is attributed to the open-air life they lead, and no doubt that is an important factor. The more animals and persons are herded together and breathe the same air in a confined and covered space, the more prevalent is tuberculosis among them. But there are evidently degrees of natural resistance also. Horses are more confined than cattle in the United Kingdom, yet they are far less affected; and on the other hand, cattle running free in the purest air may take the infection from others. Professor McEachran of Montreal states that he has seen tuberculosis prevalent in ranche cattle, few of which were ever under a roof, ranging on the foothills of the Rocky Mountains in Montana. In cows and monkeys the lungs are chiefly affected; in horses and pigs the intestine and abdominal organs. The relation between human and animal tuberculosis has not yet been determined. The bacillus in man very closely resembles that found in other mammalia, and they were considered identical or interchangeable until Koch threw doubt upon this view at the British Congress on Tuberculosis in 1901. The bacillus in birds shows cultural differences, and is regarded as a distinct variety. Further reference will be made to this question, which has an important bearing on the spread and prevention of the disease.

Distribution and Mortality.—The distribution of tuberculosis is world-wide, and seems to be unaffected by geographical situation. The experiments of Mr Swithinbank, who exposed the bacilli to the temperature of liquid air (about 186° C. below zero) for forty-two days, prove that their vitality is not destroyed by the most intense cold. It is not surprising, therefore, to find that the disease prevails in Greenland and Siberia. Bright sunlight, on the contrary, is said to render the bacilli inert in a few hours (Koch, Ransome). Nevertheless tuberculosis flourishes in the tropics, India, and Australia. The natural conditions which are least favourable to it are those which combine sunshine, abundant air-currents, dry soil, and a certain altitude. In the midlands and highlands of Natal, for instance, Europeans and natives and cattle all enjoy nearly complete immunity (Allen). But in such localities, sparsely inhabited as a rule, both men and animals generally live an open-air life. Wherever they are aggregated together in dwellings tuberculosis is found among them. This appears to be a more important condition than climate, soil, or geographical situation. The comparative immunity of uncivilized races is explained by their open-air life; when brought to live under civilized conditions and in contact with white people they succumb far more readily than the latter. The coloured population of the United States, the Maoris, and South Sea Islanders illustrate this fact. Tuberculosis is most rife in large centres of population in which the people live under the worst air conditions. In addition to its universal distribution, it is constantly active, unlike the more acute parasitic diseases, and has no periods of remission or quiescence; consequently it is more destructive to life and health than any of them, more even than all of them put together. The annual mortality of the human race from this single cause is estimated at 5,000,000, or one-seventh of the whole (Hirsch). In some countries (Russia) it is believed to be nearly one-fourth of the whole. The annual death-roll of tuberculosis is about 170,000 in Germany, 150,000 in France, 150,000 in the United States, and 60,000 in England, where it has been steadily diminishing since 1838. The exact figures for England and Wales during the ten years 1881–90 are 589,390 deaths out of 5,244,771, that is, one-ninth of the total number. Consumption accounts for more than four-fifths of this mortality, namely, 473,968, the remaining fifth — 115,422 deaths — being ascribed to other forms of tuberculosis. It is probable that in countries where less progress has been made in combating consumption, its preponderance over other tubercular diseases is still greater; but full data are lacking. Attention has naturally been centred on consumption, on account of its excessive destructiveness, and a good deal of information has been collected with regard to its mortality in different countries and cities. The following table gives approximately the annual rates among European nations :—

Rates of Mortality from Consumption per 100,000 Living.

Russia (principal towns, 1890–92)	399
Austria (1895–96)	362
Hungary (1893–95)	318
France (principal towns, 1894–97)	302
Sweden (principal towns, 1894–97)	231
Germany (1894–97)	224
Switzerland (1894–97)	203
Ireland (1894–97)	203
Denmark (principal towns, 1894–97)	191
Holland (1892–95)	188
Italy (1895–97)	187
Belgium (1890)	177
Norway (1891–95)	173
Scotland (1893–96)	173
England and Wales (1894–97)	135

The excessive prevalence in Russia is explained by (1) low standard of living; (2) overcrowding in unventilated and overheated rooms in winter; (3) the use of furs, which harbour germs and are handed down from father to son. The two last factors operate also in other countries in central and northern Europe, but in a less degree.

Turning to the great cities, we find much higher rates prevailing. The following are towns of half a million inhabitants and upwards :—

Moscow (1889–92)	457	Berlin (1894–97)	237
St Petersburg (1889–92)	441	Glasgow (1894)	226
Vienna (1894–97)	427	Hamburg (1894–97)	211
Budapest (1894–97)	414	Manchester (1894)	196
Paris (1894–97)	387	Amsterdam (1894–97)	187
Rio de Janeiro (1894–97)	380	London (1894–97)	177
New York (1894–97)	252	Naples (1894–97)	176
Warsaw (1894–97)	245	Buenos Aires (1894–97)	165

The favourable position occupied by Naples is ascribed to the fact that for a century the Italians, forestalling science, have regarded consumption as infectious, and have practised the isolation of patients suffering from advanced phthisis.

The following table of mortality rates from consumption in American cities in 1895–99 is taken from statistics prepared by the Prudential Insurance Company of America :—

Denver	357	Dayton	186
San Francisco	288	Hartford	176
Albany, N.Y.	266	Atlanta	163
Newark	259	Fall River	161
New York	246	Chicago	154
Jersey City	241	Lynn, Mass.	141
Sacramento	240	Buffalo	129
Boston	237	Milwaukee	129
Providence	213	Spokane	126
Cincinnati	211	Reading, Pa.	124
Philadelphia	210	Minneapolis	123
Syracuse	199	Pittsburg	116
Camden	193	Nashville	102
Indianapolis	193	Salt Lake City	64
St Louis	187		

These figures compare favourably with those for provincial towns in Germany and France, as may be seen from the following rates for the year 1894 (*Münchener Medizinische Wochenschrift*) :—

Würzburg	524	Lyons	336
Havre	500	Augsburg	335
Rouen	450	Rheims	326
Nüremberg	393	Munich	308
Breslau	349	Nantes	301
Nancy	337	Roubaix	297

According to the registered mortality, tuberculosis has been decreasing in some countries for a number of years. This is the case with regard both to consumption and tuberculosis generally.

Death-rates from Tubercular Diseases per 100,000.

Year.	New York.	London.	Paris.	Berlin.	Vienna.
1884	445	312	519	362	720
1894	316	243	510	251	506

The records for England and Wales, which go back farther than any others, show a progressive diminution since 1838; but for strict comparison they are too imperfect in the early years of registration. Beginning with 1851–60, we find the death-rate from all tubercular diseases, which was 348 in that decade, had fallen gradually to 212 in 1891–95. Further details are given below. From the United States we have the following statistics (Hoffmann):—

Death-rates from Consumption in Five Eastern States and Ten other Cities, with a Total Population of 14,301,595 in 1899.

1871	333	1886	281
1885	289	1900	212
Mean	307	Mean	232

In six large cities during the same period the death-rate among the white population fell gradually from 418 to 227, while among the coloured it fluctuated irregularly, but was always far higher, ranging from a maximum of 648 in 1885 to a minimum of 474 in 1899. In Saxony the death-rate from tubercular diseases is said to have fallen since 1892 from 250 to 210, and in Baden from 300 to 260.

Age and Sex.—The most complete information under this heading is derived from the English records. "In both sexes," says Dr Tatham, "the real liability to phthisis begins somewhere between the fifteenth and the twentieth year. Among males it attains its maximum at age 45–55, when it reaches 3173 per million living. Among females it attains its maximum (2096) at age 35–45. In both sexes the rate rapidly declines after the attainment of its maximum. Practically the incidence of phthisis is upon the ages from 15 to 75 years, very old people and young children being comparatively exempt. According to recent experience, females seem to be rather *less liable* than males to death by phthisis at ages under 5 years, *more liable* at the age of 5–20, and again *less liable* at subsequent ages." These observations, it must be noted, refer only to consumption. The comparative immunity of the very young does not extend to all forms of tubercular disease. On the contrary, tuberculosis of the bowels, or tabes mesenterica, and tubercular meningitis are pre-eminently diseases of childhood. The following tables show in detail the relative incidence of consumption at different ages, and the steady diminution of the disease in England and Wales since 1850:—

ENGLAND AND WALES.

Tubercular Phthisis.—Mortality in several Periods, 1851–99. Annual Rate per Million Living.

MALES.

Period.	Ages.											
	All Ages.	Under 5 Years.	5—	10—	15—	20—	25—	35—	45—	55—	65—	75—
1851–60	2579	1329	525	763	2399	4052	4031	4004	3830	3331	2389	928
1861–70	2467	990	431	605	2190	3883	4094	4166	3861	3297	2024	659
1871–80	2209	783	340	481	1675	3092	3699	4120	3860	3195	1924	603
1881–85	1927	584	274	372	1381	2467	3246	3726	3567	2937	1800	645
1886–90	1781	521	234	318	1212	2222	2842	3436	3446	2904	1845	733
1891–95	1634	467	197	260	1075	2026	2548	3268	3205	2686	1572	563
1896–99	1521	403	140	195	908	1841	2341	3110	3173	2627	1530	549

FEMALES.

Period.	Ages.											
	All Ages.	Under 5 Years.	5—	10—	15—	20—	25—	35—	45—	55—	65—	75—
1851–60	2774	1281	620	1293	3516	4288	4575	4178	3121	2383	1635	716
1861–70	2483	947	477	1045	3112	3967	4378	3900	2850	2065	1239	447
1871–80	2028	750	375	846	2397	3140	3543	3401	2464	1777	1093	407
1881–85	1738	553	350	749	2006	2596	3070	2927	2197	1541	995	372
1886–90	1497	483	307	658	1626	2075	2552	2563	1936	1490	966	423
1891–95	1303	421	260	561	1428	1740	2155	2305	1742	1294	800	350
1896–99	1141	334	201	410	1165	1547	1862	2096	1597	1242	787	366

Commenting on these tables, Dr Tatham remarks that, "with a few trifling exceptions, every age group in both sexes has experienced *a decrease* in the mortality ascribed to phthisis. In every case the mortality in 1895–99 was lower than it had been in 1851–60; but the rate of decrease has varied widely, and has been much greater among females than among males. The reduction indicated by the table may not be wholly real, and may be due in part to the vaguer statement of causes of death in the earlier period; as, for instance, by the habitual use of the terms 'consumption' and 'decline' to describe any lingering disease of the lungs attended by 'wasting.' The figures must therefore be taken for what they are worth." The same qualification applies to all death-rates when an early period is compared with a later one, and it should be always borne in mind; but it is less likely to vitiate statistics which show an apparent decrease than those which show an apparent increase, as in the case of alcoholism or cancer, because in the earlier periods a large number of deaths were not classified at all. The greater diminution of consumption among females noted above is in agreement with experience in America. The figures given for a number of towns by Mr Hoffmann of the Prudential Insurance Company show that between 1871 and 1900 the death-rate fell from 361 to 274 among males, and from 369 to 183 among females.

Occupation has a marked influence on the prevalence of tuberculosis. The comparative mortality figures for various occupations compiled at the Registrar-General's Office (Supplement to 55th Annual Report) show very great differences. The following are the highest and the lowest among adult males in England and Wales:—

ADULT MALES IN ENGLAND AND WALES.

Highest.		*Lowest.*	
Tin miners	508	Coal miners (Derby, Notts)	69
Inn and hotel servants	476	Farmers	79
Unoccupied males	448	Brick and tile makers	84
Costermongers	443	Ironstone miners	90
File makers	402	Corn-millers	143
Cutlers	382	Engravers	146
Lead miners	380	Lead workers	148
Potters	333	Blacksmiths	159
Copper miners	331	Carpenters and shopkeepers	172
Printers	326	Bakers	185
Bookbinders	325	Butchers	195

The high incidence in the first group appears to be due to three causes: (1) Dust (file-makers, cutlers, potters, &c.); (2) exposure (costermongers and (?) miners); (3) alcoholism (inn-servants and unoccupied males). The two last classes have a high death-rate from alcoholism, as have costermongers; but a general comparison of the occupational mortality from consumption and alcoholism does not bear out the opinion expressed by Dr Brouardel at the London Congress in 1901 that there is a close connexion between them. This theory is contradicted by some of the conclusions to be drawn from the figures. Many industries show a low death-rate from alcoholism and a high one from consumption. Printers and cutlers, for instance, have a comparatively low alcoholic death-rate, butchers a very high one. The favourable position occupied by coal miners and ironstone miners is remarkable, and all the more so when contrasted with the excessive mortality among miners of tin, lead, and copper. The English experience is broadly corroborated by similar but much less complete statistics from the United States (Hoffmann), where miners (presumably coal miners) also enjoy the greatest immunity. These figures for the United States are shown in the following table:—

UNITED STATES.

Highest.		*Lowest.*	
Stone workers	431	Miners	64
Printers	394	Brakesmen	124
Glass workers	380	Sailors	145
Brass workers	376	Merchants	172
Book-keepers	358	Blacksmiths	186
Plumbers	353	Tailors	187
Salesmen	346	Carpenters	188
Hatters	345	Butchers	193
Silk workers	339	Masons	198
Cigar makers	330	Iron and steel workers	210
Potters	287	Weavers	214

The influence of dust is obvious in the first column. Dr Von Körösy has tabulated the result of seventeen years' observation in Budapest, which is an excessively tuberculous town. His figures include both males and females above fifteen years of age, and extend to 106,944 deaths. The field of observation is evidently very different from those which furnished the statistics already given. His results are: (1) *Males*—printers 606, butlers 520, shoemakers 494, dyers 493, millers 492, joiners 485, tinkers and locksmiths 484, masons 467, labourers 433, tailors 418, bakers 398, drivers 370, servants 360, carpenters 339, officials 336, butchers 333, merchants 253, innkeepers 272, lawyers 205, physicians 118, capitalists 106; (2) *Females*—servants 353, day labourers (? charwomen) 333, washerwomen 314, gardeners 269, capitalists 42. The inmates of lunatic asylums, who are classed among the "unoccupied," suffer excessively from tubercle. According to Dr Mott, pathologist to the London County Council, tubercular lesions are found in more than one-third of the bodies examined post mortem. The majority contract the disease in the asylums.

Heredity.—Medical opinion has undergone a great change with regard to the influence of heredity. The frequent occurrence of consumption among members of the same family used to be explained by assuming the existence of a tubercular "diathesis" or inherent liability to consumption which "ran in families" and was handed down from one generation to another. As the real nature of the disease was not understood, the inherited diathesis was regarded as a sort of latent or potential consumption which might develop at any time and could hardly be avoided. The children of consumptive parents had the "seeds" of the disease in them, and were thought to be doomed with more or less certainty. Great importance was therefore attached to heredity as a factor in the incidence of tuberculosis. The discovery that it is caused by a specific parasitic infection placed the question in a different light, and led to a more careful examination of the facts, which has resulted in a general and increasing tendency to minimize or deny the influence of heredity. At the Berlin Congress on Tuberculosis in 1899 Professor Virchow pronounced his disbelief in the theory on pathological grounds. "I dispute this heredity absolutely," he said. "For a course of years I have been pointing out that if we examine the bodies of infants newly born, who have had no life apart from the mother, we find no tuberculosis in them. I am convinced that what looked like tuberculosis in the newly born was none of it tuberculosis. In my opinion there is no authenticated case of tubercle having been found in a dissected newly-born infant." Observations on animals similarly tend to disprove the existence of congenital tuberculosis (Nocard). The theory that the germs may remain latent in the offspring of tuberculous parents (Baumgarten) is unsupported by evidence. The occurrence of disease in such offspring is ascribed to infection by the parents, and this view is confirmed by the fact that the incidence in consumptive families is greater on female children, who are more constantly exposed to home infection, than on the male (Squire). The statistical evidence, so far as it goes, points in the same direction. It is even denied that the children of consumptives are specially predisposed. An examination of the family history of 1000 cases by Dr Squire showed that the incidence was only about 9 per cent. higher on the children of consumptive than on those of non-consumptive parents. In view of the chances of infection at home run by the former, this small difference does not support the theory that they are particularly susceptible. Dr Maxon King of New York goes farther, and believes that a family history of tuberculosis, instead of predisposing to the disease, tends rather to confer some degree of resistance. Out of 103 fatal cases, 76 were of non-tubercular, and only 27 of tubercular parentage; and the average duration of the disease among the latter was 4·01 years, against 2·93 years among the former. The facts are interesting, but the numbers are not sufficient to warrant a decided conclusion. In the most recently published work on the subject (*Diseases of the Organs of Respiration*, by Samuel West, M.D., 1902), Dr West accepts "family predisposition" as an "essential factor in phthisis," but thinks that its influence is less important than was formerly believed, and that only an "increased vulnerability of tissues" is transmitted. The whole question is still in a fluid state, and needs further elucidation. Perhaps the tendency to emphasize infection to the exclusion of other factors has been a little overdone, just as too much stress was formerly laid on the family inheritance of disease and death.

Density of Population and Overcrowding.—Recognition of the communicability of tuberculosis has directed attention to the influence of conditions in which people live massed together in close proximity. The prevalence of the disease in large centres of population has already been noted, and the influence of aggregation is no doubt considerable; but it does not always hold good. The distribution in England and Wales does not correspond with density of population, and some purely rural districts have a very high mortality. Broadly, however, the rural counties have a low mortality, and those containing large urban populations a high one. The following are the seven highest and lowest counties; London heads the list. The density of population is expressed by figures in six grades—1 to 6—according to the number of persons per square mile; 6 represents the greatest density.

Death-rates from Consumption in English Counties, 1895–99.

Highest.			Lowest.		
Counties.	Death-rate.	Density of Population.	Counties.	Death-rate.	Density of Population.
London	176	6	Rutland	74	1
Northumberland	166	2	Westmorland	85	1
North Wales	156	1	Monmouth	94	3
Lancashire	151	6	Buckinghamshire	96	2
Hampshire	145	3	Worcestershire	98	4
South Wales	143	2	Hereford	98	1
Durham	136	5	Wiltshire	[illegible]	1

Among those with the highest death-rates is one large and purely rural area—North Wales. The others all contain large towns. Among the lowest, Worcestershire, though a populous county, contains no large towns. The density of population, as measured by the number of persons to the square mile, is misleading, as a large area might consist of one or two large towns and the rest bare country, which is somewhat the case with Northumberland. On the whole the distribution in England shows that the greatest incidence is on towns, but is not at all confined to them. When the "crude" death-rates are corrected by reference to the age distribution, it is found that the rural population has a higher rate during youth, a lower one in later life; and that up to middle life consumption is not commoner in towns than in the country (Beevor).

A somewhat different conclusion is suggested by the following statistics of French towns prepared by Dr Lagneau. They go to show that the average incidence of tuberculosis is directly proportionate to the size of the communities.

	Death-rate from Tuberculosis.
Paris	490
Eleven towns having over 100,000 inhabitants .	363
Forty-six towns having 30,000 to 100,000 inhabitants	305
Fifty towns having 20,000 to 30,000 inhabitants .	288
One hundred and twenty-seven towns having 10,000 to 20,000 inhabitants	271
Three hundred and thirty-two towns having 5000 to 10,000 inhabitants	216
Ninety-five towns having under 5000 inhabitants .	181

A more detailed investigation in London by the medical officer to the London County Council gave the following results:—

Phthisis, 1894–98.

Proportion of total population living more than two in a room (in tenements of less than five rooms).	Death-rates per 1000 living.				
	1894.	1895.	1896.	1897.	1898.
Districts with under 10 per cent.	1·07	1·18	1·07	1·14	1·10
,, ,, 10 to 15 ,,	1·38	1·49	1·46	1·42	1·43
,, ,, 15 to 20 ,,	1·57	1·64	1·61	1·63	1·61
,, ,, 20 to 25 ,,	1·81	1·83	1·67	1·75	1·80
,, ,, 25 to 30 ,,	2·11	2·09	2·06	2·10	2·07
,, ,, 30 to 35 ,,	2·26	2·42	2·13	2·32	2·42
,, ,, over 35 ,,	2·46	2·66	2·55	2·64	2·63

"There is therefore obviously relation between the amount of overcrowding and the phthisis death-rate. The figures do not, however, suffice to show whether the overcrowding caused phthisis; or whether the disease by adding to family expenditure or by diminishing the wage-earning power left less money available for rent, and thus brought about the overcrowding; or whether, again, overcrowding is associated with some other condition or conditions which are favourable to disease. In all probability all these circumstances have tended to produce the results shown in the table" (Shirley Murphy). Comparing phthisis with other diseases in relation to overcrowding, the same authority found that "while associated with overcrowding is a tendency of the population to die from disease generally, this tendency is especially manifested in the case of phthisis, and is not manifested in the case of every disease."

Other Conditions.—Poverty, insufficient food, and insanitary dwellings are always more or less associated with overcrowding, and it is difficult to distinguish the relative influence of these factors. An analysis of 553 deaths in Edinburgh according to rentals in 1899 gave these results: under £10, 230; from £10 to £20, 190; above £20, 106 (Littlejohn); but the corresponding population is not stated. An investigation of selected houses in Manchester gave some interesting results (Coates). The houses were divided into three classes: (1) infected and dirty; (2) infected but clean; (3) dirty but not infected; infected meaning occupied by a tuberculous person. Dust was taken from all parts of the rooms and submitted to bacteriological tests. The conclusions may be summarized thus: The effects of overcrowding were not apparent; a large cubic space was found to be of little avail if the ventilation was bad; the beneficial effects of light and fresh air were markedly shown even in the dirtiest houses; ordinary cleanliness was found not sufficient to prevent accumulation of infectious material in rooms occupied by a consumptive; no tuberculous dust was found in dirty houses in which there was no consumption. The upshot is to emphasize the importance of light and air, and to minimize that of mere dirt. This is quite in keeping with earlier investigations, and particularly those of Dr Tatham on back-to-back houses. Darkness and stuffiness are the friends of the tubercle bacillus. Another condition believed to be important is damp. A good deal of evidence has been collected on the subject in Great Britain. Sir George Buchanan, formerly medical officer to the Local Government Board, expressed the opinion that "wetness of soil is a cause of phthisis to the population living upon it. He based this conclusion on the comparative immunity enjoyed by persons living in pervious, high-lying, and sloping soils—that is, dry soils—contrasted with the opposite conditions, and on the fact that phthisis had been greatly reduced in towns where the water of the soil had been removed by drainage, and had not been reduced in towns where the soil had not been so dried. The English experience has been confirmed by observers in other countries, including Massachusetts (Bowditch), though some authorities in the United States deny that the connexion between a wet soil and consumption holds good in that country as a whole. It is not known in what manner wetness acts, whether by harbouring the bacillus or increasing susceptibility. An investigation into the relative prevalence of phthisis in Devonshire parishes, by Dr W. Gordon, showed a much greater incidence in places exposed to west and south-west winds (*i.e.*, wet winds) than in sheltered ones.

The influence of tuberculosis on animals is at present the subject of controversy and investigation. Until recently the result of research in various countries had led to a general consensus of opinion that tuberculous meat presents little danger, but that milk from tuberculous cows may convey the disease, and is particularly dangerous to children. Administrative measures of great importance to agricultural and other commercial interests had been based on that opinion, which is still generally held. But at the British Congress in 1901 it was strongly attacked by Professor Koch, who in effect denied the connexion between human and animal tuberculosis. The weight attached to the utterances of this eminent authority has led to a revision of the question, which is now being made the subject of special experiments in Germany, Great Britain, the United States, and elsewhere. In the unsettled state of the scientific evidence, to discuss the arguments would be out of place here; but it may be pointed out that primary tuberculosis of the intestinal tract, which at least throws suspicion on food, is by no means rare in Great Britain, and that no amount of negative evidence can dispose of recorded cases of accidental inoculation in human beings from bovine tuberculosis.

Prevention.—Measures for the prevention of tuberculosis may be divided into two classes: (1) general; (2) special. Great attention has been paid to the latter since the infectious nature of the disease was established. The former include all means by which the conditions of life are improved among the mass of the people. The most important of these are probably housing and food supply. The reduction of the disease recorded in England is attributed to the great changes which have gradually taken place in such conditions since, say, 1850. Wages have been raised, food cheapened, housing improved, protection afforded in dangerous trades, air spaces provided, locomotion increased, the ground and the atmosphere have been cleaned and dried by sanitary means. In addition to these general measures, foreign admirers have pointed to a special one, in which also England has taken the lead, namely, the provision of consumption hospitals, which act by segregating a certain amount of disease. Yet all these things, beneficial as they may be, do not wholly account for the reduction, for if the records can be trusted, it was in progress before they had made any way or had even been begun. This observation, coupled with the apparently general tendency to diminution among civilized races, suggests the operation of some larger agency. The theory of acquired resistance, which has been already mentioned, would explain the diminution; and it is also in keeping with other facts, such as the great susceptibility of savage races, which have not been long exposed to tuberculosis, and the results of laboratory experiments in artificial immunity. The point is of great importance, and deserves careful attention; for if the theory be correct, the special measures for preventing tuberculosis, which are occupying so much attention, may eventually have unexpected results. Their general aim is the avoidance of infection, and they include (1) the provision of special institutions—hospitals, sanatoria, and dispensaries; (2) the prevention of spitting; (3) the notification of consumption; (4) the administrative control of tuberculosis in animals; (5) the dissemination of popular knowledge concerning the nature of the disease. (1) The sanatoria and other institutions are preventive measures, in that they involve the segregation of infected persons, but they may more properly be discussed under the head of treatment. (2) The greatest stress is laid upon the prevention of spitting, because the germs are contained in the sputum of consumptive persons, and are scattered broadcast by expectoration. The sputum quickly dries, and the bacilli are blown about with the dust. There is no question that infection is so conveyed. The Manchester scientific experiments, mentioned above, are only one series out of many which prove the infectivity of dust in the proximity of consumptive persons, and they are confirmed by actual experience. Several cases are recorded of healthy persons having contracted the disease after occupying rooms in which consumptive persons had previously lived. Inhalation is clearly the mode by which the poison most frequently gains entrance; hence the overwhelming incidence upon the lungs. It is doubtful if the bacilli are carried directly into the lungs; probably the actual seat of infection is more often the tissues of the throat at the junction of the air and food passages; but they enter with the breath. Once in the mouth they may, in susceptible persons, attack the throat and the lungs, or, being swallowed, the intestinal organs. These considerations explain the importance attached to control of the sputum. It is a legitimate inference that spitting in public is an important means of disseminating tuberculosis, though it may be noticed that international prevalence by no means corresponds with this disgusting practice which is a perfect curse in Great Britain, and far more common both there and in the United States than on the continent of Europe. Prohibition of spitting under a statutory penalty is attended with certain difficulties, as it is obviously impossible to make any distinction between tuberculous and other persons; but it has been applied in New York and elsewhere in America, and some local authorities in Great Britain have adopted bye-laws to check the practice. Another means of controlling dangerous sputa is more practicable, and probably more effective, namely, the use of pocket spittoons by consumptive persons. Convenient patterns are available, and their use should always be insisted on, both in public and in private. The most effective way of destroying the sputa is by burning. For this purpose spittoons of papier-mâché and of turf have been successfully used in the Vienna hospitals (Schrötter). When glass spittoons are used the contents can be sterilized by disinfectants and passed down the drain. (3) Notification is of great service as an aid to practical measures of prevention. It has been applied to that purpose with good results in several cities and states in America, and in some towns in Great Britain. New York has made the most systematic use of it. Voluntary notification was adopted there in 1894, and in 1897 it was made compulsory. The measures linked with it are the sanitary supervision of infected houses, the education of the people, and the provision of hospitals. In England, Manchester has led the way. Voluntary notification was adopted there in 1899: it was at first limited to public institutions, but in 1900 private practitioners were invited to notify their cases, and they heartily responded. The objects aimed at are to visit homes and instruct the household, to arrange and provide disinfection, to obtain information bearing on the modes of infection, to secure bacteriological examination of sputum, and to collect information to serve as a basis of hospital provision. Disinfection is carried out by stripping off paper, previously soaked with a solution of chlorinated lime (1½ oz. to the gallon), and washing the bare walls, ceiling, floor, and everything washable, with the same solution. This is found effective even in very dirty houses. In clean ones, where the patients have not been in the habit of spitting about the rooms, it is sufficient to rub the walls with bread-crumb and wash the rest with soap and water. Clothing, bedding, &c., are disinfected by steam. The advantages of these sanitary measures are obvious. Notification is no less important as a step towards the most advantageous use of hospitals and sanatoria by enabling a proper selection of patients to be made. It is compulsory throughout Norway, and is being adopted elsewhere, chiefly in the voluntary form. (4) As already explained, the question of animal tuberculosis is still *sub judice*. Its importance from the point of view of prevention lies in the probability that abdominal tuberculosis, which is a very fatal form of the disease in young children, and has not diminished in prevalence like other forms, is caused by the ingestion of tuberculous milk. Whether it be so or not, it is obviously desirable that both meat and milk should not be tuberculous, if it can be prevented without undue interference with commercial interests. Preventive measures may be divided into two classes. They may deal merely with the sale of meat and milk, or they may aim at the suppression of bovine tuberculosis altogether. The former is a comparatively easy matter, and may be summed up in the words "efficient inspection." The latter is probably impracticable. If practicable, it would be excessively costly, for in many herds one half the animals or even more are believed to be tuberculous, though not necessarily the sources of tuberculous food. Unless the danger is proved to be very much greater than there is any reason to suppose, "stamping out" may be put aside. Efficient inspection involves the administrative control of slaughter-houses, cowsheds, and dairies. The powers and regulations under this head vary much in different countries; but it would be useless to discuss them at length until the scientific question is settled, for if the reality of the danger remains doubtful, oppressive restrictions, such as the compulsory slaughter of tuberculous cows, will not have the support of public opinion. Whatever measures may be taken for the public protection, individuals can readily protect themselves from the most serious danger by boiling milk; and unless the source is beyond suspicion, parents are recommended, in the present state of knowledge, so to treat the milk given to young children. (5) A great deal has been done in most countries for the dissemination of popular knowledge by forming societies, holding conferences and meetings, issuing cheap literature, and so forth. It is an important item in the general campaign against tuberculosis, because popular intelligence and support are the most powerful levers for setting all other forces in motion.

Treatment.—To discuss at all fully the treatment of the various forms of tuberculosis or even of consumption alone would be quite beyond the scope of this article. It must suffice to mention the more recent points. The open-air treatment of consumption has naturally attracted much attention. Neither the curability of this disease nor the advantages of fresh air are new things. Nature's method of spontaneous healing, explained above, has long been recognized and understood. There are, indeed, few diseases involving definite lesions which exhibit a more marked tendency to spontaneous arrest. Every case, except the most acute, bears signs of Nature's effort in this direction; and complete success is not at all uncommon, even under the ordinary conditions of life. Perhaps it was not always so: the ominous character popularly attributed to consumption may once have been justified, and the power of resistance, as we see it now, may be the result of acquired immunity or of the gradual elimination of the susceptible. However this may be, the natural tendency to cure is undoubtedly much assisted by the modern system of treatment, which makes pure air its first consideration. The principle was known to Sydenham, who observed the benefit derived by consumptives from horse exercise in the open air; and about 1830 George Boddington proposed the regular treatment of patients on the lines now generally recognized. The method has been most systematically developed in Germany by the provision of special sanatoria, where patients can virtually live in the open air. The example has been followed in other countries to a certain extent, and a good many of these establishments have been provided in Great Britain and elsewhere; but they are, for the most part, of a private character for the reception of paying patients. Germany has extended these advantages to the working classes on a large scale. This has been accomplished by the united efforts of friendly and philanthropic societies, local authorities, and the state; but the most striking feature is the part played by the State insurance institutes, which are the outcome of the Acts of 1889 and 1899, providing for the compulsory insurance of workpeople against sickness and old age. The sanatoria have been erected as a matter of business, in order to keep insured members off the pension list, and they are supported by the sick clubs affiliated to the institutes. They number forty-five, and can give three months' treatment to 20,000 patients in the year. The clinical and economic results are said to be very encouraging. In about 70 per cent. of the cases the disease has been so far arrested as to enable the patients to return to work.

The important features of the sanatorium treatment are life in the open air, independently of weather, in a healthy situation, rest, and abundance of food. The last has been carried to rather extravagant lengths in some institutions, where the patients are stuffed with food whether they want it or not. The sanatorium movement on the German model is rapidly extending in all countries. It should, however, be remembered that the benefits of fresh air are not confined to sanatoria. If the superstitious dread of the outer air, particularly at night, could be abolished in ordinary life, more would be done for public health than by the most costly devices for eluding microbes. Not only consumption, but the other respiratory diseases, which are equally destructive, are chiefly fomented by the universal practice of breathing vitiated air in stuffy and overheated rooms. The cases most suitable for the treatment are those in an early stage. Other special institutions for dealing with consumption are hospitals, in which England is far in advance of other countries, and dispensaries; the latter find much favour in France and Belgium. Both have their uses. Hospitals are particularly valuable for the reception of advanced cases, unsuitable for sanatoria. Of specific remedies it must suffice to say that a great many substances have been tried, chiefly by injection and inhalation, and good results have been claimed for some of them, but none has met with general acceptance. The most notable of them is Koch's tuberculin, a toxin prepared from tubercle bacilli. Three varieties have been tried. The first, announced in 1890, proved unsuccessful. The more recent preparations, known as T.O. and T.R., are said to have produced better results in consumption and lupus, but their efficacy has not been established. On the other hand, the value of tuberculin for diagnosing disease in cattle is generally recognized. Some serum preparations have also been tried, but without success. The only other specific methods of treatment that need mention are the application of light and of the Röntgen rays to lupus. Both have met with decided success. The light treatment is the invention of Professor Finsen of Denmark, who employs the concentrated actinic rays from the sun, or a special electric lamp. The latter is very elaborate and expensive, but may be replaced by more simple forms of apparatus recently devised.

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Tübingen, a town of Würtemberg, Germany, on the Neckar, 45 miles by rail south by west of Stuttgart. It is the seat of the national university, which in 1900 was attended by 1544 students and had 104 professors, and the new buildings of which include the anatomical, surgical, physiological, and other medical institutes. There are also Protestant and Roman Catholic theological seminaries, chemical laboratories, a botanical garden, natural science collections, a numismatic collection, and a meteorological station. A monument to the poet Hölderlin was erected in 1881. Population (1895), 13,976; (1900), 15,323.

Tubuai. See TAHITI.

Tucson, a city of Arizona, U.S.A., capital of Pima county, on the Santa Cruz river, and on the southern overland line of the Southern Pacific railroad, in the southern part of the territory. It is regularly laid out on a level site, and has a good water-supply. It contains smelters for gold, silver, and copper ores. It is the seat of the University of Arizona, a non-sectarian institution, opened in 1891. In 1899 this had a faculty of 16 and was attended by 133 students, 60 of whom were women. Population (1890), 5150; (1900), 7531, of whom 2352 were foreign-born and 474 coloured, including 86 negroes.

Tucumán, a province in the west of the Argentine Republic, bounded on the N. by the province of Salta, on the W. and S. by that of Catamarca, on the E. by that of Santiago, 780 miles from Buenos Aires by rail, on the Rio Salí. It has a national college, normal school, public library, hospital, theatre, &c. Official area at the census of 1895, 8926 square miles. Population (1869), 108,953; (1895), 215,742. It is divided into twenty-one departments. In 1895 there were 9973 farms and 80,172 acres planted in cereals.

Tucumán, a city of the Argentine Republic, and capital of the province of the same name, 780 miles from Buenos Aires by rail, on the right bank of the Rio Salí. It was founded in 1565 by Diego Villarroel. It has a national college, normal school, public library, hospital, theatres, &c., and is also the head of a provincial railway running to Medina. Population (1895), 34,305.

Tudela, a town of Spain, in the province of Navarre, on the Ebro, on the Saragossa–Alsasua railway, and terminus of the Tudela to Tarazona line. The industries include distilleries, saw-mills, fruit preserves, linen. Some of the public buildings, hospitals, schools, bull-ring, and town hall are modern. Population (1887), 9213; (1897), 8748.

Tuguegarao, capital of the province of Cagayan, in Northern Luzon, Philippine Islands. It is situated on the Cagayan river, about sixty miles from the mouth, and can be reached by large steam-launches or by stern-wheel steamers of light draught. Its climate is extremely good. The rich valley of the Cagayan river is the great tobacco-producing region of the Philippines, and Tuguegarao is important for its shipments of this article. Population, 16,000.

Tula, a government of Central Russia, lying to the south of Moscow. It has an area of 11,954 square miles, and its population in 1897 was 1,432,743 (domiciled only), of whom 754,820 were women, and 166,350 lived in towns. The great proportion of women to men, 111 to 100, merely shows that as the census was taken in the winter a considerable part of the male population had left the province in search of work, chiefly as carpenters in the Black Sea provinces. The government is divided into twelve districts, the chief towns of which are Tula, Bogoroditsk (11,210), Alexin (2268), Byeleff (9567), Epifañ (4176), Efremoff (9044), Kashira (4046), Krapivna (6797), Novosil (2919), Odoyeff (4443), Tcherñ (3612), and Venev (5219). Only 2·6 per cent. of the aggregate area is considered as unavailable for culture, the remainder being distributed as follows:—peasants, 3,655,000 acres as allotments and 72,000 acres bought; nobility, 2,489,400 acres; other private landowners, 842,000 acres; Crown, towns, 161,300 acres. The forest covers about 675,000 acres. Agriculture is the chief occupation. There were in 1900 1,951,900 acres under crops, and the average yield in 1895–99 was: rye, 8,714,000 cwt.; wheat, 145,000 cwt.; oats, 6,163,000 cwt.; and barley, 42,000 cwt.—all cereals, 15,720,000 cwt. Grain is exported, but the crops are sometimes insufficient for the population, and years of famine have been experienced by parts of the province. The area under beetroot is increasing, but tobacco-culture is on the decline. The yield of potatoes in 1900 was 12,152,000 cwt. (chiefly for distilleries). Cattle-breeding is subsidiary only to agriculture, there being in 1900 356,260 horses, 320,460 horned cattle, 966,500 sheep, and 142,650 pigs in the province. Small trades and domestic industries, which have always been flourishing, have not suffered from the development of manufacturing industries as carried on in factories, though this has been great; on the contrary, several new domestic industries have been introduced. The aggregate annual return of the factories, which employ 20,600 persons, now amounts to 24,500,000 roubles; the principal establishments are machinery works, hardware factories, flour-mills, sugar works, and distilleries. Coal is extracted in seven mines (127,000 tons in 1899), as also pyrites and iron ore. Metallurgy is a growing industry. Education is on a better footing than in many other provinces of Central Russia, there being in the villages one school for each 884 inhabitants; the aggregate number of schools in 1899 was 1692, with 54,965 boys and 22,100 girls.

Tula, capital of the above province, on both banks of the Upa river, 120 miles by rail south of Moscow. It has become an industrial town of considerable importance, and its population has almost doubled since 1882, being 111,048 in 1897. It has a large imperial gun factory, a large sugar refinery, and a number of small factories and workshops for the manufacture of small-arms, bicycles, tea-urns, harmoniums, and all sorts of ironmongery; for these works more than 10,000 tons of iron, steel, and brass are imported every year. The factories employed in 1899 13,025 persons, and showed a yearly return of 10,295,000 roubles. The city is well provided with schools, and carries on a considerable trade. A number of factories have been built around it, and a variety of domestic industries are carried on in the neighbouring villages.

Tulcea, chief town of the district of the same name, Rumania, picturesquely situated on the right bank of the Danube, 42 miles from its mouth, at Sulina, on the Black Sea. It is the seat of a court of first instance. The principal commerce is in fish and grain. The population, which is extremely mixed, is composed of Rumanians, Russians, Turks, Greeks, and Jews, and numbered 18,800 in 1900. Wool is exported to France and Austria, and skins to Turkey.

Tulchin, a town of Russia, government of Podolia, district of Bratslav, 8 miles from the Zhuravlevka station of the South-western railway. It must have been founded by the Hungarians, as is shown by the name of its suburb, Nesterwar, and suffered a great deal in the 16th and 17th centuries during the wars of the Cossacks with Poland. It was annexed to Russia in 1793. It is a depôt for grain and flour, and has several flour-mills, distilleries, tanneries, and military depôts. Population (1897), 19,202.

Tulle, chief town of the department of Corrèze, France, and a bishop's see, 60 miles east of Périgueux by the railway to Clermont-Ferrand. In addition to the national small-arms factory, it has manufactories of perfumery, leather, and breweries. Population (1901), 17,400.

Tunbridge, a town in the Tunbridge parliamentary division of Kent, England, 41 miles by rail south-east of London, with a station on the South-Eastern and Chatham railway. Since 1894 it has been controlled by an urban district council. On the banks of the Medway, upon which the town stands, there are gunpowder mills. Wool-stapling is a considerable trade. Population (1891), 10,117; (1901), 12,736.

Tunbridge Wells, a municipal borough (since 1889), fashionable watering place, and market-town of Kent, England, in the Tunbridge parliamentary division, on the South-Eastern and Chatham, and London, Brighton, and South Coast railways. The water of the celebrated chalybeate spring is of great purity. The chief industry consists in the manufacture of the noted Tunbridge ware—wood inlaid in mosaic—which is applied to numerous purposes. Amongst modern buildings are a new church (St Barnabas), erected 1890, the post office, 1897, and a drinking fountain and tower, in memory of Canon Hoare (died 1894), in 1897. Population (1881), 24,119; (1891, extended area), 29,254; (1901), 33,388.

Tungu, or Toungoo, a district in the Tenasserim division of Lower Burma; area, 6172 square miles. Population (1891), 211,784; (1901), 280,254. There were 1129 villages in the district in 1898–99, paying Rs.4,69,142 revenue. The population was in 1891 made up of Buddhists and Jains, 164,694; aborigines, chiefly Karens, 14,681; Hindus, 3488; Mahommedans, 3081; Parsis, 11; and Christians, 25,829, the great majority of whom are Karens. The total acreage of the district is 3,950,080. Of this 195,749 acres were cultivated in 1898–99, and the remainder consisted of forests, 906,405 acres; uncultivable land, 1,784,707 acres; cultivable land, 1,062,882 acres; and current fallow, 337 acres. The rainfall in 1898–99 was 74·85 inches. There are eleven railway stations in the district. Rice is the chief cultivation, but coffee cultivation has prospered sufficiently to supply the whole province with the berry. Tungu, the headquarters of the district, had a population of 19,232 in 1891. The detachment of British infantry stationed there before the annexation of Burma has been withdrawn, and its place is taken by a military police battalion.

Tunicata.—The article Tunicata in vol. xxiii. of this work was published in 1888, and although far more investigations have been carried out and published on this group of animals since that time than in any previous similar period, still no epoch-making discoveries and no fundamental changes in our conclusions and ideas have been made. The statements in the former article still hold good, except in some quite minor details. It is not so much alterations and corrections as additions to our knowledge that we have now to record.

New Forms.—It is to the great national exploring expeditions that we owe the chief additions to our knowledge of new forms of Tunicata, and of the geographical distribution of the group; but private collectors have also been active in many remote parts of the world. The third and last report upon the Tunicata of the *Challenger* expedition (1888) contained the description of a new *Pyrosoma* (*P. spinosum*) of enormous size, over 4 feet in length; of several new species of *Doliolum* and *Salpa*, and of the remarkable new family Octacnemidæ (Fig. 1). Metcalf has since discovered a new species belonging to the genus *Octacnemus* (*O. patagoniensis*), in which there is an aggregated or "chain" form, consisting of a small number of individuals (Fig. 1, B) united by a slender cord composed of test and body-wall. *Octacnemus* has always been obtained from great depths (1050 to 2160 fathoms), and was described as an abyssal representative of the pelagic Salpidæ, probably fixed at the bottom. Metcalf, however, considers that the aggregated form described by him is more nearly allied to the Clavelinidæ, and that therefore *Octacnemus* does not belong to the Thaliacea. The reports on the German Plankton expedition have added considerably to our knowledge of the details of distribution, both horizontally and vertically, of the pelagic Tunicates and especially of the Salpidæ and Appendicularidæ. Several new species of *Salpa* were described by Borgert, and of Appendicularia by Lohmann. Chun (1888) also made known some remarkable deep-sea Appendicularidæ of large size from the Mediterranean. One of these species, *Megalocercus abyssorum* (30 mm. long), is the largest known Appendicularian. Seeliger and Herdman have both published new figures of transverse sections of a typical Appendicularian (*Oikopleura*). We give one of those here (Fig. 2) as illustrating, along with the longitudinal section (Fig. 12) in the former article (vol. xxiii.), the structure of these forms. It now seems clear that the supposed segmentation or vertebration of the tail in Appendicularia is an artifact and not an indication of true metameric segmentation. Ritter has described some new Ascidians from the far north, about Bering Sea; Sluiter has been indefatigable in bringing to our knowledge new species—twenty from the Antilles, thirty from South Africa, and others from Australia and elsewhere; Gottschald thas made known twenty-two new species from Ternate, and Michaelsen about fifteen from the Southern Ocean. Herdman has found and described some new forms from Puget Sound in the Pacific, and has drawn up a *Descriptive Catalogue* of Australian Tunicata (1899), which contains 183 species, of which 63 are described and figured for the first time. These are only a few of the considerable number of systematic papers recently published, and the number of new species which are found by such investigations shows that we must still be very far from having anything like a complete knowledge of the Tunicata of our globe. Many of the new species have revealed anatomical features of considerable interest, some of which are noted below.

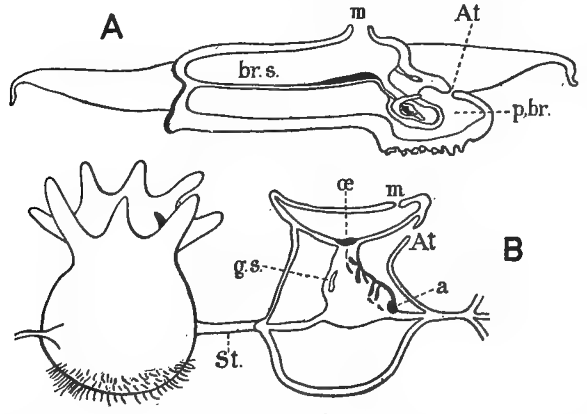

Fig. 1.—*Octacnemus.* A, Solitary form (*after Herdman*); B, aggregated form (*after Metcalf*). *a*, anus; *At*, atrial aperture; *br.s.*, branchial sac; *g.s.*, gill slit; *m*, mouth; *œ*, œsophagus; *p.br.*, peribranchial cavity; *st*, stolon,

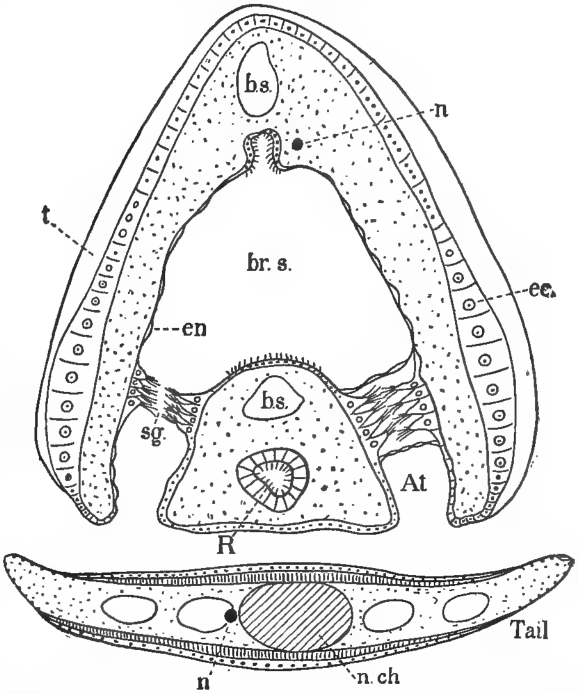

Fig. 2.—Transverse section of *Oikopleura*; anterior part of body and tail. *At*, atrial passage; *b.s.*, blood sinus; *br.s.*, branchial sac (pharynx); *ec*, ectoderm; *en*, endoderm; *n*, nerve; *n.ch.*, notochord; *R*, rectum; *sg*, stigma; *t*, test.

As to changes in classification since the previous article, Herdman issued in 1891 a *Revised Classification*, with definitions of all groups down to species, in which the classification of the *Challenger* reports was adhered to with little change; and this has also been in the main adopted by Seeliger in his great work on the Tunicata, in Bronn's *Thier-Reich.* Sluiter has proposed as a change in classification that the families of Compound Ascidians with short individual bodies, viz., the Botryllidæ and Polystyelidæ, should be united with Simple Ascidians under the term "Holosomata," while the remaining families of Compound Ascidians along with the Pyrosomatidæ form the "Merosomata." Herdman has suggested that these terms should be adopted in a somewhat restricted sense as indicating merely the two groups of Compound Ascidians—the Simple Ascidians being kept distinct from the Holosomata.

Anatomy and Histology.—One of the most important new facts that has been ascertained in regard to the minute structure of Tunicata is that the cells in the test or outer gelatinous tunic are derived from the mesoderm, and not, as was formerly supposed, from the ectoderm. In 1892 Kowalevsky made the remarkable discovery that cells belonging to the mesenchyme of the larva make their way through the ectoderm to the exterior during the metamorphosis, and become the first cells of the young test. The thin structureless test of the free-swimming tailed larva previous to this has no cells. This discovery has since been corroborated and established by several investigators for other sections of the Tunicata, as, for example, by Salensky in the case of *Pyrosoma;* and it accords well with the observations made by several investigators, that in Compound Ascidians the cells of the test act as phagocytes. Later research has shown, however, that some at least of the cells in the adult test may be of ectodermal origin.

It has been shown that some of the cells in the lateral walls of the endostyle (Fig. 3) are sensory bipolar cells. Nerve-endings have also been found in the peripharyngeal bands and other parts of the wall of the pharynx. The sensory nature of the oral tentacles has been demonstrated, and that of the dorsal tubercle, long suspected, has been confirmed. Atrial tentacles have now been found in a number of the Cynthiidæ and Polystyelidæ, mainly in species which live aggregated together in masses. The so-called "otocysts" of *Salpa* have been shown by Metcalf to be glandular organs very possibly related to the neural gland of Ascidians. The function of the neural gland must still be regarded as doubtful. The secretion is formed by the degeneration and disintegration of cells proliferated from the walls of the duct or its branches, and no concretions are found. The ciliated funnel of the dorsal tubercle is a sense organ, innervated by a large nerve from the ganglion.

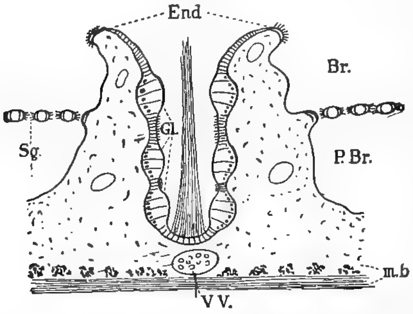

Fig. 3.—Transverse section of the endostyle of an Ascidian. *br*, branchial sac; *end*, lips of endostyle; *gl*, glandular tracts; *m.b.*, muscle bands; *p.br.*, peribranchial cavity; *sg*, stigma; *v.v.*, ventral vessel.

Physiology.—It is well known that in the family Botryllidæ, amongst Compound Ascidians, the ectodermal vessels containing blood which ramify through the common test and serve to connect the vascular systems of the various members of the colony have numerous large ovate dilatations, the ampullæ, upon their terminal twigs (Fig. 4). Various functions have been assigned to these ampullæ in the past, and Bancroft has shown that in addition to acting as storage reservoirs for blood, organs for the secretion of test matrix, and accessory organs of respiration, they are also organs for blood propulsion. The ampullæ execute co-ordinated pulsations, the co-ordination being due to variations in the blood-pressure. It was actually found that the ampullæ could keep up the circulation for some time in a portion of a colony independently of the hearts of the ascidiozooids. All the hearts in a colony of *Botryllus* contract simultaneously and in the same direction. The reversal of the circulation may be regarded as due to the engorgement of the ampullæ in the superficial parts of the colony. These when distended overcome the resistance of the heart's action, and cause it to stop and then reverse. Fig. 4 shows the ampullæ, and their relation to the rest of the colony; and Fig. 5 gives a better representation of the scheme of circulation in an Ascidian than that shown in Fig. 9 of the article in the ninth edition of this work.

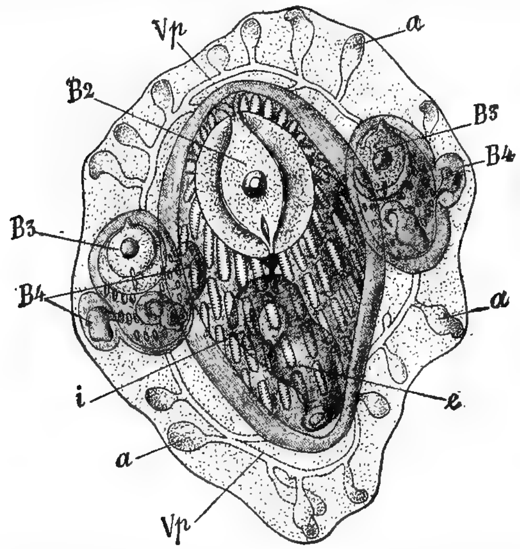

Fig. 4.—Young colony of *Botryllus*, showing buds and ampullæ (*after Pizon*). *a*, ampullæ; *b2*, *b3*, *b4*, successive generations of buds; *e*, stomach, *i*, intestine; *vp*, vessels of the test.

It will be remembered that Appendicularians have a remarkable temporary cuticular formation, probably representing the test of other Tunicata, and known commonly as the "House." This may be formed with great rapidity, attain a great size, be rapidly cast off, and again reformed. Lohmann has made a careful study of the mode of formation of this "House" from certain large ectoderm cells the "oikoplasts," and he considers that it probably fulfils the following functions:—Its complicated apparatus of passages with partial septa form a finely perforated network, through which a relatively large volume of water is strained so as to entrap microscopic food particles; it helps in locomotion by its hydrostatic effect, and it is also a protection to the animal, which may escape from enemies by throwing off the house, which is many times its own size.

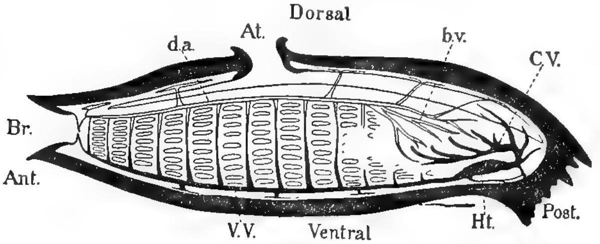

Fig. 5.—Diagram of the blood circulation in an Ascidian. The test is solid black. *at*, atrial aperture; *br*, branchial aperture; *bv*, branchio-visceral vessel; *c.v.*, cardio-visceral system; *da*, dorsal aorta; *ht*, heart; *v.v.*, ventral vessel.

Embryology and Life-History.—We owe to Castle (1896) the most complete account which has yet been given of the early stages of development in an Ascidian. His careful study of the cell lineage in *Ciona* has made it clear that some of the conflicting statements of his predecessors arose from incorrect orientation of the embryos. One of the most important of his conclusions is that the mesoderm of Ascidians, and probably that of the archaic Vertebrates, is derived from both primary layers, ectoderm and endoderm. Further, he finds that *Ciona* produces both ova and spermatozoa at the same time, but self-fertilization very rarely occurs. The eggs are laid just before dawn, and the larva is hatched during the following night. The test cells adhering to the young homogeneous test have, it is now well known, no connexion with the cells found later in the adult test. The larvæ are free-swimming for from one to several days. They avoid the light. The spermatozoon enters at the ventral hemisphere, and that point determines the median plane and the posterior end of the embryo. The ventral is the animal pole. The cleavage is from the beginning bilateral. The first cleavage plane is vertical, and separates the right and left halves of the embryo. The four smaller dorsal cells with yolk give rise to the endodermal hemisphere; the four larger, more protoplasmic cells form the ventral ectodermal hemisphere. The cells of the latter hemisphere divide more rapidly, and form the future aboral surface. When the dorsal hemisphere has twenty-two cells the ventral has fifty-four. The gastrulation is a combination of epiboly and invagination. The ventral ectoderm grows over, so as to envelop the dorsal hemisphere, while the latter sinks down and becomes saucer-shaped. In the centre of the dorsal surface ten cells form the future endoderm. Round these comes a ring of cells, the chorda-mesenchyme ring, from which the notochord and mesenchyme arise. Outside this ring is a row of cells, the neuro-muscular ring. The more anterior of these cells form the medullary plate, the more posterior the longitudinal musculature of the larva. The remainder of the cells (in the 112-cell stage) form ectoderm. By growth at the anterior end the blastopore gets pushed posteriorly, and the anterior chorda cells are covered up, and come to lie in the dorsal wall of the archenteron, sixteen cells in two rows, one over the other. The blastopore closes in the posterior part of the dorsal surface. In front of it is the medullary plate, with a continuation backwards at the sides of the blastopore. This region forms the trunk of the larva, the part posterior to it being drawn out to form the tail. The chorda cells pass back into the tail, while the mesenchyme cells shift forwards into the trunk. The muscle cells, derived from the neuro-muscular ring, lie behind the blastopore, and form the muscles of the tail. The closure of the medullary canal takes place from the blastopore forwards, and then the nerve cord is grown over by ectoderm. After closure of the blastopore the mesenchyme cells lie as lateral masses in the trunk; later they become the blood corpuscles and the mantle cells, &c.

Castle also discusses some important theoretical questions. He points out that, in *Ciona* at least, the chorda-mesenchyme ring takes part along with endoderm in the primary invagination, and so belongs to the primary endoderm; while the rest of the mesoderm, the muscle cells of the neuro-muscular ring, are carried in by a secondary invagination, and belong to the outer layer of the young gastrula, or primary ectoderm. He considers that the chorda must be regarded as a mesodermal organ. He agrees with former observers in seeing no trace of enterocœle formation, and he doubts whether any Chordata are Enterocœla. He does not believe in distinguishing those Metazoa with a mesoderm from those with a "mesenchyme." He considers that embryology gives no support to the Annelid hypothesis as to the origin of Chordates.

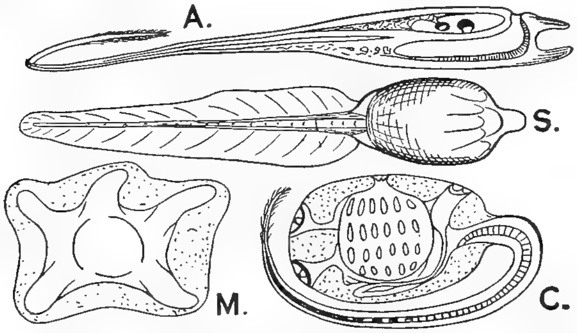

Fig. 6.—Sketches of Ascidian larvæ. A, *Ascidia;* S, *Styela;* M, *Anurella;* C, Compound Ascidian.

Fig. 6 shows a few characteristic forms of Ascidian "tadpoles," or free-swimming larvæ. A and S are typical simple Ascidians; M is the aberrant tailless form found in some Molgulidæ; and C is the larva of a typical Compound Ascidian.

A long-continued discussion as to the origin, nature, and fate of certain cells, the "testa-zellen," which make their appearance between the young embryo and its follicle (Fig. 7), has ended in practical agreement that these small cells are derived from the follicle-cells, and have nothing to do with the test. In *Salpa*, however, certain follicle-cells enter the embryo, and perform important functions in guiding the development for a time.

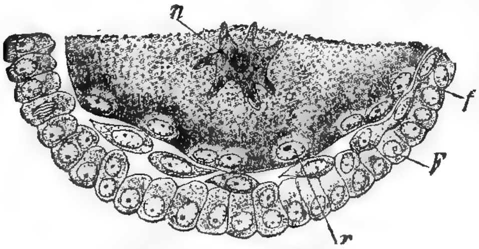

Fig. 7.—Portion of mature ovum of Ascidian, showing F, follicle, and *f*, *r*, "test-cells." (*After Pizon.*)

Gemmation and Growth of Colonies.—A number of new observations have been made in recent years upon the budding of Compound Ascidians, some of which are very puzzling and contradictory in their results. Metschnikoff, Kowalevsky, Giard, Hjort, Pizon, Seeliger, Ritter, van Beneden, and Julin have all in turn added to our knowledge of the details of development and life-history, of the various processes of gemmation and of the formation of colonies. It is impossible as yet to reconcile all the conflicting accounts, but the following points at least seem pretty clear:—

Gemmation may be very different in its details in closely related Compound Ascidians. There are, however, two main types of budding, to one or other of which most of the described methods may be referred. There is first the "stolonial" or "epicardiac" type, seen in the Merosomata, typically in Distomidæ and Polyclinidæ, and comparable with the gemmation in Clavelinidæ, Pyrosomidæ, and Thaliacea outside this group. Secondly, there is the "parietal" or "peribranchial" type, seen in the Holosomata, typically in the Botryllidæ. The remarkable process of gemmation seen in the families Didemnidæ and Diplosomidæ may probably be regarded as a modification of the stolonial type. The double embryo in the Diplosomidæ is probably to be interpreted as precocious budding (rather than as embryonic fission), due to acceleration in development (tachygenesis). The type of budding, and even details such as the length of the stolon, have much to do with differences in the nature and appearance of the colonies produced. The stolon, which has a wall continuous with the body-wall of the parent, contains an endodermal element in the form of the so-called "epicardium," and also a prolongation of the ovary, or at least a string of migrating germ-cells, so that the reproductive elements are also handed on. Still, it is clear from recent researches that the development of the bud (blastozooid) and that of the embryo (oozooid) do not proceed along parallel lines. It is impossible to harmonize the facts of gemmation with the germ-layer theory, and attempts to explain budding in Ascidians as a process of regeneration, by which the organs of the parent or their germ-layers give rise to the corresponding organs in the bud, have signally failed.

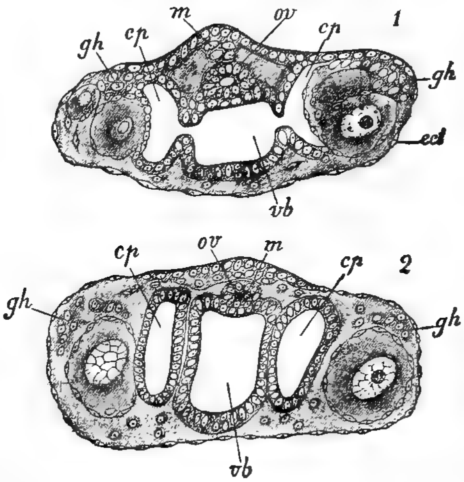

Fig. 8.—Young buds of *Botryllus* sectioned to show the separation of the branchial (*vb*) from the peribranchial (*cp*) cavities. *ov*, dorsal tube; *m*, mesoderm cells; *gh*, germ cells; *ect*, ectoderm. (*After Pizon.*)

Figs. 4 and 8 show the buds in the Botryllidæ, after Pizon, who has followed day by day the changes of growth in young colonies of Botryllidæ, tracing the rise of successive generations of buds and the degeneration of their parents. The buds are parietal, arising from the walls of the peribranchial cavities (Fig. 4), and at an early period they acquire the structure shown in Fig. 8, where there are two vesicles undergoing further subdivision and differentiation, but investigators still differ as to whether the inner, which gives rise to the branchial sac and alimentary canal, is not produced along with the outer from the ectoderm of the parent.

A remarkable case of polymorphism has been found by Caullery in the buds of the Compound Ascidian *Colella*. Some of the buds have an abundant store of reserve materials in their outer layer of cells, while others are without this supply. The former are placed deeply in the stalk, develop slowly, and probably serve to regenerate the colony when the head portion has been removed or has died down. In these cases where the ectoderm has taken on the function of storing the reserve material, it is found that all the organs of the bud are formed from the cells of the endodermic vesicle.

Figs. 9 and 10 illustrate some details of structure of branchial sac and of stomach in various Ascidians which are made use of in classification, and in definitions of genera and larger groups.

Geographical Distribution.—The new forms described from Puget Sound and Alaska have drawn renewed attention to the similarity of the fauna in that region of the North Pacific and the fauna of north-west Europe. There is probably a common circumpolar Tunicate fauna which sends extensions downwards in both Atlantic and Pacific. As the result of the careful quantitative work of the German Plankton expedition, Borgert thinks that the temperature of the water has more to do with both the horizontal and the vertical distribution of pelagic Tunicata in the sea than any other factor. It is probable that the occasional phenomenal swarms of *Doliolum* which have been met with in summer in the North Atlantic are a result of the curious life-history which in favourable circumstances allows a small number of budding forms to produce from the numerous minute buds an enormous number of the next generation. The great increase in the number of species known from nearly all seas during the last twelve or fifteen years of the 19th century enables us now to form a truer estimate of the geographical distribution of the group than was possible when the *Challenger* collections were described, and shows that the Tunicata at least give no support to the "bi-polar theory" of the distribution of animals.

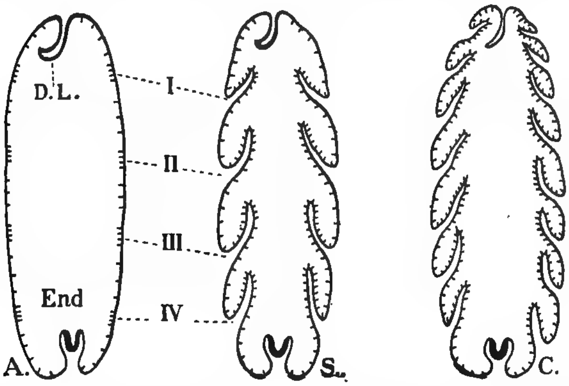

Fig. 9.—Diagrams showing transverse sections of typical branchial sacs. A, Unfolded type; S, *Styela*, with four folds on each side; C, *Cynthia*, with eight folds on one side and seven on the other; *D. L*, dorsal lamina; *End*, endostyle; I. II. &c., folds.

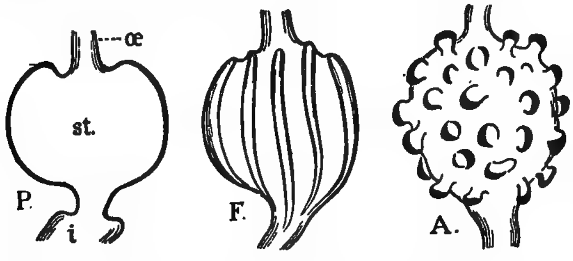

Fig. 10.—Types of stomach amongst Compound Ascidians. P, plain; F, folded; A, areolated; *i*, intestine; *œ*, œsophagus; *st*, stomach.

Finally, it may be useful to add that the volume on Tunicata, in the new edition of Bronn's *Thier-Reich*, by Prof. O. Seeliger, is now in course of publication, and if this fine work is completed in the same exhaustive and judicious manner which characterizes the first thirty parts, there can be no doubt that it will be a most authoritative work of reference on the group for years to come.

(W. A. He.)

Tunisia (Regency of Tunis).—*Geographical Boundaries and Area.*—Tunisia reaches the farthest point north of any part of Africa, Cape Blanc[1] (Ras-al-Abiadh) being in 37° 20′ N. On the south the boundary of the Tunisian Sahara is as yet undetermined, but it may be roughly placed at 32° N. This would give, therefore, a greatest length of something like 380 miles. The country lies between 11° 40′ E. and 7° 35′ E. The average length is about 300 miles, and the average breadth 150 miles; consequently the area may be estimated at 45,000 miles.[2] Geographically speaking, Tunisia is merely the eastern prolongation of the Mauritanian projection of northern Africa, of that strip of mountainous, fertile, and fairly well-watered country north of the Sahara desert, which in its flora and its fauna, and to some extent in its human race, belongs rather to Europe than to Africa. Tunisia is divided into four fairly distinct regions:—1. On the north and north-west the Aures Mountains of Algeria are prolonged into Tunis, and constitute the mountainous region of the north, which lies between the Majerda river and the sea, and also includes the vicinity of the town of Tunis and the peninsula of the Dakhelat el Mawin, which terminates in Ras Addar (Cape Bon). This first division is called by the French "the Majerda Mountains." It includes within its limits the once famous district of the "Kroumirs,"[3] a tribe whose occasional thefts of cattle across the frontier gave the French an excuse to invade Tunis in 1881. The highest point which the mountains attain in this first and northern division of Tunis is about 4125 feet, near Ain Draham in Kroumiria. The country, however, all round about Bizerta is very mountainous, though the summits do not attain a greater altitude than about 3000 feet. The district between Bizerta and the Gulf of Tunis is a most attractive country, resembling greatly the mountainous regions of South Wales. All this country is well watered by streams more or less perennial. Its vegetation is abundant, and recalls that of the more fertile districts of southern Spain and of Italy. On the higher mountains the flora has a very English character, though the actual species of plants may not be the same. 2. The central plateau region, stretching between the Majerda valley and the mountains of Gafsa. The average elevation of this country is about 2000 feet. The climate, therefore, in parts is exceedingly cold and bleak in winter, and as it is very wind-swept and parched in summer by the terrible south wind (*qibli* or "scirocco"), it is much less attractive in appearance than the favoured region on the northern littoral. Although it is almost always covered with some kind of vegetation, trees are relatively rare. A few of the higher mountains have the Aleppo pine and the juniper; elsewhere only a rare wild terebinth is to be seen. In these two regions the date palm is never met with growing naturally wild. Its presence is always due to its having been planted by man at some time or another, and therefore it is never seen far from human habitations. These central uplands of Tunis in an uncultivated state are covered with alfa or esparto grass; but they also grow considerable amounts of cereals—wheat in the north, barley in the south. The range of the Saharan Atlas of Algeria divides (roughly speaking) into two at the Tunisian frontier. One branch extends northwards up this frontier, and north-eastwards across the central Tunisian tableland, and the other continues south-eastwards between Gafsa and the salt lakes of the Jerīd. The greatest altitudes of the whole of Tunis are attained on this central tableland, where Mount Sidi Ali bu Musin ascends to about 5700 feet. About 30 miles to the south of the town of Tunis is the picturesque mountain of Zaghwan, which is approximately 4000 feet in altitude, and from whose perennial springs comes the water-supply of Tunis to-day as it did in the time of the Carthaginians and Romans. North-east of Zaghwan, and nearer Tunis, is the Jebel Resās, or Mountain of Lead, the height of which is just under 4000 feet. 3. The Sahel. This well-known Arab term for coast-belt (which in the plural form reappears as the familiar Swahili of Zanzibar) is applied to a third division of Tunis, which is the littoral region stretching from the Gulf of Hammamet to the south of Sfax. It is a region varying from 30 to 60 miles in breadth, fairly well watered and fertile. In a less marked way this fertile coast region is continued southwards in an ever-narrowing belt to the Tripolitan frontier. This region is relatively flat, in some districts slightly marshy, but the water oozing from the soil is often brackish, and in places large, shallow salt lakes are formed. Quite close to the sea, all along the coast from Hammamet to Sfax, there are great fertility and much cultivation; but a little distance inland the country has a rather wild and desolate aspect, though it is nowhere a desert until the latitude of Sfax has been passed. 4. The Tunisian Sahara. This occupies the whole of the southern division of Tunis, but although desert predominates, it is by no means all desert. At the south-eastern extremity of Tunisia there is a clump of mountainous country, the wind-and-water-worn fragments of an ancient plateau, which for convenience may be styled the Matmata tableland. Here altitudes of over 3000 feet are reached in places, and in all the upper parts of this tableland there is fairly abundant vegetation, grass and herbage with low junipers, but with no pine-trees. Fairly high mountains (in places verging on 4000 feet) are found beyond Gafsa and the salt lakes of the Jerīd.

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[1] It is possible that Ras-ben-Sekka, a little to the west of Cape Blanc, may be actually the most northerly point.

[2] Or 51,000 miles, if certain Sahara districts are allotted to Tunis instead of to Algeria.

[3] The French seem systematically unable to master certain sounds foreign to their own language, or sounds which they suppose to be foreign. Thus the "w," though constantly represented in French by "ou," is continually changed by them into "v," when they transcribe foreign languages, just as the Greek χ and the German and Scottish "ch" is almost invariably rendered by the French in Algeria and Tunis as "kr." Add to this the insertion of vowel sounds where they are lacking in the Arabic, and you derive from the real word *Khmir* the modern French term of Kroumir. In like manner *sebkha*, a salt lake, is constantly written by the French as *sebkra*.

These salt lakes are a very curious feature. They stretch with only two short breaks in a line from the Mediterranean at the Gulf of Gabes to the Algerian frontier, which they penetrate for a considerable distance. They are called by the French (with their usual inaccuracy of pronunciation and spelling) "chotts"; the word should really be the Arabic *shat*, the common Arab term for an inland sea, estuary, or lake. These shats, however, are, strictly speaking, not lakes at all at the present day. They are smooth, depressed areas (in the case of the largest, the Shat el Jerīd, lying a few feet below the level of the Mediterranean), which for more than half the year are expanses of dried mud covered with a thick incrustation of white or grey salt. This salt covering gives them at a distance the appearance of big sheets of water. During the winter, however, when the effect of the rare winter rains is felt, there may actually be 3 or 4 feet of water in these shats, which by liquefying the mud makes them perfectly impassable. Otherwise, for about seven months of the year they can be crossed on foot or on horseback. It would seem probable that at one time these shats (at any rate the Shat el Jerīd) were an inlet of the Mediterranean, which by the elevation of a narrow strip of land on the Gulf of Gabes has been cut off from them. It is, however, a region of past volcanic activity, and these salt depressions may be due to that cause. Man is probably the principal agent at the present day in causing these shats to be without water. All round these salt lakes there are numerous springs gushing from the sandy hillocks. Almost all these springs are at a very hot temperature, often at boiling-point. Some of them are charged with salt, others are perfectly fresh and sweet though boiling hot. So abundant is their volume that in several places they form actual ever-flowing rivers. But for the intervention of man these rivers would at all times find their way into the adjoining depressions, which they would maintain as lakes of water. But for a long period past the fresh-water streams (which predominate) have been used for irrigation to such a degree that very little of the precious water is allowed to run to waste into the lake basins; so that these latter receive only a few salt streams, which deposit on their surface the salt they contain and then evaporate. This abundant supply of fresh warm water maintains oases of extraordinary luxuriance in a country where rain falls very rarely. Perennial streams of the description referred to are found between the Algerian frontier and Gabes on the coast. The town of Gabes itself is on the fringe of a splendid oasis, which is maintained by the water of an ever-running stream emptying itself into the sea at Gabes after a course of not more than 20 miles. All this region round the shats has been called the "Jerīd" from the time of the Arab occupation. "Jerīd" means in Arabic "a palm frond," and inferentially "a palm grove." The fame of this Belad-el-Jerīd, or "Country of the Date Palms," was so exaggerated during the 17th and 18th centuries that the European geographers extended the designation from this small area in the south of Tunis to cover much of inner Africa. With this country of Jerīd may be included the island of Jerba, which lies close to the coast of Tunis in the Gulf of Gabes. The present writer believes that the date palm was really indigenous to this district of the Jerīd, as it is to countries of similar description in southern Morocco, southern Algeria, parts of the Tripolitaine, Egypt, Mesopotamia, southern Persia, and north-western India; but that north of the latitude of the Jerīd the date did not grow naturally in Mauritania, just as it was foreign to all parts of Europe, in which, as in true north Africa, its presence is due to the hand of man. To some extent it may be said that true north Africa lies to the north of this Jerīd country, which, besides its Saharan, Arabian, and Persian affinities, has a touch about it of real Africa, some such touch as may be observed in the valley of the Jordan. In the oases of the Jerīd are found several species of tropical African mammals and two or three of Senegalese birds, and the vegetation seems to have greater affinities with tropical Africa than with Europe. In fact, the country between the Matmata highlands and the strait separating Jerba from the mainland is singularly African in the character and aspect of its flora. To the south of the Jerīd the country is mainly desert—vast unexplored tracts of shifting sand with rare oases. Nevertheless, all this southern district of Tunis bears evidence of once having been subject to a heavy rainfall, which scooped out deep valleys in the original tableland, and has justified the present existence of immense water-courses—water-courses which are still, near their origin, favoured with a little water.

Rainfall.—There is no important running river in Tunis but the Majerda and its affluents. The rainfall in the first geographical division is pretty constant, and may reach a yearly average of about 22 inches. Over the second and third divisions the rainfall is less constant, and its yearly average may not exceed 17 inches. In the fourth division rain is most uncertain. Occasionally two or three years may pass without any rainfall; then may come floods after a heavy downfall of a few weeks. Perhaps if an average could be struck it would amount to 9 or 10 inches per annum.

Geology.—The region of the Sahel and all the other great plains of Tunis are of relatively recent Quaternary formation; the Kroumir country and much of the extreme north-west of Tunisia is of marine formation, and is of the Miocene and Pliocene divisions of the Tertiary epoch. Much of the interior tableland and of the ranges of hills round the shats is Cretaceous[1]; the hilly country about the central Majerda, on the central plateau (Maktar), El Kef, and farther south, and in the northern part of the Jerīd, belongs to the Upper and Lower Eocene. There are a few patches of the Lower Cretaceous all over the country.

Minerals.—Tunisia is better endowed with mineral wealth than was formerly believed. Coal has been discovered in the Kroumir country, but the principal mines at present worked in Tunis are those of lead and zinc. Zinc is chiefly found in the form of calamine. Valuable deposits of phosphates are present, chiefly in the south-west of Tunisia, round about the district of Gafsa. Marble is found in the valley of the Majerda (at Shemtu), at Jebel Ust (about 35 miles to the south of Tunis), and at Jebel Dissa, near Gabes. The marbles of Shemtu are the finest pink Numidian marbles, which were much esteemed by the Carthaginians and Romans. It has been sought to work again the ancient quarries of Shemtu, but it was found that the marble had been spoilt by ferruginous and calcareous veins. Hot and mineral springs may be almost said to constitute one of the specialities of Tunisia. They offered a singular attraction to the Romans, and their presence in remote parts of the country no doubt was often the principal cause of Roman settlement. Even at the present day their value is much appreciated by the natives, who continue to bathe in the ruined Roman baths. The principal mineral springs of medicinal value are those of Korbus and Hamman Lif (of remarkable efficacy in rheumatic and syphilitic affections and certain skin diseases), of the Jehrīd and Gafsa, of El Hamma, near Gabes, and of various sites in the Kroumir country.

Flora.—The flora of Tunis is very nearly identical with that of Algeria, though it offers a few species either peculiar to itself or not found in the last-named country. On the whole its character is less Saharan than that of parts of Algeria, for the influences of the desert do not penetrate so far north in Tunis as they do in Algeria. There are very few patches of real forest outside the Kroumir country, though it is probable that in the time of the Romans the land was a good deal more covered with trees than at the present day. Some authorities, however, dispute this, in a measure, by saying that it was not naturally forested, and that the trees growing represented orchards of olives or other fruit trees planted by the Romans or Romanized Berbers. But in the Majerda Mountains there are dense primeval forests lingering to the present day, and consisting chiefly of the cork oak (*Quercus ruber*), and two other species of oak, *Quercus mirbeckii* and *Q. kermes*, the pistachio or terebinth tree, the sumach (*Rhus pentaphila*), and other species of *Rhus* which are widely spread. In the mountains of Kroumiria and the central plateau there are also the alder, the poplar, the Aleppo pine, the caroub, the tamarisk, the maple, the nettle-tree, several willows and junipers. The jujube-tree (*Zizyphus*) is found at various places along the eastern littoral. The retama shrub is met with in sandy districts, especially in the Sahara, but also right up to the north of Tunis. The wild olive, the wild cherry, two species of wild plums, the myrtle, the ivy, arbutus, and two species of holly are found in the mountains of Kroumiria, at various sites at high elevation near Tunis and Bizerta, and along the mountainous belt of the south-west which forms the frontier region between Tunis and Algeria. The present writer, riding up to these frontier mountains from the thoroughly Saharan country round Gafsa, found himself surrounded by a flora very reminiscent of Switzerland or

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[1] A patch of Pliocene formation also reappears in the very centre of Tunis, to the west of Kairwan.

England. On the other hand, the flora of the *shat* region, of the south-eastern littoral, and of the Kerkena islands opposite Sfax, is thoroughly Saharan, with a dash, as it were, in places of an African element. The date palm grows wild, as has been already related, in Jerba. The only other species of palm found wild in Tunisia is the *Chamærops humilis*, or dwarf palm, which is found on the mountains of the north at no very great altitude. The wild flowers of the north of Tunis are so extremely beautiful during the months of February, March, and April as to constitute a distinct attraction in themselves.[1]

Fauna.—The fauna of Tunis at the present day is much impoverished as regards mammals, birds, and reptiles. In 1880 the present writer actually saw lions killed in the north-west of Tunis, but now the lion is said to be practically extinct in the regency, though occasional rumours of his appearance come from the Kroumir Mountains and near Feriana. Leopards of large size are still found in the north-west of central Tunisia. The cheetah lingers in the extreme south of the Jerīd; so also does the caracal lynx. The pardine lynx is found fairly abundantly in the west of Tunisia in the mountains and forest. The striped hyæna is scattered over the country sparsely. The genet and the common jackal are fairly abundant. The common ichneumon is rare. The zorilla, another purely African species, is found in the south of Tunis. The Barbary otter is present in the Majerda and in some of the salt lakes. The Tunisian hedgehog is peculiar to that country and to Algeria. There is a second species (*Erinaceus deserti*) which is common to all North Africa. In the south of Tunis, especially about the shats, the elephant-shrew (*Macroscelides*) is found, an animal of purely African affinities. Tunisia does not appear to possess the Barbary ape, which is found in Algeria and Morocco. Natives of Morocco and of the Sahara oases occasionally bring with them young baboons which they assert are obtained in various Sahara countries to the south and south-west of Tunis. These baboons appear to belong to the Nubian species, but they cannot be considered indigenous to any part of Tunis. The porcupine, and a large rodent called *Ctenodactylus*, the jerboa (two species), the hare, and various other rodents are met with in Tunisia. The wild boar inhabits the country, in spite of much persecution at the hands of "chasseurs." The forested regions shelter the handsome Barbary stag, which is peculiar to this region and the adjoining districts of Algeria. In the extreme south, in the Sahara desert, the addax antelope is still found. The hartebeest appears now to be quite extinct; so also is the leucoryx, though formerly these two antelopes were found right up to the centre of Tunis, as was also the ostrich, now entirely absent from the country. In the marshy lake near Mater (north Tunisia), round the mountain island of Jebel Ashkel, is a herd of over 50 buffaloes; these are said to resemble the domestic (Indian) buffalo of the Levant and Italy, and to have their origin in a gift of domestic buffaloes from a former King of Naples to a bey or dey of Tunis. Others again assert the buffaloes to have been there from time immemorial; in which case it is very desirable that a specimen should be submitted for examination. They are the private property of the bey, who very properly preserves them. Far down in the Sahara, to the south of Tunis, the Arabs report the existence of a wild ass, apparently identical with that of Nubia. Roman mosaics show representations not only of this ass, but of the oryx, hartebeest, and perhaps of the addax. The dorcas gazelle is still common in the south of Tunis; but perhaps the most interesting ruminant is the magnificent udad or Barbary sheep, which is found in the sterile mountainous regions of south Tunisia. The birds have been ably illustrated by Mr Whitaker in the *Ibis* magazine of the British Ornithological Union. They are, as a rule, common to the south Mediterranean region. A beautiful little bird, almost peculiar to the south of Tunis and the adjoining regions of Algeria, is a species of bunting (*Fringilla*), called by the Arabs *bu-habibi.*[2] This little bird, which is about the size of the linnet, has the head and back silvery blue, and the rest of the plumage chocolate red-brown. It is of the most engaging tameness, being fortunately protected by popular sentiment from injury. It inhabits the Jerīd, and extends thence across the Algerian frontier. Among reptiles the Egyptian cobra seems to be indigenous in the south, where also is found the dreaded horned viper. Some nine or ten other species of snakes are present, together with an abundance of lizards, including the *Varanus*, and most species of Mediterranean tortoises are represented. The coasts are very rich in fish, and the tunny fisheries of the north are one of the principal sources from which the world's supply of tunny is derived.

Population.—As regards the natives of Tunis at the present day, they belong mainly to two stocks, which we may roughly classify as the Berber and the Arab, about two-thirds being of Berber and the remaining third of Arab descent. But the Berbers of to-day are little more than an incomplete fusion of some four earlier and once independent stocks. These four divisions taken in the order of their assumed priority of invasion or habitation are: (1) the "Neanderthal" type, which is found in the districts of the shats and the adjoining Matmata tableland in the south, and in the Kroumir country of the north-west;[3] (2) ordinary Berbers, dolichocephalous, and of brown complexion, found over the greater part of Tunisia, especially in the east and south centre; (3) the short-headed Berbers, found in part of the Matmata country, part of the Sahara, the Island of Jerba, the Cape Bon Peninsula, and the vicinity of Susa, Kairwan, and Sfax; (4) Berbers of a blond type, that is to say, with a tendency to brown or yellow moustaches, brown beard and head hair, and grey eyes. These are met with in the west and north-west of Tunisia, and in one patch on the coast of the Cape Bon Peninsula, near Nabeul. The Arabs of more or less unmixed descent are purely nomads. They are met with in a long strip of country south of Majerda, between the Algerian frontier and the sea-coast north of Susa, also inland, to the south-west of Susa, and near Kef; also in another long strip between the vicinity of Sfax on the north and the Jerīd on the south. The extreme south of Tunis is ranged over by Berber Tawareq[4] or Tamasheq. Berber dialects are still spoken in Tunisia in the island of Jerba, in the Matmata country, and in the Tunisian Sahara. Elsewhere to a remarkable degree the Arabic language has extinguished the Berber tongue, though no doubt in vulgar Tunisian a good many Berber words remain. A short vocabulary of the Berber spoken in the Tunisian Sahara has been published by the present writer in the *Proceedings* of the Royal Geographical Society. On the north-eastern littoral of Tunis the population is of course very mixed. The inhabitants of the Cape Bon Peninsula show evident signs of Greek blood arising from Greek invasions, which began in prehistoric times and finished with the downfall of the Byzantine empire in North Africa. The presence of the Romans, and the constant introduction of the Italians, first as slaves, and quite recently as colonists, has also added an Italian element to the north Tunisian population. But from the fact that the bulk of the Tunisian population belongs to the

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[1] *List of Plants commonly met with in northern Tunisia.*

Adonis microcarpa, DC.
Nigella damascena, L.
Fumaria spicata, L.
Cistus halimifolius, L.
Silene rubella, L.
Oxalis cernua, Thunb.
Geranium tuberosum, L.
Malva sylvestris, L.
Tetragonolobus purpureus, Moench.
Retama retam, Webb.
Fedia cornucopiæ, Gaertn.
Helichrysum Stœchas, DC.
Centaurea (Seridia), sp.
Urospermum Dalechampi, Desf.
Scorzonera alexandrina, Boiss.
Stachys hirta, L.
Stachys, sp. not identified.
Anagallis collina, Schousb.
Convolvulus tricolor, L.
Solenanthus lanatus, DC.
Echium sericeum, Vahl.
Echium maritimum, Willd.
Anchusa italica, Retz.
Lycium europæum, L.
Solanum sodomæum, L.
Celsia cretica, L.
Linaria, sp. allied to *L. reflexa*, Desf.
Linaria triphylla, L. var.
Orobanche, sp.
Trixago apula, Stev.
Cynomorium coccineum.
Plantago albicans, L.
Euphorbia serrata, L.
Ophrys fusca, Link.
Orchis papilionacea, L.
Romulea bulbocodium, Sebast. and Mauri.
Gladiolus byzantinus, Mill.
Ornithogalum umbellatum, L.
Allium roseum, L.
Asphodelus fistulosus, L.
Muscari comosum, Mill.
Arum italicum, Mill.
Lagurus ovatus, L.

To this list should also be added the common wild tulip, the Italian cyclamen, the common scarlet poppy, the fennel, wild carrot, and many varieties of thistle, some of gorgeous colouring.

[2] "Father of my friend."

[3] In this Matmata country are the celebrated Troglodytes, people living in caves and underground dwellings now, much as they did in the days when the early Greek geographers alluded to them. See "A Journey in the Tunisian Sahara," by the present writer, in the *Geographical Magazine*, June 1898.

[4] Tawareq (Tuareg) seems to be the Arab corruption of their tribal name.

Iberian section of the Berbers, and to this being no doubt the fundamental stock of most Italian peoples, the intermixture of the Italianized Berber with his African brother has not much affected the physique of the people, though it may have slightly tinged their mental characteristics.

The Phœnicians have left no marked trace of their presence; but inasmuch as they were probably of nearly the same race as the Arabs, it would not be easy to distinguish the two types. Of course Arab and Berber have mingled to some extent, though no considerable fusion of the two elements has taken place. In fact, it is thought by some French students of the country that the Arab element will probably be eliminated from Tunis, as it is the most unsettled. It is considered that these nomads will be gently pushed back towards the Sahara, leaving cultivable Tunis to the settled Berber stock, a stock fundamentally one with the peoples of Mediterranean Europe. The present population of Tunis numbers approximately 1,925,000, and consists of:—

Berbers, more or less of pure race, say . .	600,000
Arabs, ,, ,, ,, . .	500,000
Mixed Arab and Berber peoples, say . .	500,000
"Moors" (chiefly the population of the principal cities, of mixed Roman, Berber, Spanish, Moor, and Christian races, say . . .	100,000
Sudanese negroes and natives of Morocco, Tripoli, and Turkey, say	40,000
Jews (mostly natives of Tunis, indeed, some descended from families settled at Carthage before the destruction of Jerusalem) . .	60,000
Europeans (Christians)[1]	125,000

Towns.—Besides the capital, TUNIS (population about 150,000), which has been sufficiently described in vol. xxiii. of this Encyclopædia, the next most important town of Tunisia is probably Sfax, with a present population of nearly 50,000. Sfax, Susa, Kairwan, and most of the principal towns have not changed much. Bizerta (properly pronounced Ben Zert, the Roman and Greek-Carthaginian *Hippo Diarrhytus*) is situated on the banks of a narrow canal, more or less artificial, which connects the Mediterranean with a very large and deep salt lake, the Lake of Bizerta. Beyond this large salt lake (with an area of about 45 square miles) is a smaller freshwater lake, connected with the salt lake by a narrow and impassable outlet. The French have determined to make Bizerta their second most important naval port in the Mediterranean. A new canal has been cut from the Mediterranean into the lake; but this not being wide and deep enough, it is proposed to double the width and increase the depth. A great arsenal is being established on the shores of this lake, out of the reach of any marine artillery which could be directed on it from the sea. But the canal transit of some two miles from the open sea to the inner lake will always remain such a source of risk and danger to fleets passing in and out in a hurry, that it is questionable whether Bizerta can ever attain a high position as a great naval port.

Kairwan (see also *Ency. Brit.* vol. xiii.) is a most interesting city, which still displays the Moorish colour and picturesqueness prevalent before the Europeanization of the country. Gafsa, in the south of Tunis, is well worth a visit; it is a most interesting old Roman town, with hot springs. Almost all the existing towns of Tunis were originally Roman or Romanized Berber settlements; consequently the remains of Roman buildings form a large part of the material of which their existing structures are composed.

Objects of Interest.—In the first rank of these will probably come the Phœnician and Roman antiquities. An excellent museum has been founded at Carthage by the White Fathers of Cardinal Lavigerie's mission. Here may be seen many objects illustrating Phœnician art and culture, and still more the Roman and Byzantine civilization which followed. These objects have been obtained from the site of Carthage and its vicinity. Near this museum also may be seen vast cemeteries—Byzantine, Roman, and Carthaginian (Phœnician), the order usually being in layers, with the Phœnician at the bottom. The site of Carthage itself has been hideously vulgarized. On the monticule, where formerly stood the citadel and the magnificent palace of the Roman pro-consul, have been erected (1) a cathedral in the architectural style of a Moorish music-hall;[2] (2) a hotel of the most ugly description, built by a former Belgian consul as a speculation; and (3) a "bicoque," or preposterous châlet, built by General Boulanger's son-in-law in theatrical imitation of a French "donjon." The site of the citadel of Carthage, which is seen from far and wide, and overlooks such a splendid panorama of gulf, mountain, lake, plain, and orchards, has been ruined for a time until some wise iconoclast will remove by an act of force the singularly ugly and tasteless erections which disfigure it. At the Bardo Museum, near Tunis, M. Paul Gauckler, the director of the Department of Art and Antiquities in the Tunisian Government, has assembled a magnificent collection of Carthaginian and above all Roman antiquities, especially Roman mosaics, and has also striven to illustrate the Saracenic art of Tunisia. The principal Roman ruins are the following:—the Roman aqueducts in the vicinity of Tunis; the Temple of the Waters on Zaghwan Mountain; the great reservoir near Carthage; the magnificent amphitheatre of El Djem (between Susa and Kairwan), the second or third largest in the world; the ruins of Dougga, near Teboursouk (the amphitheatre of Dougga, the ancient *Thugga*, is a magnificent spectacle); the temples, bridge, and other ruins of Sbeitla (the ancient *Suffetula*); the baths and temples of Feriana (the ancient *Thelepte*)—the whole route between Feriana in Tunisia and Tebessa in Algeria is simply strewn on both sides with Roman ruins; the old houses[3] and other ruins at and near Thala; the baths and other ruins of Gafsa; the old Roman baths at Tuzer, El Hamma, and Gabes. There is also an interesting Phœnician burial-ground near Mehdia. There are other Roman ruins, but scarcely known, in the vicinity of Beja and the country of the Mogods. In short, Tunisia is as much strewn with Roman remains as is Italy itself.

Saracenic art has perhaps not attained here the high degree it reached in western Algeria, Spain, and Egypt; still it presents much that is beautiful to see and worthy to be studied. One of the most ancient, as it is one of the loveliest fragments, strange to say, is found at Tuzer, in the Jerīd, the *mahrab* of a ruined mosque.[4] There are some very beautiful doorways to mosques and other specimens of Moorish art at Gabes. In some respects perhaps Kairwan contains what is best worth seeing in this way, but unhappily its Saracenic art treasures have suffered cruelly, firstly, in the vulgarization which followed the Turkish occupation, and, secondly, in the well-meant but blundering attempts of the Franco-Tunisian authorities to restore buildings that were falling into ruin. Tunis itself and the Bardo palace near Tunis offer some fine specimens of carved and painted ceilings, of tiles, and of that beautiful *naksha hadida*, or carved stucco work, which is brought to such perfection in the Alhambra. But the visible remains of Saracenic art in Tunis and its vicinity are of relatively recent date, the few mosques which might offer earlier examples not being open to inspection by Christians. It may be noted, however, as a general condition that the native towns and villages of Tunisia, where they have not been spoiled by the shocking tastelessness of Mediterranean Europe, are exceedingly picturesque, and offer exceptional attractions to the painter.

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[1] Of recent introduction for the most part, consisting (1901) of about 72,000 Italians, 37,500 French colonists and soldiers, 12,000 Maltese, 1000 Greeks, and the remainder British, German, Austrian, &c.

[2] The idea of Cardinal Lavigerie was that if he built his cathedral as much as possible like a showy mosque, he might induce Arabs to worship there.

[3] Some of these old Roman dwellings are said still to retain their roofs.

[4] Of which a reproduction was sent to the Paris Exhibition of 1900.

Commerce.—The commerce of Tunisia is thriving under the French protectorate, having risen from an annual total of about £1,700,000 in 1881 to £3,915,119 in 1898 and £4,163,000 in 1900. During this period the value of British trade with Tunis has also risen, though undergoing vacillations at times. It stood at considerably over £600,000 in annual value during the year 1897, and again in 1898. The principal exports are olive oil, wheat, esparto grass, barley, sponges, dates, and fish. The imports consist mainly of European manufactured goods (especially British cotton), machinery, flour, alcohol, and petroleum. The town of Tunis now being connected with the sea by a navigable canal, the port of Goletta has lost all its former importance. Excellent ports have also been made by the French at Bizerta, Susa, and Sfax.

Industries.—The principal industries are agriculture (cultivation of cereals, olives, dates, almonds, vines, figs, oranges, roses and jasmines for perfume); stock-rearing (camels, horses, cattle, sheep, goats—horses and cattle are exported to Malta in large numbers); working of minerals and phosphates; fisheries, sponge-fishing; pottery-making, leather work, silk-weaving, wool manufacture, carpet-weaving, dyeing, and perfume-making.

Railways.—The "Bône-Guelma et Prolongements" Company has constructed and works nearly all the railways of eastern Algeria and Tunisia. It has bought the little railway (Tunis-Goletta-Marsa) originally constructed by a British company in the early 'seventies and then sold to an Italian company. The Tunisian railway system consists of (1) a line from the Algerian frontier to Tunis and Bizerta, (2) a line from Tunis to Goletta and Marsa, (3) a line from Tunis to Zaghwan, (4) a line from Tunis to Hammam Lif, Nabeul, Hammamet, Susa, and Kairwan; and (5) a line from Sfax to Gafsa. All but the last-named are worked by the Bône-Guelma Company, and are well managed.

Posts and Telegraphs.—The whole of Tunisia is covered with a network of telegraph lines, and there are telephones working in most of the large towns. The telegraph system penetrates to the farthest French post in the Sahara, is connected with the Turkish system on the Tripolitan frontier and with Algeria, and by cable with Sicily, Malta, Sardinia, and Marseilles. There are about 69 telegraph stations, 11 telephone stations, and 246 post offices.

Finance.—The principal bank is the Banque de Tunisie. The coinage formerly was the caroub and piastre (the latter worth about 6d.), but in 1891 the French reformed the coinage, substituting the franc as a unit, and having the money minted at Paris. The values of the coinage are pieces of 5 and 10 centimes in bronze, of 50 centimes, 1 franc and 2 francs in silver, of 10 francs and 20 francs in gold. The inscriptions are in French and Arabic. The public debt was consolidated in 1884 into a total of £5,702,000. Since 1888 it has been converted into a loan paying 3½ per cent. interest. It is guaranteed by France. The weights and measures are those of France. The revenue for the year 1900 was £1,456,640, and the expenditure was £1,452,597. The principal sources of revenue are direct taxation, stamp and death duties, customs, port and lighthouse dues, octroi and tithes, tobacco, salt, and gunpowder monopolies, postal and telegraph receipts, and revenue from the state domains (lands, fisheries, forests, mines). The civil list paid to the bey of Tunis amounts to £36,000 per annum, and the endowment of the princes and princesses of the beylical family to £31,200 a year more.

Administration.—From a native's point of view Tunisia still appears to be governed by the bey of Tunis, his Arab ministers, and his Arab officials, the French only exercising an indirect—though a very real—control over the indigenous population (Mahommedans and Jews). But all Christians and foreigners are directly governed by the French; and the native administration is supervised by a large staff of French "contrôleurs" and their subordinates. All the departments of state have Frenchmen at their head, and the larger proportion of the bey's ministers are likewise French. France is directly represented in Tunisia by a minister Resident-General, and by an assistant Resident. The French Resident-General is the virtual viceroy of Tunisia.

History.—The following facts about the French occupation may be noted. The French having, on more or less fictitious pretexts, invaded the country in 1881 (the real cause of their invasion being an assurance given by Great Britain at the Conference of Berlin in 1878 that French predominance in Tunis would not be unfavourably regarded by Great Britain), they contented themselves at first with the occupation of various points of the so-called regency of Tunis (for Tunis, before the French occupation, was practically a fief of the Turkish empire). But in 1883 it was decided to undertake a thorough reform of the government and administration of the country, and from 1884 onwards Tunisia has been practically governed by the French minister Resident-General. Nevertheless, the Bey (Prince Sidi Muhammad, who succeeded his brother in 1882) continues to reign in a measure over his native subjects, and is the ostensible head of the Government in their eyes. On the whole French control over the country has been indirectly and wisely exercised, so that the benefits of French rule have hitherto been much more apparent than the exercise of the firm hand that has put an end to Oriental corruption. In the last two or three years of the 19th century, however, an agitation sprang up among the French "colonists" for a government which should be less that of the benevolent despotism carried on by the present triumvirate of the French minister of foreign affairs, the French minister Resident, and the Bey of Tunis, than a kind of constitutional or parliamentary control, by which the small body of French colonists are to direct and control the administration. In short, some 10,000 French settlers would like to turn what is practically analogous to an English Crown colony into one with representative institutions. Such a policy might have much to recommend it in a country like West Australia, where the native population is very sparse, but in a country like Tunis, where there are 1,800,000 Mahommedan Berbers and Arabs as compared with 125,000 Christians, such a proposition is altogether another matter, and would lead to very serious troubles, as has been the case in Algeria. Sooner or later the position of the puppet prince must become a superfluity, but Tunisia must continue to be governed despotically, wisely, and well by a single French viceroy or pro-consul, until perhaps some distant epoch when the Arabs and Mahommedanism have jointly disappeared, and the great mass of the Berber population of Roman Africa has abandoned its fatal connexion with the East, and returned to that community of European nations to which by blood and affinities it belongs.

Besides the list of works given at the conclusion of the article on TUNIS in vol. xxiii., may be added the two important articles on Tunisia in Nos. 22 and 23 of the *Revue Générale des Sciences* (30th November and 15th December 1896), Paris; and the still more important *La Tunisie Française*, in two volumes, a Government publication (Berger, Levrault et Cie., Paris, 1896). An article on the "Tunisian Sahara, the Tunisian Cave-Dwellers, and Berber Languages," &c., by the writer of the present article, was published in the *Geographical Journal* for June 1898. Other articles by the same author appeared in the *Graphic* during the years 1899, 1900, and 1902. An interesting dissertation on the question of the Berber race appears in Professor A. H. KEANE's *Man, Past and Present.* Numerous other works in English and French have been published on Tunis from the tourist's point of view, but they are for the most part lacking in accuracy or novelty of observation. *L'Afrique Romaine*, by GASTON BOISSIER, is a picturesque but somewhat superficial *aperçu* of the principal Roman ruins. *Salammbo*, by FLAUBERT, ought always to be read by those who visit Carthage and Tunis. It was mainly written at La Marsa, near Carthage.

(H. H. J.)

Tunnelling.—Progress has been made in the methods of cooling and ventilating tunnels, in the details of drilling machines, and notably in the use of shields for sub-aqueous and soft-ground tunnels.

The Simplon railway tunnel in the Alps, near the Simplon Pass, begun in August 1898, will have a length

Rock tunnels.

of about 12¼ miles, or one-third greater than the St Gothard tunnel. A novel method is introduced in the use of two parallel bores (56 feet apart, connected at intervals of 660 feet by oblique galleries), which will greatly facilitate ventilation, and tend to increased economy and rapidity of construction. One bore in the first instance, and as soon as required by the traffic the other also, will be made large enough for a single-track railway. It was expected that the first would be completed in 1904. The aggregate contract cost of the two (not including track) is about £2,750,000. The rock consists of margarite, chalk, gneiss, mica, and gypsum. The rock in the middle of the tunnel will probably have a maximum natural temperature of 120° F., which during construction will be lowered to a maximum of 80° F. by very ample ventilation and cold water sprays.

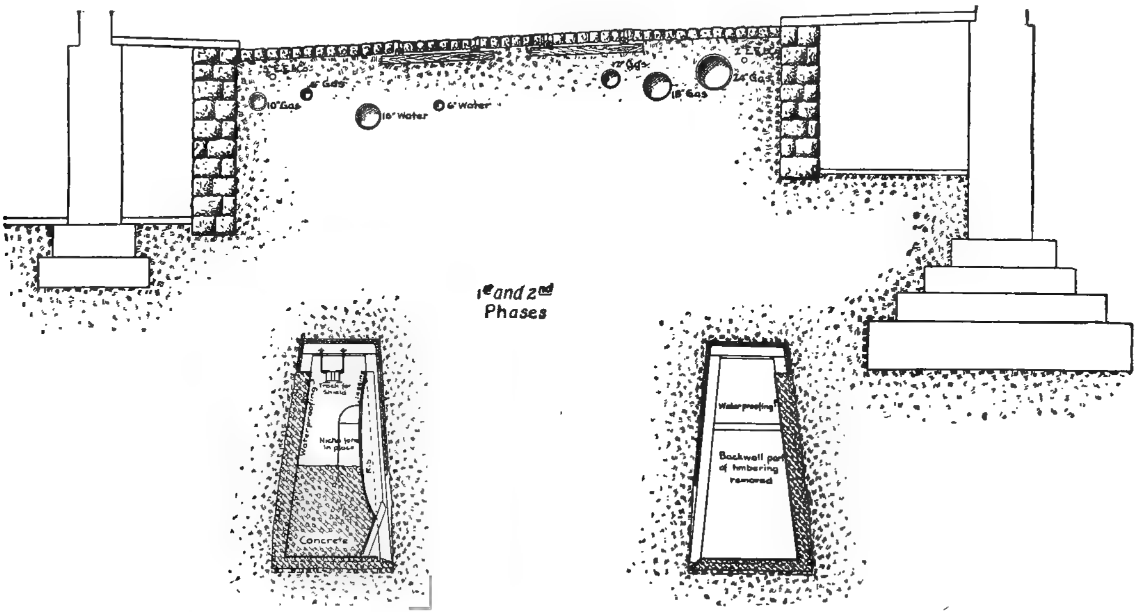

FIG. 1.—Boston Subway, first and second phases.

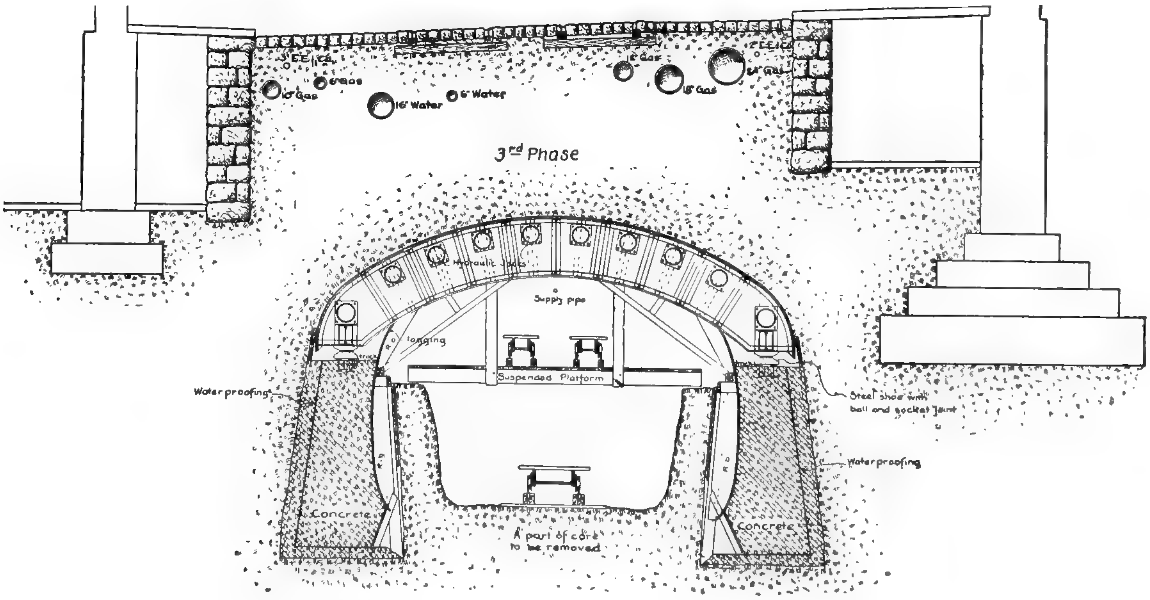

FIG. 2.—Boston Subway, third phase.

Electric propulsion of trains is proposed, to prevent vitiation of the air and to lessen the corrosion of metal, which has been so great in other tunnels. Alfred Brandt, the directing engineer on the north end, a man of great ability, whose drills have been used with much success, died in November 1899, and his place was taken by Colonel Edward Locher. The directing engineer on the south end is Carl Brandau.

Among other recent rock tunnels may be mentioned the Tequixquiac, for draining the valley of Mexico, 6 miles long, about 14 feet diameter, through sandstone and other rocks, costing about $6,760,000; the Albula, through a granite ridge of the Rhætian Alps, for a single-track narrow-gauge railroad, 3·6 miles long; tunnels on the Dore and Chinley railway, near Totley in Derbyshire, over 3·5 miles long, largely in shale; Cowburn, over 2 miles long, shale and harder rock, each 27 feet wide and 20·5 feet high inside; the Cascade on the Great Northern railway, state of Washington, 2·5 miles long, 24 feet high by 20 wide, through shattered granite,

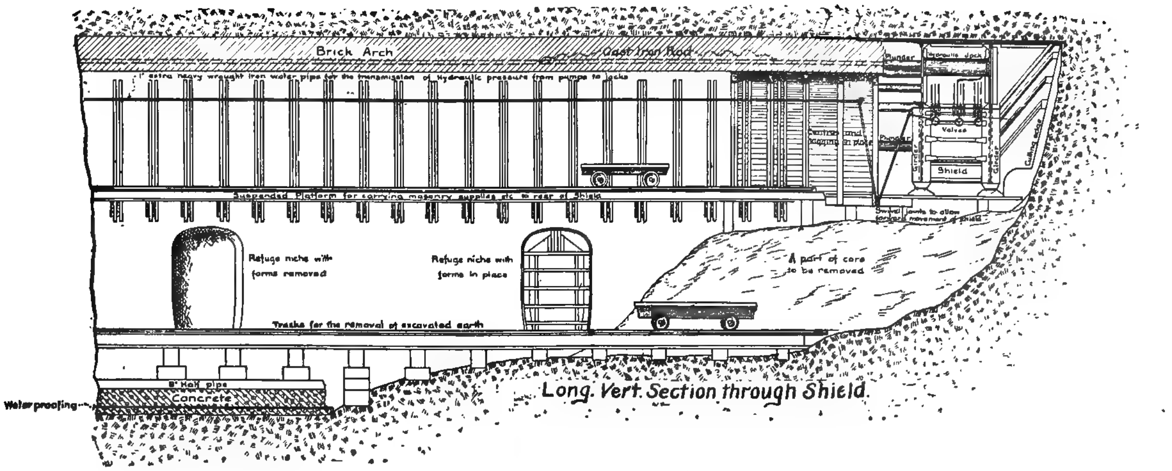
Brick Arch
Cast Iron Rod
1" extra heavy wrought iron water pipes for the transmission of Hydraulic pressure from pumps to jacks
Plunger
Hydraulic Jack
Centres and lagging in place
Plunger
Valves
Girder
Shield
Girder
Cutting edge
Suspended Platform for carrying masonry supplies etc. to rear of Shield
Swivel joints to allow forward movement of shield
Refuge niche with forms removed
Refuge niche with forms in place
A part of core to be removed
Tracks for the removal of excavated earth
8" Half pipe
Concrete
Waterproofing
Long. Vert. Section through Shield.

Fig. 3.—Boston Subway, longitudinal vertical section through shield.

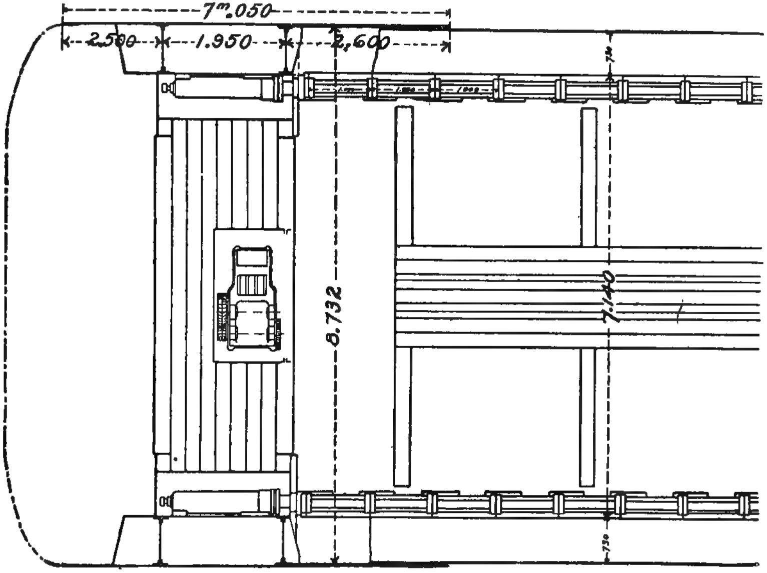

Fig. 4.—Paris Métropolitain Tunnel, longitudinal horizontal section.

costing about $3,000,000; the Suram, on the Trans-Caucasus railway, for double track, 2·47 miles long, through soft rock; the tail-race tunnel for the Niagara Falls Water Power Company, 1·3 mile long, 19 feet wide and 21 feet high, through argillaceous shale and limestone, costing about $1,250,000; the narrow-gauge single-track electric railway tunnel from the Eiger Glacier to near the summit of the Jungfrau, about 6 miles long, 3·6 metres wide and 3·8 metres high; portions of the Rapid Transit railroad in Park Avenue and Upper Broadway, New York, aggregating about 3·5 miles in length, 25 feet wide by 18 feet high, mostly through gneiss.

Soft ground tunnels with iron walls.

The use of compressed air in the Hudson River tunnel by D. C. Haskin (in 1880 and succeeding years), and the use of annular shields and cast-iron lined tunnel in constructing the City and South London railway by Greathead (1886 to 1890) became widely known, and greatly influenced subaqueous and soft-ground tunnelling thereafter. The pair of tunnels for the City and South London railway, from near the Monument to Stockwell, a distance of about 3⅛ miles, from 10 feet 2 inches to 10 feet 6 inches

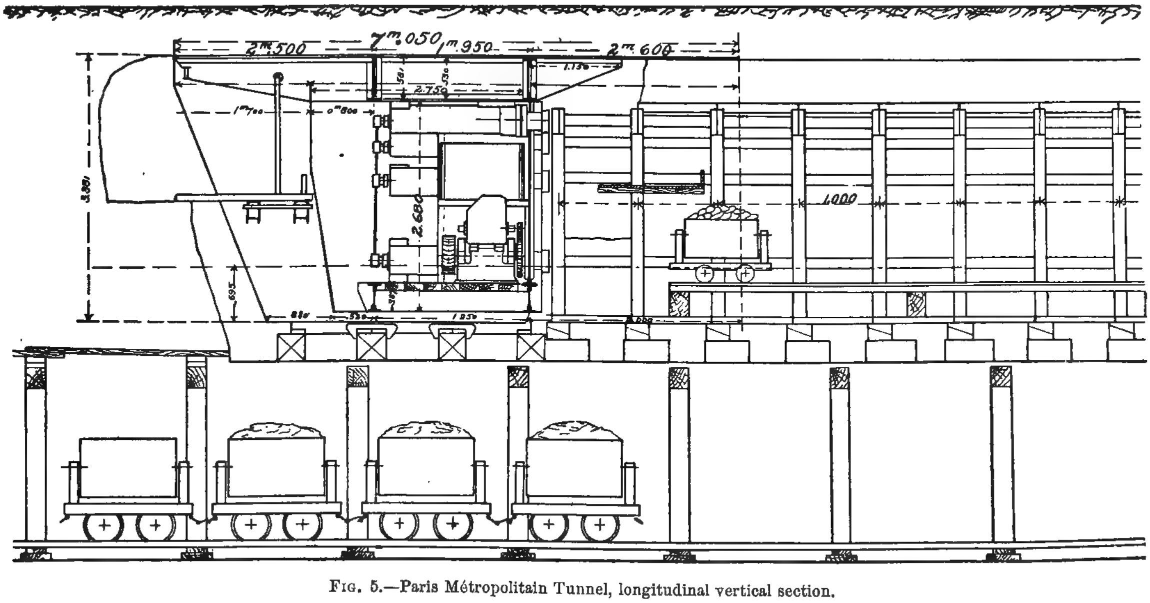

Fig. 5.—Paris Métropolitain Tunnel, longitudinal vertical section.

interior diameter, were constructed mostly in clay and without the use of compressed air, except for a comparatively short distance through water-bearing gravel. In this gravel a timber heading was made, through which the shield was pushed. The reported total cost was £840,000. Among the tunnels constructed after the City and South London work was well advanced, lined with cast-iron segments, and constructed by means of annular shields and the use of compressed air, were a further extension of the Hudson River tunnel, through silt, 2000 feet, between 1888 and 1891, when work again stopped for lack of funds; the St Clair, from Sarnia to Port Huron, 1889–90, through clay, and for a short distance through water-bearing gravel, 6000 feet, 18 feet internal diameter; and the notable Blackwall tunnel under the Thames, through clay and several hundred feet of water-saturated gravel, 1892–97, about 3116 feet long, 24 feet 3 inches in internal diameter; the shield, 19 feet 6 inches long, contained a bulkhead with movable shutters and other important features foreshadowed in Baker's proposed shield (see *Ency. Brit.* vol. xxiii. p. 625). Numerous tunnels of small diameter have been similarly constructed in London and Glasgow for electric and cable ways, &c., one under the Mersey above Liverpool for water-pipes, one under the East River in New York for gas-pipes, several for sewers in Melbourne, and two under the Seine at Paris for sewer siphons. Shields about 23 feet diameter were used in constructing stations on the Central London railway, and one 32 feet 4 inches in diameter and only 9 feet 3 inches long on the Clapham extension of the City and South London railway.

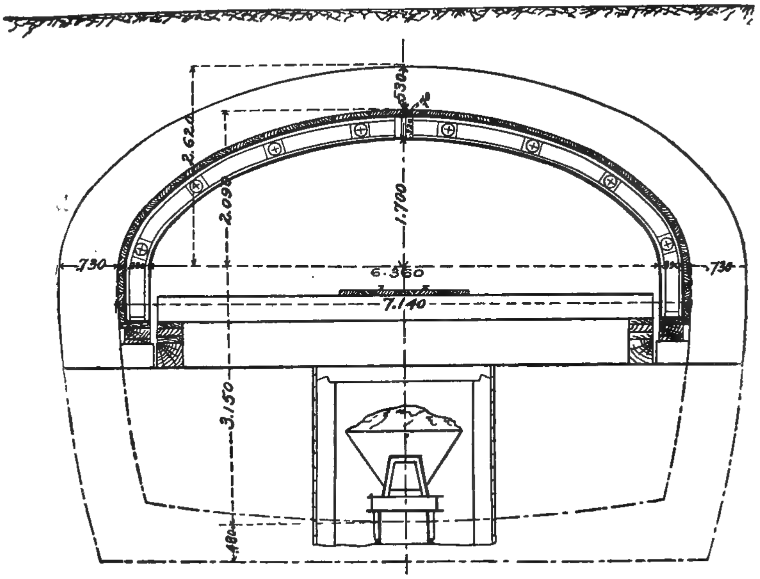

Fig. 6.—Paris Métropolitain Tunnel, section through centres.

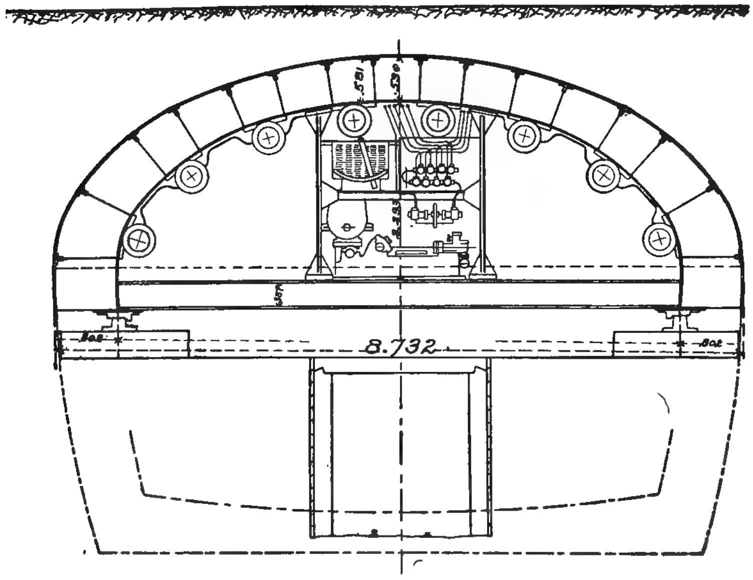

Fig. 7.—Paris Métropolitain Tunnel, section through shield.

Soft ground masonry tunnels.

The Baltimore (U.S.A.) Belt railroad tunnel under Howard Street, about 1·4 mile in length, for a double-track railway, through sand and clay, was built mostly by the crown-bar method of timbering, in 1890–93; it is notable on account of an attempt to tunnel by means of a roof-shield running on side-walls previously made. In 1896 this method with a roof-shield (exterior diameter 29 feet 4 inches) was successfully used on a portion of the Boston subway on Tremont Street. Each hydraulic press of the shield reacted against a small continuous cast-iron rod imbedded in the brick arch. Among the important masonry tunnels built in Paris by the aid of roof-shields are: the Collecteur de Clichy (extra-mural), 1896–97, about 1·1 mile long, 6 metres wide, 5 metres high; the prolongation of the Orléans railway under the quays south of the Seine, between the Austerlitz station and the Quai d'Orsay, in 1898–99, interior width 8 to 9 metres, with a height of about 5 metres above the rail; and a portion of the Métropolitain railway system from the Porte de Vincennes to the Porte Maillot, with branches, 1898–1900, 7·1 metres wide, 5·2 metres high inside. In the Orléans tunnel the shields moved on side-walls previously constructed, as in Boston. In the other two they moved on timber platforms with steel rails, the under portions of the tunnels being made by underpinning. In all the shields were pushed from the strongly-braced ribs of the masonry centres. The Thirty-ninth Street sewerage tunnel in Chicago, through clay and quicksand, about 2 miles long, has an internal diameter of 20 feet. The shields are pushed from a wall 8 inches thick of oak plank surrounding the brick walls (18 inches thick) of the sewer. The East Boston tunnel, the first example of a shield-built monolithic concrete arch, from the Boston subway under the harbour to East Boston, is 1·4 mile long, of which 1 mile is to be excavated (begun October 1900) by tunnelling with roof-shields about 29 feet wide and 12 feet 6 inches long through clay containing some pockets of sand and gravel. Some 23 miles of water-works brick-lined tunnels have been built since 1864 in clay under the Great Lakes, without the use of shields, but the more recent ones with the use of compressed air. The latest Cleveland tunnel, 9 feet interior diameter, was built at the rate of 17 feet per day, and cost about $18 per foot.

See latest editions of Simm's and of Drinker's *Tunnelling;* Paris editions of Legouëz and of Philippe on *Le Bouclier;* 4th and 7th *Annual Reports Boston Transit Commission.*

(H. A. C.)

Tunstall, a market town and railway station, in the North-Western parliamentary division of Staffordshire, England, 4 miles north-west of Stoke. The Victoria Institute was erected at a cost of £15,000, and in 1891 a public free library was accommodated in the institute buildings. Public baths were opened in 1890, and a drill hall was built in 1895. There are many collieries, ironworks, and potteries in the immediate neighbourhood. Population (1891), 17,112; (1901), 19,492.

Tupper, Sir Charles, Bart. (1821-——), British colonial statesman, son of the Rev. Charles Tupper, D.D., was born at Amherst, Nova Scotia, on 2nd July 1821, and was educated at Horton Academy. He afterwards studied for the medical profession at Edinburgh University, where he received the diplomas of M.D. and L.R.C.S. In 1855 he was returned to the Nova Scotia Assembly for Cumberland county. In 1862 he was appointed, by Act of Parliament, governor of Dalhousie College, Halifax; and from 1867 till 1870 he was president of the Canadian Medical Association. Mr Tupper was a member of the Executive Council and provincial secretary of Nova Scotia from 1857 to 1860, and from 1863 to 1867. He became prime minister of Nova Scotia in 1864, and held that office until the Union Act came into force on 1st July 1867, when his Government retired. He was a delegate to Great Britain on public business from the Nova Scotia Government in 1858 and 1865, and from the Dominion Government in March 1868. Mr Tupper was leader of the delegation from Nova Scotia to the Union Conference at Charlottetown in 1864, and to that of Quebec during the same year; and to the final Colonial Conference in London, which assembled to complete the terms of union, in 1866–67. On that occasion he received a patent of rank and precedence from Queen Victoria as an executive councillor of Nova Scotia. He was sworn a member of the Privy Council of Canada, June 1870, and was president of that body from that date until 1st July 1872, when he was appointed Minister of Inland Revenue. This office he held until February 1873, when he became Minister of Customs. His colleague, Sir John A. Macdonald, the first premier of the Dominion House of Commons, resigned at the close of 1873, and Mr Tupper retired with him; but on Sir John's return to power in 1878, Mr Tupper became Minister of Public Works, and in the following year Minister of Railways and Canals. At this time he was made K.C.M.G. Mr Tupper was the author of the Public Schools Act of Nova Scotia, and had been largely instrumental in moulding the Dominion Confederation Bill and other important measures. Sir Charles represented the county of Cumberland, Nova Scotia, for thirty-two years in succession—first in the Nova Scotia Assembly, and subsequently in the Dominion Parliament until 1884, when he resigned his seat on being appointed High Commissioner for Canada in London. He was appointed by the Dominion Government Executive Commissioner for Canada to the Antwerp Exhibition of 1885 and the Colonial and Indian Exhibition of 1886, of which also he was appointed Royal Commissioner by Queen Victoria. Shortly before the Canadian Federal elections of February 1887, Sir Charles re-entered the Conservative cabinet as Finance Minister. By his efforts the Canadian Pacific railway was enabled to float a loan of $30,000,000, on the strength of which the line was finished several years before the expiration of the contract time. He resigned the office of Finance Minister in May 1888, when he was reappointed High Commissioner for the Dominion of Canada in London. Sir Charles was designated one of the plenipotentiaries of her Majesty Queen Victoria to the Fisheries Convention at Washington in 1887, the result of which conference was the signing of a treaty in February 1888—subject to ratification—for the settlement of the matters in dispute between Canada and the United States in connexion with the Atlantic fisheries. He was created a baronet in September 1888. When the Dominion cabinet, under Sir Mackenzie Bowell, was reconstituted in January 1896 Sir Charles Tupper accepted office, and in the following April he succeeded Bowell in the premiership. On both patriotic and commercial grounds he urged the adoption of a preferential tariff with Great Britain and the sister colonies. At the general election in the ensuing June the Conservatives were severely defeated, chiefly on the question of the Manitoba Roman Catholic schools, and Sir Charles Tupper and his colleagues resigned, Sir Wilfrid Laurier becoming premier. The Conservative party now gradually became more and more disorganized, and at the next general election, in November 1900, they were again defeated. Sir Charles Tupper, who had long been the Conservative leader, sustained in his own constituency of Cape Breton his first defeat in forty years.

Tupper, Martin Farquhar (1810–1889), English writer, the author of *Proverbial Philosophy*, was born in London, 17th July 1810, being the son of Martin Tupper, a distinguished medical practitioner, who came of an old Huguenot family, another branch of which settled in the United States. He was educated at Charterhouse and Christ Church, Oxford, where he gained a prize for a theological essay, Gladstone being second to him. He was called to the bar at Lincoln's Inn, but never practised. He began a long career of authorship in 1832 with *Sacra Poesis*, and in 1838 he published *Geraldine, and other Poems*, and for fifty years was fertile in producing both verse and prose; but his name is indissolubly connected with his long series of didactic moralizings in blank verse, the *Proverbial Philosophy* (1838–67), which for about twenty-five years enjoyed an extraordinary popularity that has ever since been the cause of persistent satire on the part of literary critics. The first part was, however, a comparative failure, and N. P. Willis, the American author, took it to be a forgotten work of the 17th century. The uninspired character of Tupper's poetry is indubitable, and the critics who have made his name a butt were so far justified; but the *Proverbial Philosophy*, though now unread, was full of a perfectly genuine moral and religious feeling and frequently of apt and striking expressions, together with an easy flow of language, which accounted quite naturally for its success among readers to whom the subtleties of a higher order of poetry would never appeal. A genial, warm-hearted man, Tupper's humane instincts were generally in the right direction, and he espoused many reforming movements which deserved and obtained success. He was a patriotic Briton, an early supporter of the Volunteer movement, and did much to promote good relations with America. He was also a mechanical inventor in a small way. In 1886 he published *My Life as an Author;* and on 29th November 1889 he died at Albury, Surrey.

Turbines, Steam. See Engines: *Steam.*

Turgai, a province of Russian Central Asia, formerly part of the Kirghiz Steppes, now one of the four provinces of the general-governorship of the Steppes, bounded by Uralsk and Orenburg on the W. and N., Akmolinsk on the E., and Syr-darinsk and the Sea of Aral on the S. It has an area of 176,219 square miles, and its population, which was estimated at 323,110 in 1882, was 453,123 (domiciled only) in 1897, of whom 215,511 were women, and only 19,527 lived in towns. The population is still mainly composed of Kirghiz, but Russians have immigrated in large numbers, and they were estimated at 21,600 in 1890 and about 30,000 in 1897. The province is divided into four districts, the chief towns of which are Turgai (1180), which is also the capital of the province, and stands off the caravan road from Tashkend to Orsk, Ak-tube (2840), a fort, in the district of Iletsk, Irghiz (1536), and Kustanai (14,065), in the Nikolaievsk district, a prairie town which has grown with great rapidity. Agriculture is mainly carried on by the Russian settlers in the Nikolaievsk district, where the crops (chiefly wheat and oats) do not suffer so much from droughts as they do elsewhere. But the Kirghiz are also beginning to cultivate the soil, and in 1900 there were in all 612,200 acres under cereals. The average yield in 1895–99 was: rye, 19,800 cwt.; wheat, 933,000 cwt.; oats, 226,000 cwt.; barley, 22,000 cwt.; all cereals, 1,115,000 cwt.; also 22,000 cwt. of potatoes. Cattle-breeding is the leading occupation of the Kirghiz, and in 1896 there were in the province 682,000 horses, 332,000 horned cattle, 1,605,000 sheep, about 128,000 goats, and 149,000 camels, these last being kept by the nomads both for their own personal use in moving about from place to place and for the transport of goods between Bokhara, Khiva, and Russian Turkestan. Cattle-breeding, however, suffers greatly from the snow-storms, which destroyed in 1879–80, 42 per cent. of all the herds, and in 1890–91, 48 per cent. of the horses, one-third of the horned cattle, sheep, and goats, and 22 per cent. of the camels. Considerable quantities of cattle and various animal products are exported to Orenburg, Orsk, and Troitsk, and to Ust-Ui and Zverinogolovsk, where large fairs are held. Hunting continues to keep its importance. There are a few oil-works, tanneries, and flour-mills, and among the Kirghiz the making of carpets and felt goods is widely spread. Education is a little more advanced than in the other Steppe provinces; the system of "migratory schools" has been introduced for the Kirghiz.

See YA. TALFEROFF, *The Turgai Province*, 1896; DOBROSMYELOFF, *Cattle-breeding in Turgai*, 1895 (both Russian).
(P. A. K.)

Turin, a city of northern Italy, formerly capital of Piedmont and the Sardinian states, and of Italy until the removal of the seat of government to Florence in 1865. It is now capital of the province of the same name, and headquarters for the first Italian army corps. Its geographical position is excellent: built upon alluvial soil at a short distance from the Alps, it stands upon two rivers, the Dora to the north, running from west to east, and the Po to the west, running from south to north. The area of the city is 4155 acres, and its octroi circle measures nearly 9 miles. The streets and avenues, almost all of which are straight, cut each other at right angles, forming blocks of houses called "islands." In 1899 the population numbered 366,055, including the garrison 8500 strong. The marriage returns show that only 3 per cent. of the population are unable to read or write. The birth-rate is 21·7 and the death-rate 17·57 per thousand. The average length of life is 45 years.

For administrative purposes the city is divided into two municipal police sections and into seven government districts or *mandamenti*. The military organization is proportionate in importance to the strategical position of Turin near the French frontier. There is a military arsenal with laboratories, a military academy for artillery and engineer officers, a war school, and a military hospital. Important new churches built since 1870 are: Santa Maria Ansiliatrice and San Giovanni Evangelista, both the work of the Salesian Order, founded by Dom Bosco; San Gioacchino; the Sacro Cuor di Maria, in which is preserved one of the *chefs-d'œuvre* of modern Italian sculpture, "Christ on the Cross," by Pietro Canonica; Nostro Signore della Salute, still unfinished. The finest theatres are the Reggio and the Carignano, but several minor ones exist. Four public arcades have been built, namely, the Galleria Geisser, the Galleria Subalpina, the Galleria Nazionale, and the Galleria Umberto I.; the three former in the centre of the city, and the latter in the working-class quarter of Porta Palazzo. The Po is spanned by four bridges, and the Dora by six. The principal public monuments are those to Cavour (by Dupré), to Carlo Alberto and Emanuele Filiberto (by Marochetti), to the Duke of Genoa (by Balzico), to Garibaldi (by Tabacchi), to Lamarmora (by Grimaldi), to Manin (by Vela), to Victor Emmanuel II. (by Pietro Costa). An equestrian monument to Prince Amadeus of Savoy (by Calandra) was inaugurated in May 1902. It is one of the most successful pieces of modern Italian statuary. Other important monuments are those commemorative of the Mont Cenis tunnel, and the magnificent "Standard-bearer" (by Vela) in honour of the Sardinian army. The Mole Antonelliana, built by Alessandro Antonelli, is the most important example of modern architecture in Turin. It belongs to the municipality, and is used for the Risorgimento Museum. It is the highest brick edifice in Europe, its summit being 510 feet above ground. In addition to the Royal Albertine Academy, the Turin museums and galleries include the Royal Pinacoteca, containing important works of the Piedmontese schools and Vandyck's famous picture, "The Sons of Charles I."; the Museum of Antiquities, notable for its collection of Egyptian antiquities; the Civic Museum, divided into two sections of fine arts and art applied to industry; the royal armoury, one of the most complete in Europe; the museums of zoology, geology, and mineralogy; and the museum of artillery. There are several libraries, including the national, the civic, and the royal, the latter containing a collection of 40,000 medals and coins. The Turin Observatory is situated in the Palazzo Madama, formerly the seat of the Italian Senate. In regard to education Turin holds one of the first places in Italy. Its university, attended by 2700 students, comprises all the faculties. New and splendid buildings, erected in the Valentino Gardens, include the university buildings proper, physical, chemical, anatomical, and pathological laboratories. Turin possesses, besides a school of practical engineering, an industrial museum, a school of veterinary medicine, a free school of agriculture, a botanical garden, numerous hospitals, a psychiatrical institute, an obstetrical institute, a laboratory of political economy, three lyceums, six gymnasiums, a technical institute, and six technical schools, one of which is for women. The municipal elementary schools count 701 classes with 30,000 pupils. There are 40 infant asylums. Four daily political newspapers are published in Turin, besides 130 periodicals of various kinds. Musical education is cared for by the Liceo Musicale, while fine arts and annual art exhibitions are promoted by a special society and by the Artists' Club. Sport and athletics are furthered by several cycling clubs with two velodromes, an automobile club, a zootechnical society, and a racing society; a ground for the game of pallone; a skating rink, two lawn-tennis clubs, a large rifle range, several athletic clubs, including an Alpine Club which, founded in Turin, has spread throughout Italy; a rowing club and several canoe clubs, which organize frequent regattas on the Po. There are more than twenty lines of electric trams worked by two companies. The total length of tramway lines is about 53 miles. Nine lines of steam tramway start from the city, their length within the octroi circle being 11 miles.

The industries comprise metallurgy, machine-making, chemicals, silk and cotton weaving, tanning, and leather-working. The application of electricity is widely developed on account of the proximity of Alpine valleys rich in torrents. The number of persons employed in industries is 26,171, of whom 23,147 are adults (17,132 men and 6015 women), and 3024 minors (2487 males and 537 females).

Among the hospitals is that called by the name of its founder, Cottolengo, a vast institution providing for more than 5000 persons; there are also the Ospedale Maggiore di San Giovanni, the Ospedale Mauriziano, and many other hospitals for special diseases, as well as asylums and charitable institutions of all kinds. Few Italian cities are so well provided as Turin with institutions for the needy and afflicted. In regard to sanitation, Turin has reconstructed the old quarters in order to admit light and air to the most densely-populated parts, and is completing its sewers on the most modern systems. An artificial ice company has provided the city with meat storage rooms, a necessity of warm climates; the supply of drinking water, furnished by two aqueducts, is being increased by the addition of a third. The municipal budget for the year 1900 balanced with the revenue and expenditure of 14,164,803 lire. The principal sources of revenue are direct taxes and the octroi, which together produce more than 10,000,000 lire. Revenues derived from municipal properties and from municipal services yield 1,500,000 lire. Expenditure comprises 2,469,680 lire of general outlay, 2,354,000 lire for police and sanitation, 3,157,944 lire for public works, 1,786,940 lire of interest on the municipal debt, 854,710 lire of sinking fund, 2,643,895 lire for education, and 425,712 lire for worship and charity. Municipal properties are valued at 34,482,098 lire as against a debt of 33,150,771 lire, including 24,000,000 lire consolidated debt.

Though the opening of the St Gothard tunnel exercised a prejudicial influence upon the traffic of the network of railways of which Turin is the centre, by diminishing trade with France, the new agreement with the St Gothard railway and the opening of the Simplon tunnel will compensate these disadvantages. Trade has been facilitated by the opening of telephonic communication with Novara, Milan, Como, and Pinerolo. Similar communication has lately been opened with Rome, Modane, Lyons, Paris, and with the chief Swiss towns. Within the last twenty-five years of the 19th century, the activity of the Turinese succeeded in neutralizing the effect of the transfer of the capital to Florence and Rome. Since 1864 its population has nearly doubled, and the city, in virtue of its transformation into an active centre of trade and industry, has become eminently modern and progressive.

Among the surroundings of Turin the Hill of Superga (2300 feet above the sea) merits special mention. Victor Amadeus II. erected there a votive basilica in memory of the liberation of Turin from the French in 1706. King Charles Albert and other kings and princes of the Savoy dynasty are buried in the crypt. Not far from Turin are also the castles of Moncalieri, Stupinigi, Rivoli, Racconigi, Aglè, Venaria, and the ancient monastery of the Sagra di San Michele (753 metres above sea-level). The last named is interesting archæologically, and famous for its view of the Alps as far as the beginning of the Lombard plain. (A. FE.)

Turkestan, a geographical term for a vast region in Central Asia, which, after excluding from it the Chinese province of Kulja and the Turkestan khanates of Afghanistan, may conveniently be divided into (I.) Western Turkestan, and (II.) Eastern or Chinese Turkestan.

I. WESTERN TURKESTAN.

This country as a whole was fully described in the corresponding section of the article on TURKESTAN in the ninth edition of this work, and all that is now required is an account of the economic conditions of the various political divisions. These are:—(1) the vassal states of Bokhara and Khiva; the Russian provinces of (2) Turgai, Akmolinsk, and Semipalatinsk, forming part of the general-governorship of the Steppes; (3) Semiryechensk, Syr-dariinsk, Samarkand, and Fergana, composing the general-governorship of Turkestan; and (4) the Transcaspian region. These are all treated under their respective headings, and those provinces which are included in the general-governorship of the Steppes are dealt with collectively under that head. Consequently it is only necessary here to deal collectively with the provinces comprised in the general-governorship of Turkestan. The following table shows the area and population of these at the census of 1897. It should be noted that Syr-dariinsk includes the Amu-daria district, which was formerly a separate province.

Province.	Area, Square Miles.	Domiciled Population, 1897.	Density per square Mile.
Samarkand . .	26,627	857,817	32
Fergana . . .	35,654	1,560,411	43
Semiryechensk . .	152,280	990,107	7
Syr-dariinsk . .	194,853	1,479,848	7
Total . .	409,414	4,888,183	12

Notwithstanding immigration, the Russians still constitute a very small proportion of the population, except in the province of Semiryechensk, where the Cossacks, the peasants, and the artisans in towns number 130,000, and, with 10,911 Russian troops, constitute 14 per cent. of the aggregate population. The only other province containing any considerable number of Russians at all is Syr-dariinsk, where there are about 10,000 Russian settlers (less than 1 per cent. of the population). About 12,000 Russians are settled in Bokhara and about 4000 in Khiva.

There are several populous cities in Russian Turkestan. Its capital, Tashkend, in the Syr-daria province, had 156,414 inhabitants in 1897, and other cities of importance are Samarkand (54,900) in Zerafshan, Marghilan (36,592 in Old Marghilan, and 8977 in New Marghilan) in Fergana, Khojent (30,076) in Syr-daria, Kokand (82,054), Namangan (61,906), and Andijan (46,680) in Fergana.

Education.—In the way of education nearly everything has still to be done. In 1899, of middle schools, there were only four gymnasia and pro-gymnasia for boys and six for girls (346 pupils), one *real* school (50 pupils), two girls' schools of the Institution of the Empress Marie (207 pupils), one corps of cadets, and one teachers' seminarium (148 pupils). Of primary schools there were 105, with 4305 pupils in the Russian schools, and about 95,000 pupils in 6400 Mussulman schools. A technical school and an experimental agricultural station with a school have been opened at Tashkend.

Pursuits.—Agriculture and horticulture are the main pursuits of the settled population, while the nomad Kirghiz are chiefly engaged in cattle-breeding. Both agriculture and horticulture are conducted in an excellent manner and with good results.

The only statistics available showing the area cultivated and the yield per annum are those for Semiryechensk. However, approximate estimates for the crops of 1888–89 in the four Turkestan provinces are:—rye, 136,000 cwt.; winter wheat, 6,714,000 cwt.; spring wheat, 7,534,000 cwt.; oats, 1,138,000 cwt.; millet, 2,570,000 cwt.; rice, 4,124,000 cwt. About 2,500,000 cwt. of "jugara" and some Indian corn must be added. Grain is consequently exported to Bokhara and Khiva, while the Transcaspian region has to import it. Considerable quantities of melons and all sorts of vegetables, as also various sorts of haricots and oleaginous seeds, are grown by the natives; also the sunflower and the poppy (for oil) by the Russians. Garden culture stands at a high level. Since the Russian occupation progress has been made in certain branches of agriculture, notably in cotton-growing; but though efforts are being put forth to extend the area irrigated, and though ambitious schemes have been drawn up for the irrigation of the Famine Steppe, some Russian authorities consider that the native system of irrigation, taking in an area of some 3,982,000 acres, is not so well maintained now as before the advent of the Russians. The improved results obtained in cotton-growing have been chiefly brought about by the introduction of the American cotton-tree. At the same time a much larger area has been planted: whereas in 1883 only some 1300 acres were under cotton, in 1901 the trees covered nearly 719,500 acres. In 1900 the crop yielded 1,083,000 cwt. in Fergana alone, and over 1,590,000 cwt. in the four provinces, besides 2,882,000 cwt. in Khiva and 1,451,000 cwt. in Bokhara; over 800,000 cwt. of dressed cotton was obtained in 1899, of which from 500,000 cwt. to 700,000 cwt. was exported. Twenty-four steam cotton-dressing works are now in operation, and ninety in which water is the motive power. Wheat and rice of better quality are now grown. Perhaps the most characteristic feature of Turkestan agriculture is the variety of crops grown other than cereals and fodder plants. Kunjut (for oil), lucerne, madder, tobacco, rice, melons, water-melons, cucumbers, onions, and fruit-trees—chiefly the apricot, plum, pistachio, mulberry, nut, and pomegranate—are all widely cultivated, and fruit and vegetables eaten with bread form a substantial part of the food of the population. Successful attempts have also been made to introduce beetroot for the making of sugar. Sericulture was formerly a very important industry, but about 1885 the silk-worms were attacked by disease, and the production of silk almost ceased. The industry is beginning to revive, and it is estimated that some 30,000 cwt. of raw cocoons are obtained annually. The vine, which was formerly grown only for its fruit (130,000 cwt. of currants, 600,000 roubles' worth, are exported annually), is being cultivated for wine also, of which about 270,000 gallons are obtained annually. Cattle-breeding is extensively carried on, and the estimates for 1898–99 give 548,000 camels, 1,581,000 horses, 78,000 donkeys, 1,571,000 horned cattle, and over 11,500,000 sheep and goats, to which 1,000,000 horses, 300,000 camels, 700,000 cattle, and 7,000,000 sheep in Bokhara must be added. Nothing has been done to develop the not inconsiderable mineral resources of Turkestan. In 1899 some naphtha and about 30,000 cwt. of asphalt were obtained in Fergana, besides some 6000 tons of coal, chiefly in Samarkand, and small quantities of gold, copper ores, and sulphur. About 600,000 cwt. of salt were raised in Turkestan and Transcaspian in 1899.

Railways.—The Transcaspian railway now connects Turkestan with Krasnovodsk on the Caspian Sea. Its length *viâ* Merv, Charjui on the Amu, and Bokhara to Samarkand, is 938 miles. This line has been continued to Kokan, New Marghilan, and Andijan, 328 miles, with a branch from Chermyaevo station to Tashkend, 94 miles. A line from Tashkend to Orenburg, *viâ* Perovsk, Kazalinsk, and Irghiz, is now under construction. The Transcaspian railway is of great importance to Turkestan, being the main artery for the export of raw cotton and animal products and the import of manufactured goods.

II. Eastern Turkestan.

Several explorations were made in this territory during the years 1886–92, by the Russian expeditions of Pyevtsoff, Roborovski, and Kosloff (the travelling companions of Prjevalsky, who continued his epoch-making work), the brothers Grum-Grzimailo, and the geologists Bogdanovitch and Obrucheff; Captain Younghusband, Carey, M. S. Bell, and M. A. Stein; the Swedish explorer Sven Hedin; Dutreuil de Rhyns, Bonvalot, Futterer, and several others. Owing to its position on the way to the yet unexplored plateaus of Tibet and the upper courses of the Yellow and the Blue rivers, East Turkestan has been crossed over and over again by numerous expeditions. We have accurate maps of all the inhabited parts of this territory, which was a *terra incognita* when Prjevalsky began his memorable journeys;[1] and rich collections of both the flora and the fauna of East Turkestan are now found in all the chief museums of Europe. These explorations do not alter the conceptions concerning the orography and the leading topographical features of the country. Only partial additions are consequently needed to the description given in the earlier volumes of this Encyclopædia.

Administration.—East Turkestan is now part of the Chinese province of Hsin-kiang, which comprises also the eastern Tian-shan and a portion of Dzungaria, the Bei-shan and a portion of the Nan-shan highlands, and also a strip of land on the Tibet plateau along its northern border range, including the Ayak-kum and Atjiklanes. According to G. Grum-Grzimailo, East Turkestan comprises three different *dao-tais*—the *dao-tai* of Kashgar (districts: Kashgar, Yarkand, and Khotan); of Aksu (districts, Aksu, Kucha, and Kurla-Karashar); and of Urumchi (districts: Turfan and Hami). The residence of the governor-general of the whole province is at Urumchi, and its chief towns are Kashgar (from 60,000 to 70,000 inhabitants), Yarkand (60,000), Khotan, Niya, Sa-chou; Aksu, Urumchi, Khotan, Uch-Turfan, Kunya Turfan (about 15,000 to 20,000 in the two towns, Chinese and Turkish, of this name), Kucha, Karashar, Hami, and Barkul.

Physical Features.—Both the natural and the administrative limits of East Turkestan are pretty well defined by the mountains which surround it—namely, by the western and the eastern Tian-shan in the north, the eastern border-ranges of the Pamir on the west, and the succession of border ranges of the Tibet plateau which are comprised under the rather misleading name of Kuen-lun. On the east, East Turkestan is separated from the Gobi by the Bei-shan or Pe-shan—a slightly higher terrace of the plateau which joins the Hami extremity of eastern Tian-shan to the eastern extremity of the Altyn-tagh, and the Nan-shan. This terrace has an average altitude of about 4500 feet, and is intersected by a series of parallel ranges which run east-north-east, have their base on the plateau, and reach a height of from 5500 to 7400 feet. Broad longitudinal valleys, covered with gravel and partly with the red "Gobi deposits," run between these low chains of ragged mountains, which consist of granites and crystalline rocks belonging to the Palæozoic period. Two routes leading from Hami to the Chinese town Sa-chou cross the Bei-shan, and as they are better provided with water than the more western routes, they are taken in preference to the latter.

Hashun Gobi.—The eastern portion of East Turkestan, between the Bei-shan and the Tarim river, is occupied by the Hashun (or Gashun) Gobi, or Ilkhuma—a desert which has all the characteristics of the Gobi (see Mongolia). It has been crossed by several expeditions, and consists apparently of two distinct parts—a dry and stony rolling desert, about 4000 feet high, intersected by parallel ranges of hills in the north; and a slightly lower portion in the south, separated from the former by the Kuruk-tagh escarpment. This latter portion comprises the Lob-nor and the Kum-tagh deserts, 2500 to 3500 feet high, and is covered with sand, especially in the neighbourhood of the Chinese town Sa-chou (on the Tan-ho or Dañ-ho river). We have here evidently a strip of land running from the Lob-nor eastwards, between the northern foot of the Altyn-tagh escarpment and the low escarpment of Kuruk-tagh. The lowest portion of his land-strip is in the Khalachi, or Kara-nor, marshes, north of Sa-chou, and represents the remains of what formerly was a large lake, where now the Tan-ho (or Dañ-ho) and the Su-li-ho (or Bulundsir) rivers are lost.

East Turkestan Proper.—As to East Turkestan proper—*i.e.*, the trapezoidal plateau, 3000 to 4000 feet high, which stretches from the Tian-shan to the Altyn-tagh, and from the Pamir to the Hashun Gobi, and which is watered by the Yarkand-daria (or Tarim) and its tributaries—recent exploration has only confirmed the conception of it which was established by its first explorers, namely, that of a dreadful desert, the Takhla-makan, surrounded by a girdle of loosely-connected oases, which are disposed at the foot of the surrounding mountains. The numerous expeditions which have travelled along "the southern route"—that is, from Kashgar *viâ* Yarkand, the Khotan (Ilchi), Keriya, Niya, and Cherchen oases, and Lob-nor to Sa-chou—have fully disclosed the border-ridge character of the mountains which fringe the Tibet plateau from the north (see KUEN-LUN). At their western extremity these mountains join the system of parallel mountain ranges which are described under various names (Chung-kyr, Kilian, Kaskem, Sarikol ranges), and run in a south-east to north-west or "Himalayan" direction, fringing the Pamirs, and containing the Mustaghata peak (25,800 feet) so as to join farther on the Ulug-art range of the Tian-shan. It may be that—as the uplifting of the Himalaya took place at a relatively recent geological period—traces of a gulf of a Secondary period sea, obliterated by subsequent upheavals, will be found penetrating from the south into East Turkestan, and reaching perhaps by its head the corner formed by the Pamir and the Tibet border ranges about Yarkand. However, no traces of such an invasion of the sea during the Secondary age have been found as yet. It is now fully proved by the Russian explorers that the fossils which were found by Stoliczka in the Turug-art pass near Kashgar, and which he had described on the spot as Triassic, belonged in reality to the Devonian formation. Some doubt prevails, consequently, as regards the "chalk gryphæa" mentioned as having been found near Yanghi-hissar. On the contrary, distinct Carboniferous deposits have been found by Bogdanovitch in the south-western corner of Kashgaria, as well as in the Tibet border ranges west of Khotan. As to the supposed "Mesozoic and Tertiary transgressions" of which so much was written since Richthofen's journey—the sea being supposed to have invaded East Turkestan and the Gobi during the Secondary and the Tertiary periods—no traces whatever of these theoretical transgressions have been found in East Turkestan any more than they have been found in the Gobi (see MONGOLIA). The red marls, sandstones, and often unstratified or loosely stratified conglomerates, or gravels, which are found in the deserts of East Turkestan as well as of the Gobi, must have, in all probability, a *continental* origin, and they were deposited either during the Glacial period or in Post-Tertiary lakes.

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[1] The best small-scale map (1:7,500,000) is that issued in 1902 in Stieler's *Hand Atlas*, 62, by B. Domann, the orography being admirably represented.

The "northern route"—which leads through the succession of oases situated at the southern foot of the western Tian-shan (Kashgar, Uch-Turfan, Aksu, Bai, and Kucha), and the eastern Tian-shan (Korla, Karashar, with Lake Bagrach-kul, Kunya, Turfan, Lukchun, Pichan, and Hami)—has been equally well explored, as well as the mountains to the north of it. It is now known that in western Tian-shan the Kokshal-tau range (Tian-shan range on some Russian maps), which on the south-east borders the Tian-shan plateaus, or *syrts*, and faces the plains of East Turkestan, runs due south-west, from the snow-clad Khan Tengri (24,000 feet) to the passes Bedel and Terek-davan. This mighty range gives origin to large glaciers on both its north-western and south-western slopes (Semenoff's Mushketoff's, the group Inylchek on the former, and Savabtsi and Djaparlyk on the latter); and it has the parallel ranges of Boz-tagh on the south-east and Kirghiznyn-Alatau on the north-west.[1]

Eastern Tian-shan.—As to the eastern Tian-shan, its complicated structure is not yet quite clear. It seems that in its western portion, from Peak Khan Tengri to the meridian of Urumchi, it is a mere continuation of the western Tian-shan ranges and *syrts* (high plateaus). The Terskei and the Narat mountains have, indeed, a north-easterly direction. However, about Urumchi they meet with the Boro-khoro (or Iren-kabirga) mountains which come from the west-north-west, running from Kopal to Lake Bagratch-kul (with the small parallel range Kök-tekke farther south). These mountains evidently belong to a different, perhaps more recent, system of upheavals. The Barkul mountains, at the eastern extremity of the eastern Tian-shan, have the same direction—they run west-north-west to east-south-east, and are continued farther east by a range of low hills which join the extremity of the Chinese Altai. As to the intermediate space, from Urumchi to Barkul, it is occupied by the Bogdo-ola mountains, which represent a massive upheaval composed in all probability of several chains of mountains. Granites, various crystalline slates, and fossil-bearing deposits of the Palæozoic age enter into the composition of the eastern Tian-shan. Its peaks are snow-clad, and on the Bogdo-ola group, in the north of Lukchun, the snow-line lies at a height of 12,800 feet, while the passes are from 11,500 feet (Davanchin Pass near Urumchi) to 9000 feet (opposite Hami). On both its slopes the eastern Tian-shan falls as a very stately escarpment to the plateau above which it rises. On its northern slope, in Dzungaria, the altitudes of the plains are 2400 feet at Gu-chen, 3100 feet at Urumchi, and 5000 feet at Barkul; and at the southern base we find altitudes of from 2500 to 2800 feet.

Depressions.—A very interesting depression, from 50 to 100 miles wide, covered with loess, gravel, salted clays, and occasionally marshes, runs along the southern foot of the eastern Tian-shan. Its level—3000 feet in the west and 2700 in the east—is slightly below the general level of both the Takhla-makan desert and the Hashun Gobi, whose average altitudes are from 3300 to 4000 feet. It is watered in its western portion by the Yarkand-daria, while its eastern portion was formerly drained by a river that has since dried up; and it appears altogether very probable that this depression was occupied in Post-Pliocene times by an immense lake.

Lukchun.—Another still deeper depression is found in the very heart, so to say, of the eastern Tian-shan, between these mountains and the escarpment which is known as the Chol-tagh. We see here that the 2000 feet level line, very closely followed by the 3000 feet horizontal, encircles a narrow elongated space from 10 to 40 miles wide and 340 miles long, from 88° 30′ E. to 95° E. The Kurukgol river waters it. About Hami, round Shona-nor, the bottom of this depression is only 120 feet above the sea in its lowest part, while at its western extremity, about Lukchun, its bottom sinks to the sea-level, or even below it. The Lukchun depression was discovered in 1889 by the brothers Grum-Grzimailo, and a few months later by the Pyevtsoff expedition. An accurate map of it, with levellings, has been made since by Roborovski, while a meteorological station was established near Lukchun town in 1893, and observations were made there during twenty-four consecutive months.[2] It appears from this map that a lake, Bojante-kul, surrounded by marshes which cover an elliptical space about 45 miles long and 15 miles wide, lies to the west-south-west of Lukchun, and that the surface of this space is either at or below the sea-level, the lowest spot being 370 feet below the level of the observatory. The exact level of this last cannot, of course, be determined, so long as no geometrical levelling has been made; but from a comparison of the twenty-four months' observations of the barometer at Lukchun, it can be inferred that the station was 56 feet below the sea-level, with a possible error of about ± 40 feet. The most striking point is the small size of the depression. Some 30 miles east and west of Lukchun town the altitudes already are from 2500 to 3000 feet;[3] while the mountains a few miles north of Turfan rise to 5720 and 11,500 feet, and the Chol-tagh, a dozen miles south of Lake Bojante, reaches 3500 feet. Obrucheff has shown that a local subsidence of the rocks took place at Lukchun, along a narrow strip parallel to the main direction of the mountains,[4] but the extent of that subsidence not being known, we have no idea as to whether it was not purely local, and whether it would be adequate to explain the formation of the whole of the Lukchun depression, as well as the other much larger depression at the foot of the Tian-shan, whose extent has been already mentioned. Erosion must have been at work, and it is more than probable that not only an immense elongated lake formerly spread at the foot of the eastern Tian-shan, but that other lakes must have existed in its valleys. Ice must have been a powerful excavating agency in these mountains, since during the Glacial age, when the Arctic Sea covered the lowlands of western Siberia, the western Tian-shan mountains were buried under a thick layer of snow. Eastern Tian-shan can hardly have escaped glaciation, and we have, in fact, direct observation to that effect. G. Grum-Grzimailo describes immense boulders of a fine-grained grey granite, 14 to 17 feet high and up to 100 feet in circumference, which he found lying at an altitude of 3200 feet about the mouth of the Gaib gorge which descends from the Karlyk-tagh mountains (12,000 feet) of eastern Tian-shan, in the north-east of Hami. The rocks of this gorge consisted, both at this spot and higher up, of quite a different sort of granite and crystalline slates, and a succession of side moraines was seen along the walls of the gorge.

As to the present climate of the Lukchun depression, which happens to be situated in the very centre of Asia (the meteorological station was in 42° 41′ 57″ N. and 89° 42′ 28″ E.), it is typical for Central Asia: the average temperatures were for the year 56° Fahr.; for January, 17°; for July, 88°. The lowest temperature observed was as low as 4·5° Fahr., and the highest as high as 109·5° (147° in the sun). The summer is thus as hot as in the Sahara, and January as cold as at St Petersburg. The dryness of the air is extreme, and in 1894 and 1895 there were only 22 and 17 rainy days respectively, while during the year the sky was quite cloudless on 147 days.

Antiquities.—The Lukchun depression, which belongs to the Turfan oasis, and lies at the junction of the roads from China and Lob-nor to Dzungaria, is very fertile even now, owing to excellent irrigation. It was inhabited even in the remotest times, and ruins of ancient cities and monasteries abound in it. The exploration by D. Klements of the ruins of some of these monasteries, now buried in sand, has led to the discovery of extremely interesting manuscripts, some of which are written in the Uigur language, and represent partly Buddhist religious texts, or Sanskrit texts in an Uigur transcription, and partly business documents,[1] while others are written in alphabets quite unknown to linguists. Many more important discoveries may be expected when the numerous ruins, dating from the first centuries of our era down to the 13th and even 16th centuries, are explored. The same is true concerning the oases along the Tibet border, where most remarkable discoveries have been made by M. A. Stein.[2] At Dandan-uilig, situated in the Takhla-makan desert, on Hedin's route from the Khotan-daria to the Keriya-daria, fourteen detached temples and dwelling-houses were excavated; and statues, votive offerings, and remarkable al-fresco paintings, as well as most interesting MSS., partly Sanskrit, were discovered. Most important MSS., written in Kharoshthi characters on wooden tablets and on leather, were unearthed, moreover, in the remains of some dwelling-houses on the Niya river.

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[1] See A. Bolsheff's map of the Khan Tengri expedition of 1886, in the Russian *Izvestia*.

[2] *Memoirs* of the expedition to Central Asia of Roborovski in 1893–96, part iii. 1899 (Russian).

[3] At Chektym, 57 miles from Lukchun, 1100 feet; 1770 feet at Lemchjim; and 2810 feet at Hami.

[4] Reproduced in Suess's *Antlitz der Erde*, iii.

Lob-nor.—In addition to what has been said in the ninth edition about the Tarim river, with its tributaries, and Lake Lob-nor (or Lop-nor), it must be noted that the discovery by Sven Hedin of lakes along that part of the Yarkand-daria where it flows south-east and south suggested to him the idea that the real Lob-nor of the Chinese was situated to the north of the great lake (Kara-koshun-kul) which was described as Lob-nor by Prjevalsky.[3] However, this view was not accepted by most geographers, and there is little doubt that the elongated lake and marshy region which spreads in the direction in which the Cherchen-daria flows—that is, towards east-north-east from the settlement of Lob (39° 28′ N. and 88° 16′ E.), and along whose eastern coast Kosloff travelled in 1898 for 190 miles—are really what now remains of the great Chinese lake.[4] In reality, it is possible that the whole of the triangular space between the Kuruk-tagh escarpment and the route of Kosloff in 1898 was once occupied by a large lake, traces of which Hedin found in 1900 along the southern foot of the Kuruk-tagh in the shape of extensive salt deposits and horizontal beds of clay, "with vast numbers of snail-shells, *Limnæa*, &c."[5] This lake is marked as an ancient bed of the Konche-daria on the map of East Turkestan in *Stieler's Atlas* by B. Domann. During this same journey Sven Hedin descended the extremely sinuous bed of the Yarkand-daria in a boat as far as Yanghi-kul, and he explored, during a subsequent visit to Lob-nor, most interesting ruins, where important manuscripts were unearthed.[6]

Takhla-makan Desert.—As to the Takhla-makan desert, it is known that it consists of an undulating region covered mostly with gravel and partly with sand, slowly uprising from 3400 feet on the Tarim, at Shah-yar, to 4000 feet in its middle parts, and to 4680 feet at Keriya. Prjevalsky and Carey, who crossed it, as also Hedin, who was nearly lost in its western part, found the journey extremely difficult on account of a want of water and fuel.

Communications.—The communications of East Turkestan with China proper are by means of three roads, one of which is known as the military road, and another is only available for carts; all three start from Hami, cross the Bei-shan, and reach the Chinese towns of An-hsi-chou and Sa-chou. A fourth road, which, however, is seldom resorted to, connects Lob-nor with Turfan. The passages across the eastern Tian-shan are numerous, but all of them reach great heights, only one lying at an altitude of 5560 feet, while the others lie at altitudes of from 7000 to 10,384 feet. Only three passes, all very difficult, lead across the western Tian-shan mountains to Russian Turkestan, the chief of them being Muz-art; the others are the Bedel (13,700 feet) and Terek-davan (12,700 feet) passes. And finally, several very difficult passes lead to the Pamir, the chief of them being Chichiklik (14,430 feet). The communications with India are still more difficult, the chief ones being the renowned pass of Kara-korum (18,500 feet), and another leading through the Raskem.

Industries.—Being composed of several oases, situated wide apart, East Turkestan offers a great variety as regards its agriculture and industries. Every oasis has its own peculiar features. Thus, the Khotan oasis is renowned for its silks, carpets, and felt goods. In Hami and Turfan the culture of the silkworm and the fabrication of carpets are quite unknown, the distinctive feature of the latter oasis being its cotton goods. Kashgar is renowned for the dyeing of cottons, while Kucha is famed for its leather, Ak-su for its felts, metal goods, and leather, and Karashar is known for its saddlery. The East Turkestan goods are, however, considered inferior to those of Bokhara and Fergana. The system of irrigation has attained its highest perfection in the district of Turfan, where the irrigation canals are better than anywhere in Central Asia. The best gardens are found in Khotan, while the best melons come from Turfan and Hami; the former is also renowned for its raisins, rice, sorghum, kunjut (*Sesamum indicum*), and hemp. Cotton and tobacco are grown everywhere. Madder is also cultivated to some extent. East Turkestan is rich in all sorts of minerals, but their extraction continues to be very limited. Sulphur, saltpetre, and alum are obtained near Uch-Turfan and Yarkand. Jade and gold are found in the Kuen-lun mountains, lead in the west of Kashgar, where some naphtha, coal, and copper ores are also found. Some copper is extracted on the southern slopes of the Bogdo-ola mountains. Coal is found in many places at Kurla, in the Karashar, in the Turfan oasis, and to the west of Hami. Rock-salt is obtained in the east of Ak-su and in northern Turfan. But all this mineral wealth still remains untouched, and metals, as also metal goods, are imported from Russia. Cotton, leather goods, sugar, matches, and so on, as also silk stuffs, are also imported from Russia, as well as silk goods fabricated in Russian Turkestan. Tea, silver, china, opium, and various small Chinese goods are imported from China. As to the trade with India, it has nearly disappeared—only some gold brocades, colours, tea, and drugs being imported. The chief exports from East Turkestan are silver, some cottons, raw silks, felts, and carpets to Russia; dried fruit and various small goods to Dzungaria; raisins and some raw cotton to China. However, the whole country has fallen into great poverty, and both the internal and external trade are passing through a crisis. Owing to a want of meadows, cattle-breeding has never been very much developed in East Turkestan, and horses are imported from the Kirghiz and Kalmyks. Lucerne is sown, but its crops are hardly sufficient for maintaining the small number of cows. Goods are transported principally on horseback or on donkeys, camels being used only for long-distance caravans.

Aᴜᴛʜᴏʀɪᴛɪᴇs.—In addition to the works mentioned in the ninth edition, the following must be named:—Pʀᴊᴇᴠᴀʟsᴋʏ's *Fourth Journey*, 1886.—Cᴀʀᴇʏ and Dᴀʟɢʟᴇɪsʜ, in *Proceedings R. Geog. Soc.* 1887, xii., and *Suppl. Papers*, iii.—W. T. Bʟᴀɴғᴏʀᴅ. *Scientific Results of the Second Yarkand Mission, based upon the Collections of the late M. Stoliczka.* Calcutta, 1879.—S. D. Mᴏʀɢᴀɴ, in *Proceed. Geog. Soc.* 1889, 375.—M. S. Bᴇʟʟ, in *Proceedings*, 1890, 71.—Dᴜᴛʀᴇᴜɪʟ ᴅᴇ Rʜɪɴs. *L'Asie Centrale*, 1887–89; and his journeys, edited after his death; *Memoirs* (*Trudy*) *of the Tibet Exped. of Pyevtsoff*, 1891–93.—Bᴏɢᴅᴀɴᴏᴠɪᴛᴄʜ, in same publication, vol. ii. 1892.—Rᴏʙᴏʀᴏᴠsᴋɪ. *Expedition to Central Asia in 1893–95*, 3 vols. 1897–99.—G. E. Gʀᴜᴍ-Gʀᴢɪᴍᴀɪʟᴏ. *Description of a Journey* (*Opisanie Puteshestviya*) *to Western China*, 2 vols. 1897–99.—Pᴏᴛᴀɴɪɴ. *Journey of*, 1884–85, 2 vols.—*Scientific Results of Prjevalsky's Journeys.*—Oʙʀᴜᴄʜᴇғғ. *Central Asia, North China, and Nan-shan*, 2 vols. 1899 and 1901 (the last seven works in Russian, with maps and numerous photographs, published by Russian Geographical Society).—P. K. Kᴏsʟᴏғғ. "The Russian Tibet Expedition, 1899–1901," in the *Geog. Journal*, xix., May 1902.—F. E. Yᴏᴜɴɢʜᴜsʙᴀɴᴅ. *The Heart of a Continent*, 1896.—Fᴜᴛᴛᴇʀᴇʀ. *Durch Asien*, vol. i. Berlin, 1901.—Sᴠᴇɴ Hᴇᴅɪɴ. *Scientific Results of my Journeys in Central Asia in 1894–97*, in German. Gotha, 1900; and *Through Asia*, 2 vols. London, 1898; also in above-mentioned *Proceedings*.—Wᴇɢᴇɴᴇʀ. *Versuch einer Orographie des Kwen-luns*, 1891, containing a map upon which all itineraries to that date are given.—Wᴏᴇɪᴋᴏғғ. *Klimate der Erde*, 2 vols. 1887.—Rɪᴄʜᴛʜᴏғᴇɴ. "Morphology of East Asia," in *Sitzungsberichte* of the Prussian Acad. of Sc. 1900, ii.—Sᴜᴇss. *Antlitz der Erde*, especially vol. iii. 1901.

(P. A. K.)

Turkestan, or Hᴀᴢʀᴇᴛ, a town of Russia, in the Turkestan province of Syr-daria, on the highway from Orenburg to Tashkend, from which it is 180 miles distant. It lies on the right bank of the Syr river, 20 miles from it, at an altitude of 833 feet. It has a very old mosque of the saint Hazret-Yassavi, which attracts many pilgrims. It is now an important depôt for hides, wool, and other produce of cattle-breeding, the returns of its fairs reaching about 2,500,000 roubles a year. Population (1897), 11,592.

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[1] *Nachrichten über die von der K. Akad. d. Wissenschaften zu St Petersburg im Jahre 1898 ausgerüsteten Expedition*, by D. A. Klements and W. Radloff. St Petersburg, 1899.

[2] *Preliminary Report on a Journey of Archæological and Topographical Exploration in Chinese Turkestan*, by M. A. Stein. London, 1901. Also *Nature*, 1902, vol. lxvi. 285.

[3] Sven Hedin, *Through Asia*, London, 1898. Kosloff, the travelling companion of Prjevalsky, answered Sven Hedin's remarks in an elaborate paper in the *Geographical Journal*.

[4] See a map of the region by P. Kosloff in the *Geographical Journal*, June 1898, vol. vi. p. 653. "The Lob-nor Controversy."

[5] *Geogr. Journal*, February 1901, p. 182.

[6] *Ibid.* September 1901, p. 288.

TURKEY.

I. GEOGRAPHY AND STATISTICS.

THE Turkish or Ottoman empire comprises Turkey in Europe, Turkey in Asia, and the vilayets of Tripoli and Barca, or Bengazi, in North Africa; and in addition to those provinces under immediate Turkish rule, it embraces also certain tributary states, and certain others under foreign administration. Turkey in Europe, occupying the central portion of the Balkan Peninsula, lies between 38° 46′ and 42° 50′ N. and 19° 20′ and 29° 10′ E. It is bounded on the N.W. by Montenegro and Bosnia, on the N. by Servia and Bulgaria, on the E. by the Black Sea and the Bosphorus, on the S. by the Sea of Marmora, the Dardanelles, the Aegean Sea, and Greece, and on the W. by the Ionian and Adriatic Seas. Turkey in Asia, fronting Turkey in Europe to the south-east, and lying between 28° and 41° N. and 25° and 48° E., is bounded on the N. by the Black Sea, on the N.W. by the Bosphorus, the Sea of Marmora, and the Dardanelles, on the W. by the Aegean Sea, on the E. by Persia and Transcaucasia, and on the S. by Arabia and the Mediterranean. By the treaty of peace with Greece, 4th December 1897, about 180 square miles of Greek territory were ceded to Turkey—about 19 square miles being added to the vilayet of Janina, and the remainder to the independent district of Selfidje.

Population.—The following table is based, as regards European Turkey, on Petermann's *Die Bevölkerung der Erde*, Gotha, 1899, and as regards Turkey in Asia on *Petermann's Mitteilungen* (1896).

Vilayets, Districts, and Countries.	Area in sq. Miles.	Population.	Per sq. Mile.
Turkey in Europe—			
Constantinople (European portion)	1,160	895,500	772
Adrianople	15,000	1,006,500	66
Thrace	16,160	1,902,000	117
Salonica	13,600	1,165,400	85
Selfidje (independent district)	3,050	131,600	44
Monastir	7,650	715,800	94
Kossovo	12,100	961,000	80
Macedonia and Bizas (ancient Servia)	36,400	2,973,800	80
Scutari	4,570	322,000	71
Janina	7,040	648,000	92
Albania	11,610	970,000	83
Total Immediate Provinces in Europe	64,170	5,845,800	91
Turkey in Asia—			
Constantinople (Asiatic portion)	1,590	240,400	151
Archipelago	3,190	325,900	102
Ismidt (Mutessarifut[1])	4,650	222,800	48
Biglia (Mutessarifut[1])	2,890	129,400	45
Brusa	26,390	1,626,900	61
Smyrna	20,450	1,396,500	68
Konia	35,340	1,088,000	31
Adana	15,390	403,400	26
Angora	32,020	892,900	28
Kastamuni	23,110	1,018,900	44
Sivas	32,290	1,086,500	33
Trebizond	12,070	1,047,700	87
Asia Minor	209,380	9,479,300	47
Erzerum	29,590	597,000	20
Mamuret-ul-Aziz	14,550	575,300	39
Bitlis	11,520	398,600	35
Diarbekir	18,060	471,500	26
Van	18,400	430,000	23
Armenia	92,120	2,472,400	27
Aleppo	30,000	995,800	33
Beirut	11,770	533,600	45
Lebanon (Mutessarifut[2])	2,510	399,500	158
Jerusalem (Mutessarifut[2])	8,220	333,000	40
Syria	23,800	955,700	40
Zor (Mutessarifut[1])	32,820	100,000	3
Baghdad	54,480	850,000	15
Mosul	29,200	300,300	10
Bussorah (Basra)	16,470	200,000	12
Syria and Mesopotamia	209,270	4,667,900	22
Hedjaz	96,530	300,000	3
Yemen	77,170	750,000	10
Arabia	173,700	1,050,000	6
Total Turkey in Asia (Immediate Provinces)	684,470	17,669,600	26
African Turkey—			
Tripoli and Barca	397,110	-,000,000	3
Total Turkey in Asia and Africa	1,081,580	18,669,600	18
Grand total Immediate Provinces of Ottoman Empire	1,145,750	24,515,400	21
Under Turkish suzerainty, but not under its immediate government—			
Eastern Rumelia	12,880	998,431	78
Crete	3,330	299,192	88
Autonomous States	16,210	1,297,623	...
Bosnia, Herzegovina (Austria-Hungary)	19,720	1,591,036	81
Thasos	150	12,140	80
Under foreign administration	19,870	1,603,176	...
Bulgaria (Vassal State)	24,380	2,312,282	93
Total in Europe under Turkish suzerainty	60,460	5,213,081	86
Egypt	364,310	9,811,544	27
Cyprus	3,700	221,843	60
Samos	180	52,820	293
Total in Africa under Turkish suzerainty	368,190	10,086,207	28
Grand total under Turkish suzerainty	428,650	15,299,288	37
Grand total Turkish Empire	1,574,400	39,814,688	25

The following towns have over 50,000 inhabitants each:—Constantinople, 1,250,000; Smyrna, 200,000; Baghdad, 145,000; Damascus, 140,000; Aleppo, 122,000; Beirut, 118,000; Adrianople, 81,000; Brusa, 76,000; Kaisarieh, 72,000; Kerbela, 65,000; Mosul, 61,000; Mecca,

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[1] Governed chiefly from Constantinople.

[2] Governed directly from Constantinople.

60,000; Homs, 60,000; Sanaâ, 58,000; Urfa, 55,000; and Marash, 52,000.

Race and Religion.—Exact statistics are not available as regards either race or religion. The Osmanlis or Turks are supposed to number some 10 millions, of whom 1½ million belong to Turkey in Europe. Of the Semitic races the Arabs—over whom, however, the Turkish rule is little more than nominal—number some 7 millions, and in addition to about 300,000 Jews there is a large number of Syrians. Of the Aryan races the Slavs—Serbs, Bulgarians, Pomacks, and Cossacks—predominate, the other representatives being chiefly Greeks, Albanians, and Kurds. Mahommedans number more than half the population of the whole Ottoman empire. In the European provinces about two-thirds of the population are Christian and one-third Mahommedan. Full and fairly accurate statistics are available for a considerable portion of Asiatic Turkey. Out of a population of 13,241,000 (1896) in Armenia, Kurdistan, and Asia Minor, 10,030,000 were returned as Mahommedans, 1,144,000 as Armenians, 1,818,000 as other Christians, and 249,000 as Jews. There are also about 300,000 Druses and about 200,000 Gypsies. The non-Mussulman population is divided into *millets*, or religious communities, which are allowed the free exercise of their religion and the control of their own monasteries, schools, and hospitals. The communities now recognized are the Latin (or Catholic), Greek (or Orthodox), Armenian, Syrian, and United Chaldee, Maronite, Protestant, and Jewish.

Education.—The schools are of two classes: (1) public, under the immediate direction of the State; and (2) private, conducted either by individuals or by the religious communities with the permission of the Government, the religious tenets of the non-Mussulman population being thus fully respected. State education is of three degrees: primary, secondary, and superior. Primary education is gratuitous and obligatory, and superior education is gratuitous or supported by bursaries. For primary education there are three grades of schools:—

(1) Infant schools, of which there is one in every village.

(2) Primary schools in the larger villages.

(3) Superior primary schools, of which there are 100 altogether.

Secondary education is supplied by the grammar school, of which there is one in the capital of every vilayet. For superior education there is (1) the University of Constantinople, with its four faculties of letters, science, law, and medicine; and (2) special schools, including (*a*) the normal school for training teachers, (*b*) the civil imperial school, and (*c*) the school of the fine arts. In 1896 there were in European Turkey 821 Bulgarian schools, with 29,846 scholars; 1286 Greek, with 850,155 scholars; 80 Rumanian, with 3678 scholars; and 162 Servian, with 7511 scholars.

Finance.—See separate article below.

Army and Navy.—In virtue of the enactments of May 1880, of November 1886, and February 1888, military service is obligatory on all Mussulmans, Christians being exempted on payment of a small military tax. It is this religious division which mainly cramps the military strength and efficiency of the Ottoman empire. The duration of service is twenty years: four with colours and two in reserves in the active service (*nizam*), eight in the reserve (*rédif*), and six in the territorial (*mustahfiz*). There is also the irregular cavalry (*hamidieh*), raised from the Kurds and the mountain tribes of Syria, and supposed to number 200,000 horsemen, but their effective value in war must be regarded as problematical. The army consists of seven *corps d'armée*, each under a field-marshal. The headquarters of the seven army districts are Constantinople, Adrianople, Monastir, Erzinjan, Damascus, Baghdad, and Sanaâ (the Yemen). (For details see ARMIES: *Turkey*, vol. xxv. p. 665.)

For the navy the term of service is twelve years, of which five are in active service, three in the reserve, and four in the territorial. Much information as to the fleet is unattainable. The few ironclads are hopelessly out of date. There are several second-class cruisers, a considerable number of gunboats, 2 torpedo-boat destroyers, about 40 torpedo-boats, and 2 Nordenfelt submarine boats. The navy is manned by about 2500 officers and 15,000 men.

Communications.—A considerable hindrance to the development of the empire's resources has been the lack of an adequate system of communications; but although it is still deficient in good roads, much has been done of late years to develop railways, extend canals, and improve river communications. From 1250 in 1885, of which 903 were in Europe and 347 in Asia, the mileage of railways had increased to some 3000 in 1900, of which 1240 are in Europe, 1500 in Asia Minor, and 260 in Syria. While in 1885 there were 14,600 miles of telegraph, with 26,000 miles of wire, there were in 1900 about 22,000 miles of telegraph, with 35,000 miles of wire.

Productions and Industries.—The Ottoman empire is renowned for its productiveness, but enterprise and skill in utilizing its capabilities are still greatly lacking, the most primitive methods being those in most common use. For the introduction of improvements something, however, has been done by the creation in 1892 of a special ministry of agriculture, to which is attached the department of mines and forests, formerly under the minister of finance. Since the year named an agricultural bank has been established, which advances money on loan to the peasants on easy terms. Schools of agriculture have been opened in the chief towns of the vilayets, and in connexion with those schools, and elsewhere throughout the empire, model farms have been instituted, where instruction in the veterinary art can also be obtained.

To prevent the gradual destruction of the forests by unskilful management and depredations, new regulations for their preservation have been passed. Schools of forestry have also been founded, and means have been taken for regulating the cutting of wood, and for replanting districts that have been partially denuded. About 21 millions of acres are under wood, of which over 3 millions are in European Turkey. In Europe the forest trees include the oak, the beech, the pine, the linden, the elm, the hazel, the olive, the walnut, and the mulberry; in Asia the principal trees, in addition to most of those above named, are the juniper, the dogberry-tree, the pistachio, the plane, the cedar, the maple, the chestnut, and the ebony.

Wheat, maize, oats, barley, and rye are the chief agricultural products. The culture of cotton is making rapid progress, immigrants who receive a grant of land being obliged to devote one-fourth of it to cotton culture. Tobacco is grown all over the empire, the most important market for it being Smyrna. The tobacco leaf exported in 1896–97 amounted to 14,555 tons, of which 9921 tons were exported to foreign countries, and 4634 tons to other parts of the empire. Opium is mainly grown in Anatolia. All the more common fruit-trees flourish in most districts. In Palestine and elsewhere there is a large orange trade, and Bussorah, in Turkish Arabia, has the largest export of dates in the world. The vine is largely cultivated both in Europe and Asia, and much Turkish wine is exported to France and Italy for mixing purposes. From 127,785 in 1897–98 the number of vine-growers had decreased in 1898–99 to 95,488, but in 1899–1900 they had increased to 105,849. Owing to ravages of disease in the vineyards the export of wine sank from 11,984,550 kilos in 1897–98 to only 7,397,360 kilos in 1898–99; but in 1899–1900 it rose to 12,761,130 kilos, of which 4,509,662 were sent to France, 3,499,035 to Italy, and only 106,133 to England. The chief centres of export are Adrianople (more than half), Constantinople, and Smyrna, the others being Brusa, Beirut, Ismidt, Mytilene, and Salonica. Under the auspices of the Administration of Public Debt silk culture is also carried on with much success, especially in the vilayets of Brusa and Ismidt. In 1888 a school of sericulture was founded for the rearing of silkworms according to the Pasteur method. During the first decade of administration the silk revenue averaged annually £28,594. During the seven years 1892–93 to 1898–99 the average was £50,918, and in 1899–1900 the amount was £81,669. The production of salt is also under the direction of the Council of Administration, and during the seven years 1892–93 to 1898–99 the annual average produced was 217,330 tons, and in 1899–1900 the amount was 227,540 tons. About a fourth of the salt produced is exported to foreign countries, and of this about three-fourths goes to British India. Since 1885 great attention has been paid to the sponge fisheries of Tripoli, the annual value of which is about £30,000. With its extensive sea-coast, and its numerous bays and inlets, Turkey has many excellent fishing-grounds, and the industry, the value of which is estimated at over £200,000 a year, could be greatly developed. Its general progress may be seen in the increase of the fishery revenue—derived from duties, permits, &c.—of the Administration of Public Debt. During the seven years 1892–93 to 1898–99 it was £40,738, and in 1899–1900 the amount was £42,789. Among other important productions of the Ottoman empire not already mentioned are sesame, coleseed, castor oil, flax, hemp, aniseed, mohair, saffron, olive oil, gums, scammony, and liquorice. Attar of roses is produced in large quantities both in European and Asiatic Turkey, and to aid in furthering the industry numerous rose plants are distributed gratuitously. The empire is rich in minerals, including silver, lead, copper, iron, coal, mercury, borax, emery, zinc; and only capital is needed for successful exploitation. The silver, lead, and copper mines are mainly wrought by British capital. The more special industries of Turkey are tanning, and the manufacture of muslin, velvet, silk, carpets, and ornamental weapons.

Shipping and Commerce.—In 1890–91 the number of steamers that entered and cleared Turkish ports was 38,601, and of sailing vessels 140,726, the total tonnage of both classes of vessels being 30,509,861. In 1897–98 the number of steamers was 39,680 of 32,446,320 tons, the number of sailing vessels being 134,059 of 2,207,137 tons, thus giving a total tonnage of 34,653,457. About a third of the tonnage belongs to British vessels. The number of steamships belonging to Turkey in 1899–1900 was 177 of 55,938 tons, as compared with 87 of 46,498 tons in 1897–98, the number of sailing vessels in the same years being respectively 2205 of 141,055 tons and 1349 of 252,947 tons. The following tables give the total value of the exports and imports of the empire, arranged according to countries of destination, for 1890–91, 1895–96, and 1897–98:—

	Exports 1890–91.	Exports 1895–96.	Exports 1897–98.	Imports 1890–91.	Imports 1895–96.	Imports 1897–98.
Great Britain . .	£4,331,715	£5,755,602	£5,336,167	£8,930,502	£6,674,043	£8,885,731
Austria-Hungary . .	935,504	1,718,135	1,232,295	4,146,025	3,933,878	4,143,266
France	3,358,880	3,561,365	3,897,354	2,550,244	2,135,388	2,181,762
Russia	263,955	339,960	387,398	1,532,735	1,442,151	1,501,761
Italy	498,787	502,322	437,275	449,802	604,073	891,600
Rumania . . .	213,489	180,157	232,826	419,968	551,297	351,910
Bulgaria . . .	366,952	312,389	338,281	859,939	789,554	3,011
Egypt	617,099	...	17,303	56,495	478,997	130,477
Persia	14,959	13,372	163,895	526,505	502,535	526,437
Belgium . . .	11,237	86,780	163,545	450,965	535,164	518,025
Greece	460,852	255,717	400,618	320,866	354,717	240,673
Germany . . .	104,941	374,376	275,267	56,930	211,445	297,213
Holland . . .	150,661	465,780	295,032	98,577	145,945	238,548
United States . .	164,363	319,763	40,310	67,222	30,334	46,497
Tunis	721	115	126	35,800	23,985	12,861
Samos	8,328	...	...	515	170	487
Other countries . .	50,386	96,210	82,545	119,820	104,514	111,381
Total . . .	£11,552,829	£13,982,043	£13,384,776	£20,622,910	£18,518,190	£20,081,640

The total value of the exports in 1898–99 was £12,375,000, and of the imports £21,663,000. For 1896–97 the chief exports were—grapes (£1,742,620), silk (£1,313,890), wheat (£778,224), opium (£706,541), barley (£673,960), cocoons (£635,348), wool (£522,117), mohair (£408,524), ores (£437,845), figs (£414,656), cotton (£389,148), and sheep and goat skins (£371,760). The imports in the same year included quilting (£1,485,401), sugar (£1,445,330), cotton yarn (£810,246), coffee (£783,531), rice (£660,990), and woollen stuffs (£506,830). The exports from the Turkish empire to the United States for the twelve months ended 30th June 1901 amounted to $7,468,380, the amount being almost equally distributed between Turkey in Europe and Turkey in Asia. The imports from the United States for the same year amounted to only $588,590.[1] The following table gives for 1899 the value of exports and imports, and the number and tonnage of shipping of the principal ports for which statistics are available:—

	Exports.	Imports.	Ships entered.	Tonnage of Ships.
Constantinople .	...	...	15,924	11,548,056
Salonica . .	£1,651,021	£2,568,970	3,240	741,477
Smyrna . .	3,782,781	2,562,885	5,756	2,137,488
Beirut . .	1,051,950	1,580,165	3,370	849,008
Bussorah . .	1,135,583	1,190,168	650	165,574
Kavala . .	1,200,200	262,200	2,191	246,525
Alexandretta .	931,002	2,163,743	589	397,138
Trebizond . .	569,400	1,324,730	8,470	694,462
Samsun . .	541,970	471,910	2,655	823,049
Tripoli (Africa) .	410,500	384,900	874	245,036
Tripoli (Asia) .	488,300	...	3,240	741,477
Jaffa . . .	316,158	390,260	107	429,444
Scio . . .	247,400	265,900	4,179	733,666
Aivali . .	286,425	944,743	1,546	276,740

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II. History since 1876.

The union of Eastern Rumelia with Bulgaria, which was accomplished in September 1885, closed the series of territorial questions arising out of the war of 1877–78 (see vol. xxiii. p. 652). At that time Abdul Hamid had reigned nine years, in the course of which important changes had been wrought in the internal condition of the empire. They were the direct outcome of the temperament, character, and tendencies of the Sultan, and they were in the main prepared and brought about by himself. In order to trace these changes and to realize their significance, it is necessary to bear in mind that from the earliest days of Turkish rule in Constantinople to the date of the issue of the Hatt-i-Sherif of Gulhané by Sultan Abdul Medjid in 1839, the one ever constant feature in Turkish political life was the contest between the Palace and the Porte—the imperial court and the official hierarchy—for ascendancy in the direction of public affairs. The people, with whom were the Ulema, sided sometimes with the one, sometimes with the other, while the rivalry between the Sultan and the Sublime Porte was maintained in perpetuity. The Hatt of Gulhané limited the power of the Palace, and contemporaneously with its promulgation appeared a remarkable group of men—Reshid, Fuad, and A'ali—whose rare political aptitudes enabled them to follow out and render effective the purpose of the Hatt. While these men headed successive ministries, the government of the empire was conducted on the principle of ministerial responsibility; but after 1871, when A'ali Pasha, the last of the trio, died, a period of confusion followed. On the recall of Mahmûd Nedim Pasha to the grand vizierate in August 1875, the Palace again became paramount, and so continued until the *softa* riots of the following May brought about a change of ministry, Mehemed Rushdi becoming Grand Vizier, and Midhat, Minister of Justice. Then ensued the series of events which culminated, on 4th June, in the death of Sultan Abdul Aziz, followed by the enthronement of Murad, the assassination of two cabinet ministers by Hassan the Circassian, and the war with Servia and Montenegro. In August it was discovered that Murad's mental condition unfitted him for the sovereignty, and he was deposed, leaving the empire in a state of complete disorganization which seemed to threaten dissolution.

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[1] *Monthly Summary of Commerce of the U.S.* (Washington, 1901).

Accession of Abdul Hamid II.

Such was the situation when Abdul Hamid came to the throne. He accepted everything that was proposed to him, promised everything that was asked of him, acted patiently the part of a champion of Liberal ideas, and adopted the programme of the advanced party as set forth in Midhat Pasha's constitution, with a parliamentary system and every sort of individual liberty, including that of the press. The official aristocracy, who had been instrumental in bringing this about, believed that in so doing it had won the lasting gratitude and permanent support of the people, and that, this being the case, the domination of the Court was permanently superseded. But at the very first meeting of the Chamber of Deputies this illusion was dispelled. The official and popular elements in the assembly were brought into collision, and at each successive meeting the attacks of the latter on the former increased in violence; independent members apparently rejoicing in the opportunities which Parliament afforded for vituperative criticism of ministerial action. The new tyranny drove ministers to despair, and they sought deliverance from it by praying the Sultan to prorogue Parliament and suspend the Constitution, of which the working proved so different from what they had fondly anticipated when they urged the Sultan to adopt and proclaim the parliamentary system as the law of the Ottoman empire. Abdul Hamid, notwithstanding his rooted dislike to every sort of political liberty, made a show of objecting to any interference with the Constitution, and was with difficulty, as it seemed, induced to consent to the convocation of an Extraordinary Council which was held at the palace. After much discussion, the Council decided to dissolve Parliament, to suspend the Constitution, and to proclaim martial law In thus undoing the liberties of the people, the Porte practically surrendered its own traditional privileges, and allowed everything to come under the direct control of Sultan Abdul Hamid II., who in the space of a few months was transformed from a constitutional sovereign into a despotic autocrat of the most extreme type. Midhat Pasha, the author of the Constitution, had been dismissed from office and sent into banishment six weeks after his proclamation and seven weeks before the meeting of Parliament.

In compassing the overthrow of Liberalism and the complete reinstatement of Palace domination, which was his purpose from the outset, Abdul Hamid was ably seconded by his secretary, Said Pasha, who was subsequently several times Grand Vizier. Without erudition or general knowledge, Said was shrewd and adroit, with a remarkable aptitude for finding means to his ends; while his mental constitution well fitted him to be the instrument of an autocratic master. He lent himself heart and soul to the achievement of his sovereign's scheme for extinguishing the influence of the Sublime Porte and reducing ministers to the position of puppets. Before his time, ministers' reports went up to the palace, and the sovereign decree followed the ministerial recommendation as a matter of course. But Said introduced the practice of modifying ministerial decisions, and this system expanded so easily under the rule of Abdul Hamid that the respective parts of Porte and Palace were soon reversed; all essentials came into the hands of the Palace, and formalities only were left to the Porte. Later, when Said Pasha became Grand Vizier, he awoke to a painful perception of the evils of the system which he had himself introduced; but it was then too late to undo the mischief. The Sultan at this moment stood in an exceptionally strong position. He held the capital under martial law and the army under his own absolute control. Where terrorism failed, or proved imperfectly efficacious, it was supplemented by corruption in all its varied Oriental forms. Thus it was easy for Abdul Hamid to extinguish opposition. A few penal sentences sufficed to relegate to oblivion the parliamentary system and all that attached to it, and its disappearance attracted little notice, for the attention of the country was absorbed by the events of the war with Russia. Now it was that Abdul Hamid began to show how largely his mind was occupied by care for his personal safety, and how the fear of assassination was ever present with him. Feeling that for effectual self-preservation he required the fullest information about the life and conduct of every officer of state, and of every unofficial person of influence, he surrounded himself with an army of spies comprising men of every social position. There was little attempt at organization of this service; its chief was the Sultan himself, and he was always accessible to every member of it who had a denunciation to make. Year by year this system of espionage developed and expanded, until it overspread nearly the whole of the official body. Denunciators were always so liberally rewarded that even ministers found it worth their while to watch each other, and report to the Sultan anything that seemed likely to interest him. At the same time means were taken to prevent friendly intimacy between the members of the imperial household or public officials, and jealousies and rivalries among them were promoted, in order to prevent the possibility of dangerous combinations. In the early 'eighties, during which with two very brief interruptions Said Pasha was Grand Vizier, Abdul Hamid entertained three schemes on the furtherance of which he bestowed much endeavour. The most ambitious of these projects was the realization of the Pan-Islamic idea, *i.e.*, the union of all Mahommedan peoples under the spiritual headship of the Khalif-Sultan. The other two schemes were the abolition of the capitulations and the revocation of all privileges which in previous reigns had been granted by firman or other official act to the non-Mussulman communities of the empire. Said encouraged the Sultan in the pursuit of both these objects, and fostered his belief in the possibility of attaining them. But his influence was temporarily destroyed by the revolution of Philippopolis (September 1885), which proclaimed the union of Eastern Rumelia with the principality of Bulgaria.

Councils were held daily at the palace to determine what course the Government should adopt. In these councils, of which the leading men were Said Pasha and the Minister of War, the majority were in favour of military action; but an examination of the military resources revealed the fact that Turkey was wholly unprepared for war. Then the Sultan came to perceive that Said, with all his aptitude for dealing with internal affairs, was remarkably inefficient in the wider fields of policy. He had not kept in touch with the Courts of Europe, where his agents might have learnt what was preparing at Sofia. Moreover, he had failed to perceive the necessity of military reorganization which the events of 1877–78 had rendered indispensable. So, on the 24th September 1885, the Sultan dismissed Said, after six years and five months of office, and appointed Kiamil Pasha Grand Vizier in his stead.

Kiamil differed greatly from his predecessor, being free from fanaticism and narrow prejudices. In wily arts he was inferior to Said, but he had the advantage of him in general knowledge and in political judgment. Though broadly Liberal in his views, he was not disposed to force a Liberal system on the country for which he believed it to be unprepared. He was prudent, moderate, and practical, and his practice was based upon principle. Abdul Hamid took advantage of the Rumelian incident to narrow still further the Porte's spheres of action and influence. He assumed the superior direction of military affairs, and he instituted a secret intelligence service abroad, which had no connexion with the ministry for foreign affairs, and which communicated with the Palace direct. This latter undertaking was developed with great activity, so that in a very short time Turkish spies were in every European capital, and relations were established with the secret police of at least two European capitals. For the purposes of military reorganization and control, his majesty constituted a special staff under his own immediate orders, and also a permanent military commission which sat under his presidency at the palace of Yildiz. These innovations were costly, and the treasury was often embarrassed to find the money which the Palace required for the maintenance of its elaborate system.

Owing to Said Pasha's dislike of foreigners, which he did not seek to disguise, the relations of Turkey with the governments of Europe during his tenure of vizirial office waxed colder and colder, till they had lost all cordiality; but Kiamil Pasha, whose sympathies were large and untrammelled by the fetters of a narrow fanaticism, adopted a different attitude, so that the intercourse of Turkey with the European Courts was restored to a normal geniality. His ministry (1885–93) was relatively a period of calm in foreign politics. In the earlier years of it, shortly after the accession of the German Emperor William II., at the time of his first visit to Constantinople, the question was mooted of Turkey joining the Triple Alliance. The idea necessarily fell through, as the position of the Ottoman empire requires liberty of action incompatible with such a bond. While Kiamil was in power, the Armenian revolutionary committees were formed in London, Paris, and Geneva, and the association called Young Turkey was reconstituted in Geneva. The first Armenian manifestation took place at Kum-Kapu in the month of August 1890, painfully impressing the Sultan and quickening his dislike and distrust of the race. Out of these feelings certain confidants, such as Nazim Bey, minister of police, contrived to weave combinations which were highly profitable, and the way was prepared for that traffic in the Sultan's likes and dislikes, fears and fancies, which took wholesale proportions in the time of Kiamil's successors. The manifestation, which was peaceful in its character, was made a pretext for employing coercive measures towards the Armenians, and for abrogating privileges enjoyed *ab antiquo* by the community. Kiamil's fall was the consequence of Abdul Hamid's insuperable objection to anything like ministerial self-assertion. A note was sent up from the council of ministers to the imperial chancellery remarking that the decisions of the Cabinet Council were so frequently annulled by the Sultan as sometimes to disturb that consistent sequence in Governmental action which it was desirable to maintain. The Sultan had long fretted under the sense of Kiamil Pasha's moral stability and lack of obsequiousness. So the memorandum, inasmuch as it suggested that the ministry had an individuality which it was inexpedient wholly to ignore, was answered in terms which left Kiamil Pasha no alternative but to resign. He did so, and was succeeded by Djevad Pasha, who at the time of his appointment was governor-general of Crete, where he was replaced by Mahmoud Djelal-ed-Din Pasha. Djevad Pasha possessed neither the moral nor intellectual worth of Kiamil; but he was docile; and his sister was mistress of ceremonies in the imperial harem. On becoming Grand Vizier, Djevad Pasha surrendered the Porte wholly to the Sultan, who took into his own hands the direction of foreign affairs, which up to that time had been entirely managed by the Porte, and the conduct of which was generally considered to be the speciality in which the Porte excelled. But the Sultan practically took away the management of foreign affairs from the "Hardjié," which from that time has been nothing more than a sort of dragomanate and record office, interpreting to the embassies the Sultan's own views, and placing on record those expressed by the heads of the foreign missions. Thus it came to pass that, under Djevad, the relations with Great Britain, which Kiamil had carefully fostered into kindliness, once more relapsed into the sourness of Said's days, and every opportunity of opposing or thwarting Great Britain was seized with avidity. On the other hand, the relations with Germany, which in Kiamil's time had been wrought into friendliness through the influence of the late Reshid Bey, a private secretary of the Sultan, became more and more intimate, and German influence gained ascendancy at the Palace, enabling a German syndicate to obtain the concession of the Anatolian railway over the heads of British capitalists who not only offered better terms, but under a previous concession had built and opened a railway between Constantinople and Ismidt. This line—the first section of the Anatolian railway—they were compelled, in virtue of its right of purchase stipulated in the concession, to sell to the Porte, who forthwith resold it to the German syndicate to whom it conceded the line from Ismidt to Angora, extending the concession subsequently to Eski-shehr and Konieh, and in November 1899 to Baghdad and Basra. There can be no doubt that when the German Emperor and Empress, before their tour in Palestine in 1898, came to Constantinople, the concession of the extension to the Persian Gulf was promised to the German syndicate; but there was some hesitation about granting it, because Russian, French, and British applicants for it came forward offering terms less onerous than those demanded by the Germans. At length, on the 24th November 1899, the German ambassador had audience of the Sultan, and on the morning of the 26th an iradé was sent to the German embassy granting the concession to the German syndicate, and leaving the conditions for future adjustment.

The ministry of Djevad Pasha, which lasted for two years (1893–95), brought the internal affairs of the empire into a deplorable condition. Time and effort were spent upon unattainable objects which, even had they been realizable, would have been profitless. The futile project, which Said so keenly pursued and Kiamil dropped, of obtaining the abrogation of the capitulations, was revived with new ardour. But Djevad was not likely to succeed where Said had failed; the Porte could make no headway with the scheme, and met with rebuff on all sides. During Djevad's ministry the Sultan began to lay a heavy hand on the Christian communities, annulling or retrenching the privileges and immunities granted to them by his predecessors. Greeks and Armenians were laid under new restrictions and obligations which were enforced in the most vexatious manner. It is worthy of note that Mahmud Djelal-ed-Din, at that time Vali of Crete, strictly followed in that island, and with disastrous effect, the example given him by his sovereign in Constantinople. Abdul Hamid, in the ardour of his desire to concentrate all power in his own hands, did not foresee that powerful communities, with right on their side and many resources at their command, would not easily submit to his arbitrary decrees. The patriarchates resolved on resistance, and in the winter of 1893–94 a serious crisis seemed imminent. As a protest against Abdul Hamid's ordinances, the Œcumenical Patriarch, just before Christmas, closed all the Greek churches of the capital, and was only persuaded to reopen them by the Russian ambassador, whose intervention the Palace solicited. At the same time the Armenians, inspired by the committees of London and Paris, prepared in many provincial districts demonstrations which mostly ended in bloodshed, and the Cretans began to shape the plan of their last revolt. By depriving the Christian communities of their privileges, Abdul Hamid had hoped to recover the sympathies and win the respect and admiration of his Mahommedan subjects; but the Moslems perceived their sovereign's purpose, and despised it. In the midst of all this ferment came the earthquake of 10th July 1894, which turned the thoughts both of the Palace and of the public into another channel. (See CONSTANTINOPLE.)

Armenian troubles.

Meanwhile the Sultan had found means to realize his long-cherished scheme of making soldiers of the Kurds. The idea originated with Shakir Pasha, who, when ambassador at St Petersburg, thought that the Kurds might be utilized by Turkey in the same manner as Russia utilized the Circassians, and that they might be turned to protective use on the frontier, where in their lawless state they were a constant source of trouble and danger. The idea pleased Abdul Hamid, who feared the Kurds just as he did the Albanians, and was longing to establish a link between himself and them which would enable him to awaken them to the advantages derivable from loyal devotion to their imperial master. So the "Hamidieh" light cavalry was formed out of Kurdish nomads, and divided into fifty-four squadrons. The force has not, however, proved of any value for the maintenance of order. It has always shown antagonism to the Turkish civil authorities, habitually joins in the predatory operations and frontier raids of the clansmen, and in Sasun, at Diarbekir, and other scenes of massacre, its services surpassed those which won such odious distinction for the Circassian cavalry in Bulgaria. It should be noticed that in order to form the "Hamidieh" cavalry it had been necessary to heal the deadly feuds between the Kurdish clans, to give them a sense of unity, and at the same time to win them from their relations with the Armenians, who regarded them as landlords, and paid tithe to them on the increase of their flocks and herds and on the produce of their industry. The means employed by the Sultan to this end were to send sheikhs and other holy men into Kurdistan to preach Pan-Islamic doctrine, union of all true believers, and fanatical hatred of all those outside the fold of Islam. These missions were successful beyond expectation. In official circles it was felt that the ever-increasing demands of the Palace for money made it necessary to bring the Armenians of Kurdistan under taxation, which they had previously escaped on the plea that they were already taxed to excess by the Kurds, over whom the Ottoman authorities dared not attempt to exercise any restraint. This was the official interpretation of the Sultan's policy in Kurdistan, which was obviously not founded upon economic considerations. Indeed, it may safely be asserted that the main—if not the sole—purpose of Abdul Hamid in forming the "Hamidieh" cavalry, and in making it the object of his own special patronage, was to bring the Kurds under his own immediate command.

Sasun, a district lying to the west of Lake Van between the plains of Mush and Diarbekir, consists of a block of mountain, deeply seamed in every direction by torrents, making a network of ravines, in the depths of which are the villages and the cultivated land. The slopes furnish food for flocks and herds when snow covers the rich pasturage of the mountain-top. Prior to the massacre, Kurds inhabited the eastern and Armenians the western half of the district. These latter, recognizing the Kurds as lords of the domain, paid the tribute regularly levied upon their pastoral and agricultural produce, on the dowries given to their brides, and other taxable matters. In exchange for this tribute the Kurdish aghas protected the Armenians from the depredations of the semi-nomad Kurds. Neither Kurds nor Armenians paid taxes to the Imperial Government. Such up to 1892 was the mode of life in Sasun. It satisfied the two parties concerned, and the Turkish authorities did not interfere with it. But in 1892 the Mutessarif of Mush received orders from Constantinople to collect taxes from the Armenians of Sasun. He tried to do so, but was told that it was impossible for them to pay imperial taxes so long as they had to pay tribute to the Kurdish aghas. The matter was allowed to drop for the time, but was brought up again in the following year. Meanwhile, inasmuch as the understanding and relations between the Kurdish aghas and the Armenians were regarded unfavourably by the Sultan, his majesty sent out sheikhs into Kurdistan to heal tribal feuds and unite all Kurds in a bond of fanaticism against the Armenians. Thus it came to pass that in 1893, when the Mutessarif of Mush, to punish the Armenians for again pleading inability to pay the taxes he demanded, sent two tribes of nomads to feed their flocks on their mountains, no protection was afforded them by the Kurdish aghas, and a feeling of enmity was thus established between the two races. The Armenians suffered heavily from the nomads, and resolved to protect themselves in the following year, foreseeing a repetition of the measure. It was repeated; but under the guidance of one Hamparsun Boyadjian the Armenians drove back the nomads, and were thereupon reported to the Sultan as being in rebellion. Abdul Hamid promptly ordered regular troops, with a large contingent of "Hamidieh" cavalry, to reduce the Armenians to submission. The armed bands of the Kurdish aghas joined the troops. The Armenian district was surrounded; flocks and herds were seized; most of the villages were pillaged and burned; and those who were unable to escape from them by flight were massacred—men, women, and children. In the village of Guelierguzan it was reported that trenches were dug, to the edge of which the victims were driven, and there they were bayoneted and their corpses cast into the ditch. These events happened in July and August (1894), and the news of them reached Europe in October, producing a most painful impression on public opinion. The massacre necessarily called forth the intervention of the three Powers—Great Britain, France, and Russia—most interested in Turkey, and, after strenuous and prolonged opposition, their ambassadors were able to obtain the constitution of an international commission of inquiry. It began its work in January 1895, of which a full record is contained in Blue Book, Turkey, No. 1, of that year.

Reform schemes.

While these events were passing in Kurdistan, Lord Rosebery, in July 1894, brought forward a scheme of reforms for Turkey, applicable more especially to the provinces inhabited by Armenians, which he laid before the French and Russian Governments. Count Lobanoff, Russian Minister for Foreign Affairs, declared it to be impracticable, because "the Turks never change." Lord Salisbury, who succeeded Lord Rosebery at the Foreign Office, followed up the idea; but he considerably modified the scheme, cutting it down to more attainable proportions, in the hope of inducing Russia and France to join Great Britain in urging the Turks to adopt it. Meanwhile Sir Philip Currie was appointed ambassador in Constantinople, and shortly afterwards Matheos Izmirlian was elected Patriarch of the Gregorian Armenians. The negotiations opened by Great Britain with Russia in reference to reforms in Turkey, and the horror created by the reports from Sasun, Diarbekir, and other places, brought about the European Concert, in virtue of which the ambassadors in Constantinople of the six Great Powers were instructed to draw up a project of reform for the six provinces inhabited by Armenians. That project, which was based upon the organic statutes of the Lebanon and of Samos, was completed by the ambassadors in April 1895, and was submitted by them to their respective Governments. Approved in all the chancelleries, it was presented to the Porte, accompanied by a Note Identique, in May. The Porte refused the reforms, and the Sultan sought to clear the situation by a change of ministry. He accordingly dismissed Djevad Pasha from the office of Grand Vizier, and conferred it once more upon Said Pasha. At this moment the situation in the provinces was full of menace, and at the same time the "Young Turkey" committees of London and Paris were actively publishing periodicals, full of inflammatory matter, vast quantities of which were smuggled into the country and widely circulated. Their tone was bitterly, violently hostile to the Hamidian régime, and to the system upon which it was based, and the Sultan was kept in constant alarm by threatening letters and seditious placards, which were usually posted on the palace walls. Household influences, especially the Albanian element, strongly favoured Said; and as he was the acknowledged representative of "Old Turkey" views as opposed to those which the "Young Turkey" party were now so actively propagating, the choice seemed expedient. The *menchour* conferring the appointment gave Said full liberty of action, but, in order to gratify the Albanians, imposed upon him Turkhan Pasha as Minister for Foreign Affairs. On taking office Said Pasha endeavoured to grapple with the most pressing evils, but was disconcerted at the eagerness shown by the ambassadors about their reform scheme. Very adroitly, however, pleading the urgent and complex nature of the questions with which he was called upon to deal, he induced the ambassadors to agree to allow the reform scheme to stand over until he had had time thoroughly to examine it. Undoubtedly the position of affairs was one of serious embarrassment. The system of centralization, which in earlier years Said himself had done so much to develop, had absorbed everything, so that on returning to office he found the Porte impotent and the whole administration disorganized. He tried reaction, and vainly endeavoured to dislocate the direct relations which he found had been established between the Palace and the ministry of police. But all that Said gained by his endeavours to break them off was that he drew upon himself the suspicion of his sovereign. In July the ambassadors received instructions from their Governments to renew their demand for the adoption of the scheme of reforms presented two months previously and refused in the last days of Djevad's ministry. Then followed weeks of futile discussion and wrangling between the ambassadors and Turkhan Pasha, who, duly prompted from Yildiz, led the ambassadors through a long course of fruitless negotiations. Great Britain proposed coercion, but the Tsar's ambassador in Constantinople was instructed to declare that Russia would not participate in any measure which might be detrimental to the prestige of the Sultan. The doom of the reform scheme was thus sealed. Shortly afterwards a telegram went the round of Europe stating that a great Armenian rising was in preparation, and that it would lead to much bloodshed. At about the same time, in the hope of influencing the Powers to take a firmer attitude about the reform scheme, and the Porte to give ear to their representations, the "Huntchak" revolutionary committees of London and Marseilles passed the word to make an Armenian demonstration in Constantinople. Accordingly, on the 30th September 1895, it was proposed to present a memorial to the Grand Vizier Said Pasha. A large number of Armenians assembled at Kum-Kapu and marched towards the Porte. Their progress was intercepted by police and troops, who ordered them to turn back. The processionists refused to obey, and a conflict began which overspread all the quarters of the city inhabited by Armenians. Early in the day the *softas* (theological students) rushed forth and slew all the Armenians they could find. They ceased their butchery as suddenly as they began it. The carnage of the later afternoon and evening was wrought by the police in their endeavours to arrest persons on the "suspected" list of the department. The exact—even the approximate—number of Armenians put to death on this occasion has never been established, but it is estimated at about 500 more or less. There was a rush to the churches for asylum, but had it not been for the intercession of the embassies the refugees would have been dragged out to death. In the following week several hundred Armenians were massacred at Trebizond. The events of 30th September afforded the Sultan a reason for removing the Grand Vizier. So Said was dismissed, and Kiamil was once more called to office. The panic caused by the massacre continued for several days. All shops kept by Armenians were closed, and the windows and doors of all Armenian dwellings were shuttered and barred. The refugees in the churches could not be induced to return to their homes, and it was not till Sunday, 13th October, that, with the help of the embassy dragomans, the churches were emptied. As soon as he came into office, Kiamil Pasha took in hand the scheme of reforms for the provinces inhabited by Armenians, and induced the ambassadors to consent to expunge from it a clause which gave the European Concert a a right of supervision over the execution of the reforms through the instrumentality of a commissioner *ad hoc*, a foreign subject, whom they were to appoint. Kiamil having obtained this alteration of the reform convention, the Sultan accepted it, issued an iradé to that effect, and the decree was published in all the native papers. Meanwhile the slaughter of about 700 Armenians was brought about at Bitlis.

From the time of the issue of the reform decree to that of his fall, Kiamil Pasha was in difficulties about the composition of the commission of control for the new reforms. Kiamil desired to form it of men of established character and capacity, and sent up to the Sultan a list of seven names which the ambassadors highly approved. But Abdul Hamid objected to them, and while this difference of view was daily increasing the strain between the Sultan and his Grand Vizier, tidings were received in Constantinople of sanguinary events of which Marash, Baiburt, Urfa, Erzinjan, and Erzerum were severally the scenes, and which added heavily to the Armenian death-roll. In the same interval a letter addressed to the Sultan threatening his life was found on the table of Ghazi Osman Pasha, and greatly disturbed his majesty's mind. The result of the inquiry concerning this letter was that fourteen members of the imperial household were removed. Kiamil more than once intimated his desire to quit office, but his overtures were rejected. On 6th November, however, an iradé dismissed Kiamil from the cabinet, appointed him Vali of Aleppo, and put Khalil Rifaat Pasha in his place as Grand Vizier. Falling ill at the very moment of his nomination to Aleppo, Kiamil refused that post, and was transferred to Smyrna. Khalil Rifaat Pasha, who was Minister of the Interior in the previous cabinet, owed his appointment as Grand Vizier mainly to the pressing recommendations of Sheikh Ebul Huda and Lutfi Agha, the Sultan's companion. It displeased the Albanians of the imperial household, who wanted Said in the Grand Vizierate, and clamoured for his recall. Said, however, firmly refused; and, fearing that the Sultan would resent his refusal, sought refuge in the British embassy, where, notwithstanding the messages of command, threat, entreaty, or promise which streamed from the Palace, he remained the guest of Sir Philip Currie until, on the fourth day, he obtained from the Sultan a written assurance, which was formally communicated to the ambassadors, that his life and liberty should be respected. About the same period a palace chamberlain named Izzet Bey, by his denunciation of certain persons in whom the Sultan previously had confidence, established a powerful influence over his majesty's mind.

Just a fortnight after the new ministry entered upon office, five of the ambassadors demanded firmans for the inward passage of a second despatch-vessel to be attached to each embassy. Ordinary and special cabinet councils reported in favour of acceding to the ambassadors' demand, but the Sultan viewed it unfavourably, and—advised by Nazim Pasha, minister of police, that the admission of the vessels in question would dangerously excite Mahommedan feeling—placed the matter in the hands of Izzet Bey, and subsequently sent Kutchuk Said Pasha on a special mission to each ambassador praying him to relinquish the idea. They all, however, stood firm; but through Izzet Bey's proficiency in the art of procrastination three weeks elapsed before the firmans were delivered to the embassies. The disturbances in the Asiatic provinces which began while Kiamil Pasha was in office continued under the new ministry. The tragedies already mentioned were followed by similar scenes of bloodshed at Amasia, Marsovan, and Aintab, and by the drama of Zeitun—a town of about 10,000 inhabitants high up among the peaks of the Anti-Taurus. The Zeitunli had resisted taxation up to 1878, when a Turkish block-house was built near the town and garrisoned for the purpose of enforcing fiscal obligations. Alarmed at the events of the summer of 1895, the Zeitunli attacked the block-house, expelled the garrison, and closed all the approaches to the town. The Turks sent troops several times to open the place, but they were always driven back, and in December a regular campaign was opened with the object of subduing the Zeitunli. They repelled the first attack, after which all non-combatants left the place; but its defenders were soon forced to evacuate the block-house, and thereupon the ambassadors offered the mediation of the consuls to arrange a capitulation, the terms of which were concluded on 2nd March 1896. The Turks, however, were very tardy in fulfilling their engagements, and, notwithstanding the strenuous remonstrances of the combined embassies, three months passed before the capitulation was carried into effect. About this time affairs in the Haurán became critical. For many months the Sultan had fostered the intention of bringing the Druses of the Haurán and the Arab tribes of the Yemen into complete subjection. The first steps towards the attainment of this purpose were taken in December 1895, when the Martini rifles with which the Yemen troops were armed were replaced by Mausers, and the Sultan ordered that the Druses of the Haurán, who wore arms and refused to pay taxes, should surrender their weapons and submit to taxation. In pursuance of this latter command, the Vali, under promise of good usage, induced several Druse chiefs to go to Damascus to discuss differences; but, notwithstanding the promise, the chiefs were imprisoned and maltreated. This act of bad faith caused in the Haurán great exasperation, which was brought to a climax through the abduction in May by a Turkish officer of the daughter of a Druse chief. A few weeks later, about 17th June, the Druses rose against the troops and massacred four companies of infantry. The Porte thereupon sent reinforcements into the Haurán; the revolt was quelled; and the Druses paid their taxes.

Crete.

Meanwhile Cretan troubles were daily growing more acute. Karatheodory Pasha, who succeeded Mahmud Djelal-ed-Din Pasha as governor-general, and who in point both of character and ability stood in the forefront of Turkish public men, left early in 1896, and was replaced in March by Turkhan Pasha. By the middle of May the Christian population was in full insurrection; heavy reinforcements were sent to the island, and Marshal Abdullah Pasha was appointed to command them. On 6th June Abdullah Pasha asked for reinforcements, at the same time announcing the restoration of order and tranquillity. A week later the larger of two French despatch-vessels stationed at Constantinople was ordered to Canea. The European Concert had now taken the affairs of Crete in hand, and the ambassadors sought to convince the Sultan of the expediency of pacifying the island as promptly as possible. After much pressing, an imperial proclamation was sent to Abdullah Pasha informing the insurgents that if they would lay down their arms the Porte would be ready to redress well-founded grievances and to satisfy reasonable demands. At the same time the Porte asked for the assistance of the consuls in negotiating with the insurgents. But the ambiguous language of the proclamation, which had from the outset raised misgivings in the minds of the ambassadors—and especially the condition that the laying down of arms was to precede the statement of grievances,—kindled such suspicions in the minds of the Cretans that they could not be induced to negotiate upon that basis. The ambassadors therefore in a collective note urged that the Sultan should modify his proclamation, appoint a Christian governor, authorize the convocation of the assembly, and offer to renew the pact of Halepa. Following up this note by individual pressure, the ambassadors at length (27th June) obtained the Sultan's acquiescence. Georgi Pasha Berovitch, prince of Samos, was appointed Vali of Crete, and a few days later the Sultan ordered the cessation of hostilities, the proclamation of a general amnesty, and an unconditional offer to renew the Halepa pact. But meanwhile the Cretan pretensions had expanded, and it was only after two months' endeavour that the consuls succeeded in bringing the insurgents to accept the proper terms. The Sultan did nothing to redeem his promises, and on 10th October the ambassadors expostulated with the Porte concerning their non-fulfilment. But the efforts of diplomacy were fruitless, and the year closed without any approach to pacification.

Second Constantinople massacre.

After the Zeitun settlement Armenian affairs dropped for a while into the background; but the resignation of the Patriarch, whose steadiness of purpose and strength of will were displeasing to the Sultan, was brought about early in August. Mgr Izmirlian was succeeded by Mgr Bartholomeos as *locum tenens,* and his council was replaced by Palace nominees. Izmirlian was ordered to make a "pilgrimage to Jerusalem." About the middle of August a member of the council who had been mainly instrumental in procuring the resignation of Izmirlian informed the ambassadors that the Sultan would shortly proclaim an amnesty for all Armenians not suspected of revolutionary designs. A week later the Patriarch addressed a petition to the Sultan praying for this amnesty, and two days afterwards the second Constantinople massacre took place. The Patriarch Izmirlian had exercised over the revolutionists a restraining influence, which was nullified by his retirement. Just three weeks after that event the Patriotic Society put into execution the plan by which they hoped to enforce compliance with their demands. It was to place dynamite in the vaults of the Imperial Ottoman Bank, and to threaten to blow up that establishment unless the promised reforms were guaranteed. This was done in the forenoon of 26th August, when some thirty members of the society, armed with revolvers and bombs, concealed themselves in various parts of the bank; bombs were thrown into the great vestibule; a shell was exploded in the cash department; and the whole staff of the bank, panic-stricken, fled to the roof, whence some few escaped into adjacent premises, while the majority remained as hostages in the hands of the "patriots," who closed and barred the outer doors. While this was going on in the bank, bombs were thrown and revolvers fired in several parts of Galata and Pera. Troops quickly occupied the main thoroughfares, and, no less promptly, a mob of Lazes, Kurds, and Persians—the rabble of the Mahommedan populace—armed with iron-shod clubs and yataghans, poured into all the quarters north of the Golden Horn, and slaughtered every Armenian they could find, just as the *softas* had done in 1895, but on a scale proportioned to their vastly greater numbers. Neither troops nor police attempted to stay the carnage, which continued throughout the night, but ceased as if by word of command just before daybreak on the following morning. The hostages in the bank were released about midnight, in virtue of an arrangement concluded at Yildiz by the director-general of the bank, assisted by the first dragoman of the Russian embassy, by which the troops surrounding the bank were to be withdrawn, and the "patriots" were to be taken on board Sir Edgar Vincent's yacht at Kadikeui, thence to be transhipped by first steamer to England. The general conviction with regard to this frightful tragedy was that the Palace, by whose efforts the resignation of the Patriarch Izmirlian had been obtained, knew full well that some rash act on the part of the revolutionaries would follow that event, and had prepared and armed the mob of *gourdineurs* in order to take advantage of the expected opportunity. Sharing this conviction, the heads of the diplomatic missions abstained from illuminating their residences, as it is their custom to do, on the anniversary (31st August) of the Sultan's accession. The number of victims in this affair exceeded 3000, besides 1000 missing, whose fate was never ascertained. The city was plunged into consternation, prolonged by the sequel of wholesale arrests and expulsions which, notwithstanding diplomatic remonstrance, were continued up to nearly the end of September. In the course of that month upwards of 20,000 Armenians were shipped away to Black Sea or African ports, where they were landed and left in destitution. On the morrow of the massacre the six embassies presented to the Porte a collective protest against the proceedings of the previous day; but no notice was taken of it, and a second note was addressed, two days later, directly to the Sultan, declaring the state of anarchy in his capital to be intolerable, and setting forth the dangers to which it exposed his empire. The result was an iradé, issued 10th September, ordaining the constitution of a special commission, comprising delegates from the embassies, to regulate arrests, expulsions, and other matters arising out of the events of 26th August. Three days later the commission met, but achieved nothing, because the instructions given to the Turkish members were such that the questions for consideration could not be treated on a basis corresponding with the intentions of the embassies, to whose delegates, moreover, the Turkish members allowed only a consultative voice in the proceedings. However, towards the middle of the month (September) an alarm was raised about the "Young Turkey" party, suggesting the expediency of reconciliation with the Armenians. The Council of Ministers determined, therefore, to adopt conciliatory measures, and the French Ambassador in an audience was able to impress the Sultan's mind with the imperative necessity of restoring a legal order of things in the capital, and of placing the provincial administration on a stable footing. This latter recommendation his majesty followed by extending to the whole empire the inoperative charter of reforms granted in October 1895 for the six provinces inhabited by Armenians. Nevertheless arrests, condemnations, and expulsions continued throughout October; but early in November the Sultan authorized the convocation of the Armenian National Assembly in order to elect, in conformity with the prescription of the organic statute, a new Mixed Council, and to proceed to the election of a patriarch. This was carried out in the course of the month; a respectable council was constituted, and Mgr Ormanian, a prelate of high character and attainments, moderate views, and rare discretion, was elected Patriarch. In December the Sultan issued a decree of amnesty, and a month later it was officially announced that "all amnestied Armenians," including four under sentence of death, had been released. At the time of granting the amnesty the Sultan accepted a plan of reconciliation proposed by Artin Pasha, but in the iradé ordaining its adoption it was so mutilated as wholly to destroy its significance and value. This engendered much bitter feeling, and early in February wholesale arrests began again. Up to the middle of March the Patriarch was unable to obtain any concession, but the massacres of Everek and Tokat which occurred in that month called forth such severe reprobation from the ambassadors that in order to appease them an iradé was issued granting, with some slight modifications, the concessions comprised in Artin Pasha's plan. No action, however, was taken under this iradé, and the Armenians could obtain no redress of their grievances. In August some street disorders occurred; some bombs were discovered in Armenian houses; one was exploded at the Porte, and one was found in the possession of an Armenian, who proved to have just arrived from Russia, ascending the staircase of the bank. Denunciations, arrests, and expulsions began over again; and the patriarchate protested against the indiscriminate severities practised by the Turkish authorities, but the protest was unheeded. Towards the end of December the Mixed Council of Kum-Kapu presented to the Sultan a memorial embodying the twelve points of Artin Pasha's plan, together with four others relating to new grievances, and praying that his majesty would mercifully concede them. This petition elicited some vague promises which remain unfulfilled, while, on the other hand, further restrictions on Armenian liberties were imposed during 1899. Wearied of his failures, Patriarch Ormanian in the month of September presented his resignation to the Sultan, who returned it, and ordained a constitution of a commission to inquire into Armenian grievances, but this ordinance has not yet borne fruit. During the years 1895–97 Armenians from the provinces swarmed across the Russian frontier and took refuge in the Caucasus to the number of between forty and fifty thousand. In June 1898 the Russian ambassador requested the Porte to facilitate the return of these fugitives to their former homes. The Porte replied evasively, and the ambassador several times ineffectually reiterated his demand. At length on 24th May 1899 the Sultan personally requested M. Zinoview to defer the question, and the ambassador accordingly abstained from urging it until the middle of February 1900, when he renewed the demand, but, finding the Sultan still strongly opposed to the return of the fugitives, did not press it. On the 10th July his excellency presented a note to the Porte asking permission for the return of about 3000 of the expatriated Armenians, but no reply was given. The massacre of Tokat (March 1897) was the last incident of historical importance in connexion with this episode in Armenian affairs. It need only be added that in August 1899 an iradé was issued authorizing the convocation of the diocesans of the catholicosate of Sis to elect in the traditional manner a new catholicos, the office having been vacant for nearly two years in consequence of the Sultan's wish so to alter the mode of election as to give his majesty control over it.

War with Greece.

During the late months of 1896 and the early months of 1897 the affairs of Crete became worse, mainly owing to the obstructive and evasive treatment they received at the hands of the Porte. After two months' discussion the mixed commission for organizing the gendarmerie was despatched from Constantinople on 3rd December, and a few weeks afterwards the Porte, in a circular to the Powers, protested against the attitude of Greece. Early in February Greece sent troops to Crete, whereupon the Vali, Georgi Pasha Berovitch, threw up his appointment and left the island. Towards the end of the same month the Porte sent another circular to the Powers about Greek interference in Crete, and began to mobilize, moving troops from Asia into Europe, and despatching war material and stores by sea and land to depôts in more or less proximity to the Greek frontier. Edhem Pasha was called up from Syria to take command of the forces in Macedonia. On the 2nd March the six ambassadors presented a collective note to the Porte, announcing the intention of the Powers to make Crete autonomous, and declaring that there was no idea of handing over the island to Greece, which would be required to withdraw her troops and warships. Three days later the ambassadors sent in another collective note in which they stated their views about the "progressive reduction" of the Turkish forces in Crete. The Porte raised no objection to the scheme of autonomy, but replied evasively concerning the withdrawal of the imperial troops. At this period the dominant, though undeclared, idea in the mind of the Sultan's most intimate advisers was to punish Greece for meddling in Cretan affairs. In pursuance of this purpose, towards the end of March a naval squadron, composed of four ironclads, two cruisers, one gunboat, two torpedo-boats, and two torpedo-catchers, was despatched to Gallipoli, and the 2nd and 3rd army corps—of which the headquarters were Adrianople and Monastir—were reinforced. Greece replied by increasing her forces on the frontier, and the Powers, through their representatives, warned (6th April) both states that in the event of war the aggressor would be held responsible, and if victorious would obtain no advantage. The Porte issued a series of circulars to its representatives abroad, all complaining of the situation, the last (10th April) protesting against a violation by Greek troops of the frontier near Metzovo. Meanwhile Edhem Pasha pressed for orders to advance into Thessaly. An iradé issued 17th April instructed him to do so, and ordered the recall of the Ottoman minister from Athens and the delivery of passports to the Greek minister in Constantinople. Greece and Turkey were now at war. A few days revealed the fact that Greece was overmatched, and on 12th May the six ambassadors opened mediatory negotiations by presenting a collective note demanding an armistice. Shortly afterwards the mediating Powers began treating for a basis of peace, but the Turkish demand, *inter alia*, for the cession of Thessaly, and for an indemnity of ten millions sterling, rendered the negotiations laborious. They extended over four months, the Sultan's acceptance of the preliminaries being communicated to the ambassadors on 27th September. During the first week in October the plenipotentiaries for the settlement of the peace treaty were appointed: for Turkey, Tewfik Pasha, foreign minister, with Assim Bey, Ottoman minister in Athens, as coadjutor; for Greece, Prince Mavrogordato, Greek minister in Constantinople. The negotiations lasted nearly seven weeks; the treaty was signed on 4th December, and a fortnight later ratifications were exchanged.

During the first weeks of the peace negotiations diplomatic attention was withdrawn from Cretan affairs, but was attracted to them in July, when the Porte talked of sending reinforcements, and again later when Djevad Pasha, who had taken up his appointment as Vali, brought about a state of friction with the admirals which they reported to be intolerable. In the early days of October the Porte sent a circular to its representatives abroad bidding them urge the Powers to settle the Cretan question, and proposing to that end (1) the disarmament of the whole population; (2) the appointment of a Christian Vali; (3) that of a Christian or European officer in the Turkish service to the command of the troops stationed in the island. This measure was barren of result. The ambassadors had frequent meetings, in the course of which they drafted a scheme of organization for the government of the island, and at their last gathering in that year (2nd December) they refused to entertain the Porte's proposal to send fresh troops to replace about 4500 time-expired men. At the same meeting the Russian ambassador put forward the candidature of Prince George of Greece for the governorship. The Sultan manifested great repugnance to this proposal, and in a series of communications to the Powers maintained that this office could not be fitly or fairly bestowed upon any but an Ottoman subject. In March, however, Russia, seconded by Great Britain, brought the Porte to understand that the objections of Europe to that arrangement were insuperable. In June the question of a temporary régime, preparatory to the autonomy already decided upon, came under discussion. About the same time the Austrian and German ambassadors withdrew from the diplomatic conferences, and the solution of the Cretan problem was left to the representatives of France, Great Britain, Italy, and Russia, the performance of whose task the Porte did its utmost to obstruct. In official circles hopes were entertained that the German Emperor, expected in Constantinople in October, would give the Sultan effectual support in Cretan matters, and accordingly Djevad Pasha, ex-Vali of the island, was ordered to Beirut to meet the Emperor and accompany him to Palestine. About this time the four Powers gave notice to the Porte to evacuate Crete, and after some profitless endeavours to obtain a mitigation of this condition, and finding that there was nothing to expect from the Emperor William, the Porte ordered the troops to leave the island, and by the middle of November the evacuation was complete. The four embassies then notified the appointment of Prince George as High Commissioner, the Porte acknowledged the communication with many expressions of regret, and Cretan affairs passed out of the hands of the four ambassadors.

The Yemen.

It has already been mentioned that Sultan Abdul Hamid had in view the complete subjection of the Yemen, and to that end had, in 1895, furnished the 7th army corps with Mauser rifles. But with the exception of general instructions and occasional reinforcements sent to Ahmed Feizi Pasha, civil and military governor, who by unremitting severity had succeeded in establishing a certain measure of order in the province, no action was taken until the spring of 1898, when, in consequence of the then prevalent scarcity, a revolt broke out. The Sultan appointed Hassan Hilmi Effendi to be Vali, leaving the military command in the hands of Feizi Pasha. Hassan Hilmi's endeavours were pacificatory, but they were defeated by the intrigues of Ahmed Feizi, whom the Sultan recalled early in June, appointing Abdullah Pasha, commander of the 5th army corps, in his place. Abdullah prayed to be relieved of this duty. At that time the Vali was blockaded in Sanaâ by the insurgents. Their movements were ordered by the Imam Zeid, calling himself the "True Khalif," whose headquarters were at Sadeh, and whose pretensions were said to be countenanced by the Sherif of Mecca. The Sultan became seriously alarmed, ordered the despatch of reinforcements to the number of 16,000 men, and insisted that Abdullah Pasha should take command of them. In June it was officially announced that all the tribes had submitted, and that imperial authority had been established throughout the country. But it was learnt privately soon afterwards that Abdullah had been repulsed in an expedition against the Kublet-el-Azin tribes; that the tax-gatherers had been driven from Libit, a district near Hodeida; and that in the whole region north of the Hodeida–Sanaâ line the only recognized ruler was the Imam Zeid. Tidings of similar purport were received in Constantinople early in October. A few days later the Sultan issued an iradé ordaining the division of the Yemen into four viláyets, each with a governor-general and full provincial administration. That ordinance has not yet been carried into effect.

Macedonian question.

Among the many troubles of 1898 was the evil fruit of the indulgence bestowed upon the Mahommedan Albanians. This turbulent race, always prone to insubordination, defied all authority and committed every sort of outrage on the Servian, Bulgarian, and Montenegrin residents in their country, violating on several occasions the Servian and Montenegrin frontiers. The governments of these states, and of Bulgaria, formally protested, and the embassies of the Powers in Constantinople expostulated, but all that they obtained was the despatch of commissions of inquiry to Albania, and the reinforcement of the Turkish garrisons in that region. The Albanian excesses, however, went on as before, and complete anarchy overspread all the country between the river Vardar and the Adriatic. In November 1901 Kiazim Pasha, Vali and military commander of Scutari in Albania, who for four years had bravely and ably contended with this situation, resigned his post, finding it useless to persevere without support from Constantinople. Out of all these circumstances grew what has become known as the "Macedonian Question," *i.e.*, the project of transforming the Turkish provinces west of the Vardar into an autonomous state.

German commercial projects.

In the autumn of 1898 (28th October) the German Emperor and Empress, on their way to Jerusalem, paid a visit to the Sultan, and were his guests for four days in the Merassim Kiosk (specially built in Yildiz Park to receive them on their first coming in 1889), to which a new wing was added for this occasion. The outcome of the Emperor's visit was a concession (19th March 1899) to the Anatolian Railway Company, a German undertaking, for a port and bonded warehouses at Haidar Pasha, where the line has its terminus in proximity to the British (Crimean) cemetery, from which the magnificent view which it formerly commanded is now shut out by the new buildings. The Emperor also obtained a promise from the Sultan of the extension of this line from Konieh to Baghdad and Basra, and a firman to that effect was delivered to the company on the 27th November 1899. In compensation for this act of favour to Germany, Russia demanded and obtained a prior right, on equal terms, over all applicants for railway concessions in Asia Minor north of the German line. Up to the end of November 1901 the convention for the Konieh–Basra line was not concluded, as the syndicate, besides adding several branches to their original scheme, demanded many supplementary privileges and a Government guarantee of net traffic receipts to the amount of 13,000 francs per kilometre. The demand for branches and incidental privileges called forth no serious objection, but the Sultan was strongly opposed to the kilometric guarantee.

Turkish schemes in Arabia.

In April 1900 the Sultan announced his intention of constructing a railway from Damascus to the Hedjaz. In Palace circles it was said at the time that the idea originated in the Sultan's anxiety to exercise a stricter control over the caravans of pilgrims, amongst whom seditious literature was said to be largely distributed by revolutionary agents. But it is certain that the Sultan was also actuated by other motives, the most direct of which was the desire to acquire a firmer hold of his Arabian provinces—Hedjaz and Yemen—where in recent years the weakness of his authority had been made conspicuous by many untoward incidents. Moreover, he felt that the railway would show forth its founder as a benefactor of Islam, and promote Pan-Islamic views. The Sultan at once set on foot a subscription towards the cost of the railway, and appealed for contributions to Mussulmans in all parts of the world. He headed the list with a subscription of £50,000 (Turkish), and the works were begun on 31st August, the twenty-fifth anniversary of his accession to the throne. In the latter part of 1901 the Sultan's activity was also shown in various intrigues against British influence on the Persian Gulf, notably at Koweit.

Young Turkey.

The "Young Turkey" Association, resuscitated at Geneva in 1891 after an entombment of twenty-two years, lacking as it does pecuniary resources, cohesion, definite purpose, and capable leaders, has not shown itself a formidable organization. Nevertheless alarms concerning its sinister intentions have been several times raised in Constantinople, and on each occasion the Sultan has taken steps to win back to their homes and to their allegiance some of those Turks who had gone abroad to make open profession of "Young Turkey" doctrine; and inasmuch as a large proportion of them had gone into exile with the express object of being persuaded to return, many were brought back by that means. Thus there remained in Western Europe (1) those who had no faith in promises; (2) those whom the Sultan did not care to reclaim; (3) a very few who, sincerely Liberal in their views, hold the existing system in abhorrence. These are the elements of which the "Young Turkey" Association consists. In recent years the Sultan has been increasingly anxious about it, having become aware that aversion from his rule has inspired the great majority of educated Turks, including a large proportion of the Ulema, with Liberal ideas. At the end of 1900 the Sultan's anxieties about "Young Turkey" became more and more acute, and prompted him to measures of counteraction which the circumstances did not warrant, and which, by the undeserved suffering they occasioned, greatly increased the disaffection of his Mahommedan subjects and largely swelled the ranks of the malcontents.

The foreign post offices.

One of these measures brought him into serious diplomatic difficulties. In April 1901 he was warned by his ambassador in Paris that the "Young Turkey" committees were preparing a demonstration which was planned to come off in Constantinople early in June, or sooner if possible. The ambassador urged the Sultan to take all possible precautions, and especially to intercept the correspondence passing between the committees and the members of the association residing in Constantinople. The only way of accomplishing this was to break open the mail bags addressed to the foreign post-offices, which on arrival pass, sealed, through the Turkish post office, and, being inviolable according to international compact, are so delivered to the several foreign postmasters. Notwithstanding this well-established rule, the Turkish postal authorities on the 6th May opened the foreign mail bags, confiscated the letters which appeared to them suspicious, and distributed the remainder. The four embassies concerned—Austrian, British, French, and German—immediately presented to the Porte an identic note protesting against the violation of the mail bags as a breach of international law, and telegraphed to their Governments for instructions. On the following day they sent dragomans, accompanied by marines and sailors from the despatch-boats, to meet the mail train and take possession of the letter-bags addressed to their respective post offices. This was done, the Turkish postal authorities offering no resistance, but merely declaring that the Turkish post would no longer take charge of the outward bags. These the ambassadors therefore despatched by a special messenger. The Porte replied to the ambassadors' protest, justifying its action in opening the mail bags; but the ambassadors refused the Porte's note, and returned it. A second note of similar purport was returned in like manner; a third, somewhat apologetic in tone, was accepted. This change of tone was due to the fact that the Sultan had become aware that the embassies were discussing, and indeed preparing, a naval demonstration which they had recommended to the sanction of their Governments. A week later the Sultan, overpowered by his dread of a naval demonstration, sent his Minister for Foreign Affairs to the four ambassadors to inform them that his majesty retracted all that had been ordered regarding the foreign mails, and that the foreign post offices were free to work as they had previously done, and to use the Turkish post for the transmission of their bags. The Austrian, British, and French ambassadors refused to take official cognizance of this declaration, as they were awaiting instructions from their Governments; but the German ambassador immediately accepted it as a satisfactory solution of the difficulty. Three days later the Minister for Foreign Affairs again went to the three embassies, and renewed the Sultan's declarations and assurances, adding to them a humble apology and the Sultan's formal pledge that the Government would never again interfere with the foreign post offices. These overtures the ambassadors then acknowledged in a collective note, and having referred to their Governments, accepted them on the 14th May, and on the 16th May the *status quo ante* of the foreign post offices was re-established.

Crisis with France.

Another diplomatic difficulty arose in 1901. Early in the year the Quay Company, a French undertaking, brought complaints against the Turkish authorities for obstructing its works and for infringing its rights and privileges. The French embassy urged these complaints for several months at the Porte and at the Palace without obtaining any redress. The embassy had also in hand a claim in respect of the expropriation of a French subject who had bought and drained the marshes of Ada Bazar. In May the embassy put forward the long-standing pecuniary claims of two Levantine bankers, French "protected" subjects, which the Porte showed so much disinclination to admit that its relations with the French embassy became discordant, and the ambassador, M. Constans, repeatedly threatened to leave Constantinople. Convinced at length that M. Constans was in earnest, the Porte early in August adjusted the Quay question and settled the Ada Bazar claim, but still shirked those of the two bankers. M. Constans therefore broke off relations with the Porte, and left Constantinople on the 26th August. Two months passed without arriving at a settlement, and at the end of October France despatched a naval squadron, under Admiral Caillard, to Turkish waters, and presented to the Porte four new demands, compliance with which the French Government declared to be a condition *sine quâ non* of the renewal of diplomatic relations. The new demands were (1) the legal recognition of all French educational institutions, whether national or protected; (2) the legal recognition of all French religious and elementary institutions, whether national or protected; (3) firmans authorizing the restoration of all buildings, belonging to such institutions, which were damaged in the disturbances of 1894 and 1896; (4) the recognition of the Chaldean Patriarch. These demands were presented to the Porte on the 2nd November. The French squadron arrived at Mytilene on the 5th November, and on the following day the bankers' claims were arranged, an iradé recognized the Chaldean Patriarch, and satisfactory assurances were given regarding the other demands. These assurances were supplemented two days later by a formal acceptance; and by the evening of the 10th November all points were finally settled, the French squadron quitted Mytilene, and on the following day diplomatic relations were resumed. On the 9th November Khalil Rifaat Pasha died, having held office for six years, the record of which was one of steadily progressive deterioration in all departments of the public service, with a corresponding diminution of commercial and industrial prosperity alike in the capital and in the provinces. The Sultan hesitated for some days over his choice of a new Grand Vizier, but on the 16th November he recalled to that office Said Pasha, whom he had dismissed therefrom on the 2nd October 1895, and who had since been living in retirement.

The opening of the year 1902 found Turkey in friendly relations with all the European Powers, but involved in serious internal difficulties. These were financial embarrassments; stagnation and unprosperity throughout the whole domain of commerce and industry; anarchy in the eastern provinces of Asia Minor and in the western provinces of the Balkan Peninsula; disorganization in all departments of the central administration, rendering utterly impotent those of the provinces. It was in view of these difficulties, and of "Kutchuk" Said Pasha's well-known aptitude for dealing with them, that the Sultan was induced to call once more to office the long-discarded favourite of the earlier years of his reign.

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III. FINANCE.

Preliminary Sketch.—From the outset of their history the Osmanli Turks adapted to their own particular needs most of the political, economical, and administrative institutions which existed before them. Primarily their system was based on the great principles enunciated by the immediate successors of the Prophet, especially by Omar, involving the absolute distinction between, and impartiality of treatment of, the Mussulman conquerors and the races which they conquered; and from this point of view a careful study of the financial history of Turkey will afford most valuable insight into the little understood causes of what has been known for generations as the Eastern Question.

In reward for the brilliant services rendered him by Ertoghrul (the father of Osman) and by Osman himself, Ala-ed-diñ, the last of the Seljuk sultans, conferred certain provinces in fief upon these two great warriors. They in their turn distributed the lands so acquired among their sons and principal emirs on strictly feudal principles, the feudatory lands being styled *ziamet* and *timar*, a system long continued by their successors in regard to the territories which they conquered. The conquered peoples fell into an inferior caste, made to work for, and to pay for the subsistence of, their conquerors, as under the Arab domination; the principal taxes exacted from them were the *kharadj* (a kind of poll-tax paid for the privilege of gaining means of existence in a Mussulman country), and the *djiziyé*, a compulsory payment in lieu of military service. The conquerors were feudatories of the reigning prince or sultan, and their payments consisted principally in providing fighting forces to make up the armies of the prince. The *kharadj*, the *djiziyé*, and the whole feudal system disappeared in theory, although its spirit, and indeed in some respects its practice, still exists in fact, during the reforming period initiated by Sultan Selim III., culminating in the Tanzimat-i-Khairiyé (1839) of Abdul Medjid, and the Hatt-i-Humayoun issued by the same Sultan (1856). The administration of the state revenues was managed by a Government department known as the Beit-ul-Mal or Maliyé, terms generally employed throughout Islamic countries since the commencement of Islam. But the entire financial authority resided in the Sultan as keeper, by right, of the fortune of his subjects. The public revenues were passed under three principal denominations—(1) the public treasury; (2) the reserve, into which was paid any surplus of revenues over expenses from the treasury; (3) the private fortune (civil list) of the prince. Expenditure, as under the Seljuk sultans, was defrayed partly in cash, partly in "assignations" (*havalé*), a system which will be referred to later.

The Osmanli sultans, as also the Mamelukes and the Seljuks, were accustomed to give *largesse* to their military forces on their accession to the throne, or on special occasions of rejoicing, a custom which still is practised in form, as for instance on the first day of the year, or the birthday of the Prophet (*mevlûd*). Largesse was especially given on the field of victory, and was, moreover, liberally distributed to stifle sedition and mutiny among the troops, the numerical strength of whom was continually increased as the empire enlarged its borders. This vicious system, grafted as it was upon an inefficient administration, and added to the weight of a continually depreciated currency, debased both by ill-advised fiscal measures and by public cupidity, formed one of the principal causes of the financial embarrassments which assailed the treasury with ever-increasing force in the latter part of the 16th and during the 17th and 18th centuries. The Turkish historian, Kutchi Bey, attributes the origin of the decline of the empire to the reign of Suleiman the Magnificent (1520–1566), when the conversion of many *emiriyé* lands into *vakoufs* (see *infra*) was effected, and the system of farming out revenues first introduced. Impoverished by these different causes, as well as by prodigal extravagance in interior expenditure, by shameless venality among the ruling classes, and by continual wars, of which the cost, whether they were successful or not, was enormous, the public treasury was frequently empty. So long as the reserve was available, it was drawn upon to supply the void; but when that also was exhausted recourse was had to expedients, such as the borrowing, or rather seizure, of the *Vakouf* revenues (1622) and the sale of crown properties; then ensued a period of barefaced confiscation, until, to restore public confidence in some measure, state budgets were published at intervals, viz., the partial budget of Ainy-Ali (in 1018 or A.D. 1609), the budget of Ali Aga (in 1064, or 1653), and that of Eyoubi Effendi (in 1071, or 1660). At this time (1657–1681) the brilliant administration of the two Keuprulus restored temporary order to Ottoman finance. The budget of Eyoubi Effendi is particularly interesting as giving the statement of revenue and expenditure for an average year, whereas the budget of Ainy-Ali was a budget of expenditure only, and even in this respect the budget of Eyoubi Effendi is far more detailed and complete. The receipts amounted in round figures to a sum of 2,400,000,000 *aqtché*, equivalent to 60,000 purses, or 30,000,000 crowns, or about 6,000,000 modern Turkish pounds (£T1 = about 18s. 2d. in sterling), and a deficit is shown of about 308 purses (or 12,330,000 *aqtché* = 154,000 crowns). The budget of Ali Aga is almost identical with that of Eyoubi Effendi, and is worthy of special note for the conclusions which accompanied it, and which, although drawn up 250 years ago, described with striking accuracy some of the very ills from which Turkish finance is still suffering. "This budget," said the director of the Maliyé, "shows a deficit of 2000 purses" (about 1,000,000 crowns) "caused by the system of anticipation adopted by the previous grand vizier and defterdar: the receipts of 1064 have been totally absorbed, as also more than half those of 1065; consequently the revenues of those years will be almost *nil*, and there will be a large deficit. I must add that, for the most part, the salaries inscribed in the budget have not been paid to those entitled to receive them; there still remains to be paid a balance of 2000 purses, the amount of the deficit above shown."

Apart from unimportant modifications, the form of the budget must have remained unchanged until the organic reforms of Selim III., while its complete transformation into European shape dates only from the year 1278 (1862), when Fuad Pasha attached a regular budget to his report on the financial situation of the empire. Since that time there has been no further change worth noting; although the publication of the budget has only taken place at very irregular intervals, it must also be observed that the published budgets are by no means accurate. From the time of Eyoubi Effendi until the end of the grand vizierate of Ibrahim Pasha (1730), the empire experienced periodical relief from excessive financial distress under the series of remarkable grand viziers who directed the affairs of state during that time, but the recovery was not permanent. Ottoman arms met with almost systematic reverses; both the ordinary and the reserve treasuries were depleted; a proposal to contract a foreign loan (1783) came to nothing, and the public debt (*dûyûn-i-umûmiyé*) was created by the capitalization of certain revenues in the form of interest-bearing bonds (*sehims*) issued to Ottoman subjects against money lent by them to the state (1785). Then came forced loans and debased currency (1788), producing still more acute distress until, in 1791, at the close of a two years' war with Russia, in which the disaster which attended Ottoman arms may be largely ascribed to the penury of the Ottoman treasury, Selim III., the first of the "reforming sultans," attempted, with but little practical success, to introduce radical reforms into the administrative organization of his empire. These endeavours were continued with scarcely better result by each of the succeeding sultans up to the time of the Crimean war, and during the whole of that period the financial embarrassment of the empire was extreme. Partial relief was sought in the continual issue of debased currency (*beshlik*, *altilik*, and their subdivisions), of which the excess of nominal value over intrinsic value ranged between 33 and 97 per cent., and finally paper money (*kaimé*) which was first issued in 1839, bearing an interest of 8 per cent., reduced in 1842 to 6 per cent., such interest being paid on notes of 500 piastres, but not on notes of 20 or 10 piastres which were issued simultaneously. Finally, usage of paper money was restricted to the capital only, and in 1842 this partial reform of the paper currency was followed by a reform of the metallic currency, in the shape of an issue of gold, silver, and copper currency of good value. The copper coinage has since disappeared, but the gold and silver currencies of Turkey are now practically the same as they were ordered then. The gold coins issued were 500, 250, 100, 50, and 25 piastres in value, the weight of the 100-piastre piece (Turkish pound), 7·216 grammes, ·916⅔ fine. The silver coins were of 20, 10, 5, 2, 1, and ½ piastre in value, the 20-piastre piece weighing 24·055 grammes, ·830 fine. The copper money was in pieces of a nominal value of 40, 20, 10, 5, and 1 paras, 40 paras being equal to 1 piastre. In 1851 further attempts were made to withdraw the paper money from circulation, but these were interrupted by the Crimean war, and the Government was, on the contrary, obliged to issue notes of 20 and 10 piastres. Finally, at the outbreak of the Crimean war Turkey was assisted by her allies to raise a loan of £3,000,000 in London, guaranteed by Great Britain and France; in 1855 an organic law was issued regulating the budget, and in the same year a second guaranteed loan of £5,000,000 was contracted in Great Britain. In 1857 an interior loan of 150,000 purses in bonds (*esham-i-mumtazé*), repayable in three years and bearing 8 per cent. interest, was raised; the term of repayment was, however, prolonged indefinitely. In the same year another series of bonds (*hazine tahvili*), bearing 6 per cent. interest, and repayable in 1861, was issued; in 1861 the term of reimbursement was prolonged until 1875. In 1858 a third loan was contracted in Great Britain for £5,000,000, and thereafter foreign loans followed fast on one another, in 1860, 1862, 1863, 1864, 1865, 1869, 1872, 1873, and 1875, not to mention the two Egyptian tribute loans raised on Egyptian credit in 1871 and 1877. (For further information regarding the Ottoman public debt and suspension of payments in 1876, &c., see p. 510.) In 1859 the settlement of palace debts gave rise to the issue of 1,000,000 purses of new interior bonds (*esham-i-djedidé*) spread over a period of three years, repayable in twenty-four years, and bearing interest at 6 per cent. Further 6 per cent. bonds, repayable in ten years, and styled *serguis*, were issued in the same year. Seeing the rapid increase of the financial burdens of the state, a commission of experts, British, French, and Austrian, was charged (1860) with setting the affairs in order, and with their assistance Fuad Pasha drew up the budget accompanying his celebrated report to the Sultan in 1862. Meanwhile *kaimé* was being issued in great quantities (about 60,000 purses a month) and fell to a discount (December 1861) of 250 per cent. In 1862 further *sehims* were issued, and these and the loan of 1862 (£8,000,000) were devoted to the withdrawal of the *kaimé*. Later, however, the *kaimé* was again issued in very large amounts, and the years succeeding 1872 up to the Russian war presented a scarcely interrupted course of extravagance and financial disorder, the result of which is described below.

The *Budget* is supposed to be drawn up according to an excellent set of regulations sanctioned by imperial decree, dated 6th July 1290 (1875), of which the first article absolutely prohibits the increase, by the smallest sum, of any of the expenses, or the abandonment of the least iota of the revenues, fixed by the budget. The *revenues* are divided into two categories, viz., the direct and the indirect. The first category includes the "imposts" properly so called, the fixed contributions (*redevances fixes*) to be paid by the "privileged provinces," and the military exoneration tax. In the second are comprised tithes, mine-royalties, forests and domains, customs, sheep-tax, tobacco, salt, spirits, stamps, and "various." The expenses are also divided into two categories—(1) "Periodic and fixed" expenditure, which admits of neither reduction nor delay; and (2) the credits allowed to the various departments of state, which may be increased or diminished according to circumstances. The expenditure of the first category is made up of the service of foreign loans, of the general debt, of the dotations replacing *ziamet* and *timarat* (military fiefs), and of fixed contributions such as *vakoufs*. In the second category are included the imperial civil list, the departments of the Sheikhu-'l-Islamât and of religious establishments, the ministries of the interior, war, finance, public instruction, foreign affairs, marine, commerce (including mines and forests), and public works, and, finally, of the Grand Master of Ordnance. For every province (*vilayet*) a complete budget of receipts and expenditure is drawn up by its *defterdar* (keeper of accounts) under the supervision of the *vali* (governor); this budget is forwarded to the minister of finance, while each ministry and department of state receives communication of the items appertaining to it. Each ministry and department then sends in a detailed budget to the Sublime Porte before the end of December of each year. (The Turkish financial year is from 1st March to 28th February o.s.) The Sublime Porte forwards these budgets, with its own added thereto, to the minister of finance, who thereupon draws up a general budget of receipts and expenses and addresses it to the Sublime Porte before 15th December. This is summarily considered by the council of ministers, and then referred to the budget commission, which is to be composed not only of State functionaries, but of private persons "worthy of confidence, and well versed in financial matters," and which is invested with the fullest powers of investigation and inquiry. The report drawn up by the commission on the results of its labours is submitted to the Council of Ministers, which then finally draws up a general summary of the definitive budget and submits it by *mazbata* (memorandum) for the imperial sanction. When this sanction has been accorded the budget is to be published. The remaining regulations set forth the manner in which extra-budgetary and extraordinary expenses are to be dealt with, and with the manner in which the rectified budget, showing the actual revenues and expenditure as proved at the close of the year, is to be drawn up with the assistance of the state accounts department (*divân-i-mouhassebât*). This rectified budget, accompanied by an explanatory memorandum, is examined by the budget commission and the Council of Ministers, and submitted for the imperial sanction, after receiving which it is ordered that both be published. Special instructions and regulations determine the latitude left to each department in the distribution of the credits accorded to it among its various heads of expenditure, the degree of responsibility of the functionaries within each department, and the relations regarding finance and accounts between each department and its dependencies. These regulations provide carefully and well for all contingencies, but unfortunately they are only very partially carried out. It may indeed be said that it is only the *previsionary* budget (*Anglicé*, "the estimates") that receives any approximately proper care on the lines laid down, while the rule that both the estimates and the definitive budget (at the close of each year) should be published is almost wholly honoured in the breach; the budget has only twice been published, in 1880 and 1897, since the regulations were put into force. It must also be observed that not only are the budgets not published, but the utmost vigilance is exercised that no figures whatever should transpire in regard to the true position of the Turkish treasury,—which lays the accuracy of even the limited number of budgets published open to suspicion. It is therefore impossible to arrive at any trustworthy figures from published information, but the figures given below have been extracted or calculated from unpublished reports of budget commissions which did their work well and had the courage to record their opinions, and from carefully rectified budgets. If anything, rather favourable figures are given, both as regards revenue and expenditure.

Revenue.—For the sake of simplicity the revenues will be here massed into groups, certain main items being separated out:—*Direct Taxes.*—"Verghi," direct tax on realty, £T12,100,000; "Temettü," proportional tax on business profits, £T443,000; "Military exoneration tax," which submits non-Mussulman male Ottoman subjects between 15 and 75 years old (except priests and religious orders) to a tax of £T50 for 135 persons: £T665,000. Tributes and contributions from "privileged provinces" it is not proposed to deal with here. All of them, save the Egyptian tribute (£T750,000), which is entirely pledged for the service of loans, have been handed over to the international administration of the Ottoman public debt, whose revenues being hypothecated to the bondholders, do not, and probably will not for very many years, affect the general financial situation of the empire. A special section below gives a summary account of this administration. *Indirect Taxes.*—"Tithes," originally one-tenth of the agricultural produce of the country, but raised gradually under various pretences, styled "Public instruction," to 12 per cent., £T4,000,000; "Tax on sheep, camels, buffaloes, and hogs," a variation of the tithe, £T100,000; "Customs," 8 per cent. *ad valorem* duty on all articles imported pending the conclusion of new commercial treaties, £T2,000,000. The new treaties will establish specific duties. It is credibly estimated that under them, the imports remaining the same, the customs revenue will be increased by £T560,000, of which £T260,000 would be apportioned to the revenues assigned to the bondholders, and £T300,000 would fall to the share of the imperial Government. It is uncertain when the treaties, for which the negotiations have already been protracted through many years, will come into force. "Posts and telegraphs," £T320,000; "Mines and forests," 15 per cent. on the value of ores extracted and wood cut, £T273,000; "Ministry of justice," stamps and fees (tribunals), £T210,000; "Municipal taxes," various dues collected on permits granted for construction, repairs, &c., £T91,000; "Registration and transfer fees" (*tapou*), registration and transfer of real property—for special reasons this revenue was considerably less in 1897, but since these special reasons have to some extent ceased, it is considered better to take the average of several preceding years—£T218,000; "Sundries," these include receipts from the "Mahsoussé steamships," a commercial line of steamers worked directly by the Admiralty, £T202,000; "Various railway receipts," £T86,500; "Heraclea coal mines," £T42,000; "Interest on securities deposited with Imperial Ottoman Bank," £T38,700; "Rent of Tumbeki monopoly," £T40,000. Other revenues arising from various sources not included under the above headings are difficult to follow in detail, as the receipts of which they are composed are not always placed under the same heads, and the totals under various heads appear, therefore, to fluctuate without any assignable reason: £T1,992,000.

Expenditure.—(1) *Civil list*, £T1,000,000. This is the amount estimated to be drawn by the Sultan on the Treasury. It does not include the very considerable revenues obtained from the Crown lands and properties which are the Sultan's private property and are administered by a special department, the *haziné-i-hassa* (private treasury), under the authority of the "minister of the civil list," who works under the direct supervision of the Sultan himself, to whom alone he is personally responsible. The Crown lands and properties being exempt from every kind of tax, many abuses have crept in through this channel to the great detriment of the state. One of the leading instances of this is the fact that at the time of the collection of the sheep-tax private individuals drive their flocks and herds, with the connivance of the civil list (which receives a consideration for its good services), on to the Crown lands, where they can without fear claim exemption from the tax. The civil list has also an insatiable appetite for land, which it acquires often far below market price, and sometimes for nothing at all, as is easily conceivable in a land ruled by an absolute despot. It is estimated that more than one-third of the empire, and generally the richest lands, have now passed into the hands of the sovereign. Abuses of the kind described above therefore tend to increase, while more and more property is becoming legally non-taxable. The contributions of the state revenues to the civil list are secured on the customs, the *defter-khane*, and tithes of the richest provinces. (2) *Military.*—This includes the three departments of war, £T5,200,000; ordnance, £T886,000; and gendarmerie, £T1,014,000. It is curious to observe that the budget decree of 1880 stringently limited the peace strength of the Ottoman military forces to 100,000 men, "including officers and generals," in order to put a stop to the rapidly increasing military expenditure; in spite of this decree, however, which has never been formally repealed, the peace strength has gradually increased until it now stands at over 180,000 men. Nevertheless, the expenditure which stood at £T9,500,000 for the three departments mentioned has been apparently reduced to £T7,100,000. This is accounted for partially by the facts that rearmament was proceeding in 1880, and that the expenditure on gendarmerie and ordnance is now comparatively small; and for the rest by the separation of certain payments into "extraordinary expenditure" which is not shown in the budget. (3) *Marine.*—The expenditure on the marine, as shown in the budget, was cut down in 1897 from £T640,000 to £T546,000; but this was a budgetary device. The Greek war (1897) showed the Sultan the decrepit state into which his navy had fallen, and the importance of strengthening it to the point of being able to hold his own at sea, at least against the Greeks. Considerable "extraordinary" expenditure was incurred in 1902 to put the most modern Turkish men-of-war into a serviceable condition, and the ordinary expenses of the marine have remained at the previous level. (4) *Civil Departments.*—(*a*) Ministry of interior, £T784,000; (*b*) posts and telegraphs, £T350,000; (*c*) customs service, £T279,000; (*d*) mines and forests, £T83,000; other civil administrations and sundries, £T2,658,000. Total civil department, £T4,154,000. (5) *Religious Establishments and Sundries.*—These include educational expenditure, pensions, contributions to *vakoufs*, and expenses of the sacred caravan, and amount to £T750,000. (6) *Public Debt.*—Although the revenues ceded to the bondholders and the tributes were expressly left out of the revenue account, certain payments must be entered on the expenditure side. These are—

To public debt administration in lieu of ceded revenues	£T152,600
,, Service of loans (secured on tithes, railways, Tumbéki, &c.)	1,137,000
,, Railway guarantees[1]	750,000
,, Russian war indemnity	450,000
,, Commission to Ottoman Bank for treasury services and new agencies .	80,000
Total	£T2,569,600

Floating Debt.—It is impossible to fix accurately any annual outgoings under this head; financially speaking, the Turkish Government lives in such a "hand-to-mouth" manner that it is more than probable that it does not itself know what is the real amount of the floating debt. An ingenious calculation in the *Fortnightly Review* of March 1897 places it at £T55,702,000. This includes average yearly deficits of £T3,000,000 on the general budget of the empire for a period of fifteen years; as these are largely composed of salaries in arrear, and other items of a similar kind, which it is probable that the Government will never in any circumstances make good, it would be safe, as the writer in the *Fortnightly* points out, to reduce the figure considerably, but even so, it could scarcely be compressed to less than £T25,000,000. Seeing, however, the impossibility of arriving at any positive conclusions, it will be better to adopt the official figure allowed in the last published budget, viz., £T523,400, as that annually required to meet the most pressing needs of the floating debt.

Normal Budget of the Ottoman Empire exclusive of Service of Consolidated Debt and Tribute Loans.

Revenue.	£T	Expenditure.	£T
Verghi	2,100,000	Civil list	1,000,000
Temettü	443,000	Ministry of war . .	5,200,000
Military exemption tax .	665,000	Ordnance	886,000
Tithes	4 000,000	Gendarmerie . . .	1,014,000
Sheep tax	1,700,000	Marine	640,000
Customs	2,000,000	Ministry of interior . .	784,000
Posts and telegraphs .	320,000	Ministry of posts and telegraphs	350,000
Mines and forests . .	273,000	Ministry of mines and forests	83,000
Ministry of justice . .	210,000	Customs	279,000
Municipal taxes . .	91,000	Other civil administrations and sundries . . .	2,658,000
Tapou	218,000	Religious establishments and sundries . . .	750,000
Other taxes and sundries .	1,992,000	Public debt . . .	2,569,600
Total	14,012,000	Floating debt . . .	523,400
Deficit	2,725,000		
	16,737,000	Total	16,737,000

This budget represents the normal situation of Ottoman finance; it does not tally with the budget published in 1897, which was prepared with a special object in view, and was obviously full of inaccuracies, nor indeed does it agree with figures which could be officially obtained from the Porte. It is, however, compiled from the best sources of information, and it exaggerates nothing. The formidable deficit is met principally in three ways. (1) By leaving the salaries of state officials and the army unpaid. In many parts of the empire the soldiers rarely receive more than eight months' pay in the year, although in Constantinople the arrears are not so large. The reverse is the case with the civil officials, whose salaries in the provinces are paid more regularly than in Constantinople, owing to their being charged on the provincial budgets: the average arrears are from two to three months in Constantinople, and from one to three in the provinces. The arrears in civil and military salaries average annually about £T1,750,000. (2) By means of loans, both public and from individuals. By financial expedients of this kind payments were effected by the Treasury in fifteen years (1881 to 1896) amounting to £T11,666,000, or at the rate of nearly £T800,000 per annum. (3) By anticipating the revenues of future years. This is the method so frankly condemned by Ali Aga, as was seen above, in 1653. Delegations (*havalé*) are granted on the provincial treasuries for one or two years in advance, sometimes for a series of years, in order to pay pressing debts too heavy to be met in a single payment. No better description of the financial distress and disorder of the empire can be given than that set forth in the official report of the budget commission of 1888. "It has hitherto been considered necessary, owing to financial embarrassment, to commence financial years with unbalanced budgets. Later, without taking into consideration the effective amounts in cash at the disposal of the vilayets, considerable sums were drawn upon them, by means of *havalés*, out of proportion to their capacity. For these reasons, during the last two or three months of the financial year, the vilayets have not a para to remit to the central administration, and it has been considered imperatively necessary to draw on the revenues of the following year. Thus, especially during the last two years, urgent extraordinary expenses having been perforce partially covered by the proceeds of the ordinary revenues, the revenues of 1303 (1887) were already considerably anticipated in the course of 1302 (1886). The former year naturally felt the effect of this, and the tithes which should have been encashed in the last months of the year were discounted and spent several months in advance. Moreover, in order to meet to some extent the deficit arising as well from the accumulation of arrears of state departments since 1300 (1884) as, to a large degree, from gross deficiencies due to the neglect of the civil officials of the Government to encash the revenues—to meet, further, the needs of the central administration, and above all, the urgent military expenses of the empire, and to provide a guarantee for bankers and merchants in business relations with the Government and the treasury, part of the revenues of 1304 were perforce spent in 1303." This commission proved the deficit of the year to be £T4,370,000. It set out also at length the very defective and disorderly condition of the state accounts. During the finance ministry of Agop Pasha (1889 to 1894) a good deal was done to set matters in order, but most of the ground then gained has since been lost.

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[1] These naturally vary from year to year according to the receipts encashed by the various railways. The annual average is estimated at £T750,000.

Method of Collection of Taxes.—The Ottoman empire possesses a very complete system of local self-government within certain limits. Every village or town district has a kind of mayor (*moukhtar*) appointed by election and approved by the official provincial authorities, and a "council of ancients" whose members are elected directly. The taxes are collected by means of the *moukhtars*, termed for this purpose *kabz-i-mal* (receiver of treasure), and under the supervision of gendarmes specially named, termed *tahsildar* (collectors). The official authorities provide lists of all the taxes to be collected to the *tahsildars*, who hand them, against formal receipt, to the *kabz-i-mals*. The latter are bound to pay in to the local authorities all sums collected in five days in town districts, and in fifteen days in villages, if under 1500 piastres; sums of 1500 piastres and over are paid in at once. The *tahsildars* check the accounts of the *kabz-i-mals*, and, if they discover peculation, send them at once to be dealt with by the chief official authorities of the *caza* (department); all the electors of a *moukhtar* are, *ipso facto*, joint sureties for him. If the tax-payer declines to pay his due, he is brought before the proper authorities by the *tahsildar*; if he persists in his refusal, all his goods, except those indispensable for his dwelling and the pursuit of his trade, are sold by auction, without recourse to a judgment by tribunal. If he has no goods which may be seized, he may be summarily imprisoned for a term not exceeding 91 days: two imprisonments for the same debt are not permitted. The military exemption tax is not collected as above, but by the spiritual chiefs of the various non-Mussulman communities. None of the above regulations apply to Constantinople, where no military exemption tax is imposed, and where separate official regulations for the collection of taxes are in force. The system of farming out the revenues is admitted, and is almost invariably followed in the case of the tithes. When this is done, the revenues to be farmed are put up to public auction and sold to the highest bidder, provided he can prove himself amply solvent and produce sufficient sureties. Elaborate regulations are in force for this method of collection to secure the state receiving its full due from the farmers, who, on the other hand, are entitled to full official assistance to enforce their rights.

Assessment of Taxes.—For the purposes of assessment the taxes may be divided roughly into two classes: (1) Variable taxes; (2) non-variable taxes. Under the first head would be included proportional taxes dependent upon the value of the property taxed; under the second, taxes whose amount does not depend upon that value. The first class contains such revenues as the *emlak verghi-si* (duty on realty), *a'shâr* (tithes), *temettü* (patents tax), &c. In all such cases the taxable values are fixed by a commission of experts, sometimes chosen by the tax-payers themselves, sometimes by the official authorities; in all cases both tax-payers and authorities are represented on the commissions, whose decisions may be appealed against, in last resort, to the Council of State at Constantinople, whose decision is final. Instances of revenues composing the second class are the *tapou* (registration tax), the *ahali-i-gairi müsliminin bedelat-i-askeriyési* (military exemption tax), which do not vary, unless by special decree, and of which the assessment is automatic.

The systems, both of assessment and collection, are equitable and far from oppressive in theory. In practice they leave almost everything to be desired. The officials, already too numerous and underpaid, frequently, as has been stated above, find such pay as they have far in arrear. They are therefore naturally open to bribery and corruption, with the result that, while the rich often get off almost scot free, the poor are unduly taxed, and often cruelly oppressed by the tax collectors and farmers of revenue. In all departments there ensues, thus, an alarming leakage of revenue, amounting, it is credibly estimated, to quite 40 per cent.

International Administration of the Ottoman Debt.—In consequence of the piling up of the exterior public debt as described in the preliminary sketch, it amounted after the issue of "general debt" in 1875 to £T190,750,000, and swallowed up annually upwards of £T10,000,000, or nearly half the revenue of the empire as it was then constituted. The revolt of various disaffected provinces brought matters to a climax; in September 1875 one-half of the service of the interest was suspended, paper certificates known as "Ramazans" (since they were issued in the Arabic month of that name) being issued for that half in lieu of cash, and in the following March it was suspended altogether. After the war with Russia, in order to obtain credit from the Imperial Ottoman Bank and local financiers, who refused any further accommodation unless their previous and further advances were amply secured, revenues known as the "six indirect contributions" were handed over to a committee of local bankers (by decree of 22nd November 1879), to be administered and collected directly by them. These "six indirect contributions" were the revenues from tobacco, salt, wines and spirits, stamps (commercial), certain specified fisheries, and the silk tithe. Two years later, partly in view of the recommendations of the Congress of Berlin, partly to overcome insuperable difficulties in obtaining any kind of credit, the Sultan authorized the Sublime Porte to issue an invitation to the various bondholders' committees in Europe to send delegates to Constantinople for the purpose of negotiating a resumption of payments. These "committees" were the "Council of Foreign Bondholders" for Great Britain, the Imperial Ottoman Bank and its "group" for France, Herr S. Bleichroder for Berlin, the Credit-Anstalt and its "group" for Austria-Hungary, and the Chamber of Commerce and of Arts of Rome for Italy. The Dutch bondholders placed their interests in the hands of the British council. Russia declined to countenance the negotiations in any way. Delegates from the various committees assembled in Constantinople in the early summer of 1881. The commission formed by them in conjunction with the delegates of the Sublime Porte is more generally known as the "Valfrey-Bourke commission," from the leading parts played by the Right Hon. R. Bourke (Lord Connemara), the British delegate, and Monsieur Valfrey, the French delegate. The outcome of the negotiations was the issue of an imperial decree, known as the "Decree of Mouharrem," owing to its bearing the date (Turkish style) of the 28th of Mouharrem (20th December) 1881. By this decree the outstanding capital of the exterior debt, to which were added the Ramazan certificates above mentioned, and all interest fallen due, making a grand total of £252,800,000, was scaled down to £106,437,234 (£T117,080,958). On this reduced capital a minimum interest of 1 per cent. was to be paid, the rate of interest to be increased by quarters per cent. as the revenues set aside for the service of the reduced debt permitted. For purposes of sinking fund the old loans were combined into four groups:[1] Group i. containing the 1858 and 1862 loans, with a reduced nominal capital of £T7,902,259; group ii. the 1860, 1863, 1864, and 1872 loans, with a reduced nominal capital of £T11,265,153; group iii. the 1865, 1869, and 1873 loans, with a reduced nominal capital of £T33,915,762; and group iv. the "general debt," of which the last issue was in 1875, with a reduced nominal capital of £T48,365,236, and the "lottery bonds"[1] (railway loan), with a reduced nominal capital of £T15,632,548, the total of group iv. being thus £T63,997,784. As security for the service of the new reduced debt it was provided that an international council should be formed, composed of one delegate each from the bondholders of the United Kingdom, France, Germany, Austria-Hungary, Italy, and Turkey, and one representing the "priority bondholders," a term which will be explained later. On this council the Turkish Government has the right of naming an imperial commissioner with "consultative voice," *i.e.*, no voting power, but the right to express his opinion on the proceedings of the council, who would make all reports he considered necessary to his Government. The Government was empowered also to name controllers to whom all the accounts of the administration should be open for inspection on demand. In all other respects the council, provided that it kept within the limits of the laws the administration of which was entrusted to it, was to be entirely independent of the Ottoman Government, free to appoint and dismiss its own officials from highest to lowest, and to carry on its administration on such lines as it thought best. Proposals made by the council for the modification and improvement of the existing laws and regulations which concerned it were to receive an answer from the Government within six months; this provision has remained a dead letter. Any difference between the Government and the council, if not possible of adjustment, was to be settled by arbitration. To this council, with these extended powers, was handed over the absolute administration, collection, and control of the "six indirect contributions" above enumerated, for the benefit of the bondholders, and in addition, it was to encash for the same purpose bills on the customs, to be drawn half-yearly in its favour by the minister of finance, amounting annually to £T180,000, representing the tax on Tumbéki (£T50,000) and the surplus revenue of Cyprus (£T130,000); the Eastern Rumelian annuity, originally fixed at £T245,000, but gradually reduced by force of circumstances, until after frequent suspensions of payment it reached in 1897 the level of £T114,000, and has since been again suspended; the tribute of Bulgaria, the amount of which has never even been fixed, but as compensation for which the tobacco tithe up to a yearly amount of £T100,000 was ceded to the council on the same conditions as the "six indirect contributions"; the proportional parts (generally known as the "contributive parts") of the Ottoman public debt to be borne by Bulgaria, Servia, Greece, and Montenegro, which according to the Treaty of Berlin were to be adjudged by the representatives of the Great Powers at Constantinople, one of whom (the Russian) has never succeeded in obtaining his instructions, and which therefore have never been fixed; and, finally, the excess of revenue resulting from a revision of the commercial treaties. These revenues, exclusive of the "contributive parts" and the excess from commercial treaties, were estimated by Mr Bourke, in his report to the bondholders on the decree of Mouharrem, at £812,562 (£T993,818).

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[1] For simplicity's sake, the lottery bonds having a special treatment different from that of the rest of the loans, these groups, when the new bonds of the reduced debt were exchanged against the old bonds of the original loans, became "series" thus: Series A, group i.; series B, group ii.; series C, group iii.; series D, group iv.; and lottery bonds.

Table showing Revenues at Various Periods to 1900–1901.

	Heads of Revenue.	Last Year of Galata Bankers, 1881–82.	Average for First Five Years of Council of Public Debt, 1882–83, 1886–87.	Average for Second Five Years of Council of Public Debt, 1887–88, 1891–92.	Average for Third Five Years of Council of Public Debt, 1892–93, 1896–97.	1900–1901.	Observations.
		£T	£T	£T	£T	£T	
Six indirect contributions.	Tobacco (including arrears)	881,563	822,633[1]	755,489[2]	788,384[2]	720,728[2]	[1] Two years gross, 3 net from régie. [2] All net. [3] Only £T9843 collected in 1882-83 owing to tardy delivery of revenues by Government. [4] Payment suspended in 1886-87. [5] First two years' tobacco expenses running; next two tobacco revenues (régie) paid net; last year advance of £T100,000 to régie. [6] £T148,233 advance to régie during first two years, and £T150,000 paid to it during the last three, making £T59,640 per annum. [7] £T50,000 per annum paid to régie.
	Salt	634,936	651,057	702,150	755,978	949,170	
	Stamps	129 833	146,822	185,930	212,815	225,926	
	Spirits	177,163	198,356	229,059	258,848	277,121	
	Fisheries	26,064	34,356	44,307	44,337	50,504	
	Silk	17,118	24,145	39,398	56,393	69,847	
Tobacco tithe		Not collected	72,340[3]	81,866	104,688	114,073	
Eastern Rumelian annuity . .		,, ,,	150,040[4]	126,688	129,222	...	
Excess of Cyprus revenues . .		,, ,,	130,000	113,557	102,596	...	
Tax on Tumbéki		,, ,,	50,000	50,000	50,000	50,000	
Total of six indirect contributions		1,866,677	1,877,369	1,956,333	2,116,755	2,292,960	
Expenses		378,789	388,000[5]	392,403[6]	346,143[7]	473,695[7]	
Net revenues from six indirect contributions		1,487,888	1,489,369	1,563,930	1,770,612	1,819,265	

A substantial reduction, however, had to be made in favour of the 5 per cent. "priority bonds," which were bonds issued to the local banks before mentioned in satisfaction of their claims, and which formed an annual first charge of £T590,000 on the whole of the revenues ceded to the bondholders; the capital amount of the "priority bonds" was £T8,169,986, which was to be extinguished by 1906.

Table showing the Capital of the Ottoman Debt outstanding on 13th March 1902.

	Loans	Date of Issue.	Original Nominal Capital.	Rate of Interest and Amortization.	Annuity required for Service of Loan.	Capital amortized up to 13th September 1898.	Cost of Amortization 13th September 1898.	Capital outstanding on 12th September 1898.
			£T		£T	£T	£T	£T
Converted Debt.	Series A .	8–20th Dec. 1881 .	7,902,259	1 per cent. and redemption	79,023[1]	7,831,868	3,572,129	70,391[2]
	,, B .	,, ,,	11,265,153		112,651[1]	5,919,632	2,461,863	5,345,521
	,, C .	,, ,,	33,915,762		339,158[1]	4,642,056	1,158,132	29,273,706
	,, D .	,, ,,	48,365,236		483,652[1]	3,115,206	688,476	45,250,030
			101,448,410		1,014,484[1]	21,508,762	7,880,600	79,939,648[3]
Lottery Bonds .		,, ,,	15,632,548	Drawings and redemption	156,325[1]	1,930,360	3,439,982	13,702,188
4 per cent. Priority Bonds . .		18–30th April 1890 .	8,609,964	4 per cent. and 1 per cent.	430,500	1,240,800	1,240,800	7,369,164
Deutsche Bank Loan . .		27–29th October 1888	1,650,000	5 per cent. and 2 per cent.	115,500	594,176	594,176	1,055,824
Osmanieh 4 per cent. . .		18–30th April 1890 .	4,999,500	4 per cent. and 1 per cent.	249,975	760,100	760,100	4,239,400
Customs Loan .		14th May 1886 .	6,499,988	5 per cent. and 1 per cent.	390,000	1,365,122	1,233,244	5,133,766
Tumbéki Priority Bonds . .		8–20th May 1893 .	1,000,000	4 per cent. and 1 per cent.	50,000	106,700	106,700	893,310
Ottoman Railway Loan . .		10–22nd May 1894 .	1,760,000	4 p. cent. and 0·35 p. cent.	76,560	57,398	57,398	1,702,602
5 per cent. Ottoman, 1896 .		29–12th March 1896	3,272,720	5 per cent. and ½ per cent.	180,000	90,200	90,200	3,182,520
5 per cent. Ottoman, 1901[4] .		21st Nov.–4th Dec. 1901	1,254,000	5 per cent. and 1 per cent.	75,240	...	...	...
			146,127,130		2,738,584	27,653,618	15,403,200	117,218,422

[1] Exclusive of amortization. [2] Prescribed. [3] Of this amount £T945,900 is prescribed. [4] Not yet (1902) issued to the public.

Four-fifths of the net product of the revenues, after deduction of the first charge of £T590,000, was to be applied to the service of the interest on the new reduced debt, and provided that the four-fifths were sufficient to allow the distribution of 1 per cent. interest, one-fifth was to be devoted to sinking fund; but this latter fifth was to be reduced, if necessary, by an amount sufficient to maintain the rate of interest at 1 per cent. The interest on bonds amortized was to be added to the funds available for sinking fund. The sinking fund was to work as follows:—First ¼ per cent. on the whole reduced capital was to be applied to group i.; if there were any surplus this was to be applied to group ii., until that also received the same full ¼ per cent., and so on for group iii. and group iv., until the whole sinking fund amounted to 1 per cent. on the reduced capital. It was to be applied by redemption at the best price possible on the market, until that price stood at £T66.66, when, if the rate of interest served were 1 per. cent., it was to proceed by drawings; if the interest were anything more than 1 per cent., and less than 3 per cent., the limit of price for redemption was to be raised to £T75; if the interest were between 3 per cent. and 4 per cent. inclusive, the limit was to be raised to par. Any surplus of revenue beyond that necessary to provide 4 per cent. interest and 1 per cent. sinking fund was to be handed over to the Government. The lottery bonds receive a special treatment both in regard to interest and sinking fund, but as this class of security does not concern English readers, and as a considerable amount of space would be required to give a comprehensive description of the intricate arrangements made for these bonds, it is not proposed to deal with them here; full information will be found in the decree of Mouharrem and the published reports of the council of administration of the Ottoman public debt. In 1890 the sinking fund was increased by the conversion of the "priority loan" into a 4 per cent. loan and the extension of the term of its redemption for 15 years. In this manner an annuity of £T159,500 was set free, of which £T11,000 per annum was allotted as "extraordinary sinking fund" to series A and £T49,500 per annum each to series B, C, and D; the lottery bonds were originally excluded from this arrangement, and special compensation was granted to these later. Each series receives the benefit of the interest on bonds belonging to it amortized by this special annuity. Thus, in the financial year 1900–01 the total amount of the fund had risen from £T159,500 to £T231,500.

The arrangement set forth in and sanctioned by the decree of Mouharrem has on the whole worked admirably well; while the revenues not under the control of the council have largely diminished (Eastern Rumelian annuity and excess of Cyprus revenues), those administered directly by it have greatly increased. The first table on the previous page gives the product of the revenues in 1881–82, the last year of the administration of the "Galata bankers," the average during the first three quinquennial periods of that of the public debt council, and the product in the year 1900–01. It must be observed that the tobacco monopoly has been handed over to a company to be administered as a "régie."

The total external indebtedness of the Ottoman empire (exclusive of tribute loans) is given in the second table on the previous page.

Tobacco Régie.—From the commencement of the year 1884 the tobacco revenue has been worked as a monopoly by a company formed under Ottoman law, styled "La régie impériale coïntéressée des tabacs Ottomans." This company has the absolute monopoly of the manufacture and of the purchase and sale of tobacco throughout the Ottoman empire, with the exception of the Lebanon and Crete, but exportation remains free. It is bound to purchase all tobacco not exported at prices to be agreed between itself and the cultivators; if no agreement can be arrived at, the price is fixed by experts. It is obliged also to form entrepôts for the storage of the crops at reasonable distances from each other, and, on certain conditions, to grant advances to cultivators to aid them in raising the leaf. The cultivators, on the other hand, may not plant tobacco without permits from the régie, although the power of a refusal of a permit, except to known smugglers or persons of notoriously bad conduct, seems to be doubtful; nor may they sell to any purchaser, unless for export, except to the régie, while they are bound to deposit the whole of the tobacco crops which they raise in any one year in the entrepôts of the régie before the month of August of the year following, and may not move any tobacco from the place where they cultivate it without the régie's express authority. In order to facilitate supervision, a minimum area of one-half of a *deunum* (a deunum = about one-fourth of an acre) is fixed for ground upon which tobacco may be cultivated; in the suburban districts of Constantinople and some other towns, and in enclosures surrounded by walls and attached to dwelling-houses, it is altogether prohibited. For its privileges the régie has to pay a rent of £T750,000 per annum to the Government (assigned to bondholders), "even if it has no revenues at all," and after the payment of a dividend of 8 per cent. to its shareholders, and certain other deductions, it has to share profits with the Government and the bondholders according to a sliding scale agreed upon between the three parties. The régie did badly during the first four years of its existence, owing principally to two causes: (1) Its ineffectual power to deal with contraband, to which the system described above leaves the door wide open; (2) the admission of other than Turkish tobaccos into Egypt, which deprived it at once of about £T100,000 per annum. So great were its losses that in the year 1887–88 it was obliged to write them off by reducing its capital from £2,000,000 to £1,600,000. At the same time it was granted an extension of penal powers, and the losses on *reftieh* (duty on tobacco exported to Egypt) were to be partially borne by the Public Debt Administration. Things went better with it from that time until 1894–95, when, owing to internal troubles in the empire, and the consequent fear of creating worse disorders by the strict enforcement of the monopoly, the Government withdrew most of its support, and contraband enormously increased. The following table shows the movement of the revenue of the régie from the year 1887–88 inclusive:—

Year.	Gross Receipts from all Sources.	Total Expenses.[1]	Net Profits.
	£T	£T	£T
1887–88	1,776,378	1,671,013	105,365
1888–89	1,865,044	1,683,924	181,120
1889–90	1,846,720	1,709,723	136,997
1890–91	1,981,849	1,761,685	220,164
1891–92	2,151,328	1,853,136	298,192
1892–93	2,314,468	1,982,626	331,842
1893–94	2,435,716	2,084,017	351,699
1894–95	2,451,285	2,099,278	352,007
1895–96	2,383,209	2,095,010	288,199
1896–97	2,069,254	1,925,021	144,233
1897–98	1,878,694	1,814,719	63,975
1898–99	1,972,378	1,882,079	90,299
1899–1900	2,188,338	1,922,398	265,940
1900–1901	2,209,418	1,929,471	279,947

[1] Including fixed charges.

Railway Guarantees.—Up to the year 1888 the only railways existing in the Turkish empire (exclusive of Egypt) were, in Europe, the Constantinople–Adrianople–Philippopolis line and the Salonica–Mitrovitza line (finished in 1872); and in Asia Minor, the Smyrna–Aïdin (completed in 1866), the Smyrna–Kassaba (completed in 1866), the Constantinople–Ismidt (completed in 1872), the Mersina–Adana (completed in 1886). The want of railways in Asia Minor was urgently felt, but no capitalists were willing to risk their money in Turkish railways without a substantial guarantee, and a guarantee of the Turkish Government alone was not considered substantial enough. In 1888 it was proposed by the Public Debt Administration to undertake the collection of specified revenues to be set aside for the provision of railway guarantees, the principle to be followed being, generally, that such revenues should consist of the tithes of the districts through which the railways would pass, and that the Public Debt should hand over to guaranteed railway companies the amounts of their guarantees before transmitting to the Imperial Government any of the proceeds of the revenue so collected. The Government adopted this proposal, and laid down as a principle that it would guarantee the gross receipts per kilometre of guaranteed railways, such gross receipts to be settled for each railway on its own merits. Considerable competition ensued for the railway concessions under this system. The first granted was for the extension of the Constantinople–Ismidt railway to Angora to a group of German and English capitalists in 1888. The Germans having bought out the English rights, this concession became a purely German affair, although a certain proportion of the capital was found in London. Since that time various other concessions have been granted to French and German financial groups, principally the Imperial Ottoman Bank group of Paris and the Deutsche Bank group of Berlin. The following table gives the list of railway concessions, with or without guarantees, granted since and including the year 1888:—

Railways for which Concessions have been granted from 1888 to 1899 inclusive.	Date of Firman	Approximate Length of Railway in Miles.	Number of Miles completed.	Amount of Kilometric Guarantee, £T.
Ismidt–Angora (Anatolian Railway) .	Oct. 6, 1888	312	312	600
Jaffa–Jerusalem .	„ 6, „	50	50	..
Salonica–Monastir .	„ 27, 1890	136	136	572
Mudania–Brusa .	Feb. 22, 1891	26	26	..
Panderma–Konia (with branches) .	„ 23, „	500	0	..
Beirut – Damascus – Hauran . . .	June 13, „	132	132	..
Samsun – Sivas–Diarbekir . . .	July 2, „	750	0	..
St Jean d'Acre – Damascus . .	Oct. 8, „	219	0	..
Salonica – Constantinople Junction (with branches) .	May 30, 1892	316	316	620
Eski - shehr – Konia (branch of Anatolian Railway) .	Feb. 18, 1893	276	276	554
Angora–Cæsarea prolongation of Anatolian Railway .	„ 13, „	256	..	700·5
Alashehr–Karahissar (Smyrna – Kassaba extension) . .	„ 4, „	157	157	754·6

The total sum paid for guarantees in the year 1900 was £T735,000. It is estimated that for some years the average yearly amount will be about £T750,000.

The total mileage of the railways in the Ottoman empire is as follows:—

Name of Railway.		Number of Miles worked in 1900.
Constantinople–Adrianople–Mustafa–Pasha Salonica–Uskub–Mitrowitza Dedeagatch–Adrianople Uskub–Zibevche	The Oriental Railways	785
Smyrna–Diner and branches (Smyrna–Aidin Railway)		324
Smyrna–Alashehr and branches (Smyrna–Kassaba Railway)		320
Mudania–Brusa		26
Mersina–Adana		40
Jaffa–Jerusalem		54
Salonica–Monastir		136
Haidar–Pasha–Angora (Anatolian Railway)		360
Eski-shehr–Konia ,, ,,		276
Beirut–Damascus–Hauran (Syrian Railway)		155
Salonica–Constantinople Junction, and branches		316
Total		2792

Of the Hedjaz Railway, from Damascus to Mecca, about 180 miles were completed in the beginning of 1902. In February 1902 the Sultan approved of the construction, by German enterprise, of a railway to connect Konia, the terminus of the Anatolian Railway, through the Taurus range and by way of the Euphrates, Nisibin, Mosul, the Tigris, Baghdad, Kerbela, and Nejef, with Basra, thus establishing railway communication between the Bosphorus and the Persian Gulf. The total length, including branches to Adana, Aleppo, the ancient Edessa, and other places, will exceed 1550 miles or 2500 kilometres. In this case the Government guarantee is 12,000 francs (£480) of net receipts per kilometre per annum, plus 4500 francs (£180) per kilometre for working expenses.

The systems of guarantee above described are clearly faulty, since theoretically the railway company which ran no trains at all would, up to the limit of the guarantees, make the highest profits. The concessionaire companies have, however, wisely taken the view that it is better to depend upon their own revenues than upon any Government guarantee, and have done their best to develop the working value of the lines in their charge. The economic effect of the railways upon the districts through which they run is well shown by taking the comparative values of the tithes in the regions traversed by the Anatolian Railway in 1889 and 1898, in which years it so happened that prices averaged almost exactly the same. These values were as follows:—

District.	In 1889.	In 1898.	Increase.	Proportion per cent.
	£T	£T	£T	
Ismidt	28,450	35,606	7,156	25·15
Ertoghrul	27,902	44,385	16,483	59·07
Angora	31,240	49,867	18,627	59·62
Kutahia	57,786	85,612	27,826	48·15
Total	145,378	215,470	70,092	48·21

Imperial Ottoman Bank.—At the close of the Crimean war an English bank was opened in 1856 at Constantinople under the name of the Ottoman Bank, with a capital of £500,000 fully paid up. In 1863 this was merged in an Anglo-French bank, under a concession from the Turkish Government, as a state bank under the name of the Imperial Ottoman Bank, with a capital of £2,700,000, increased in 1865 to £4,050,000 and in 1875 to £10,000,000, one-half of which is paid up. The original concession to the year 1893 was in 1875 extended to the year 1913, and in 1895 to the year 1925. The bank acts as banker to the Government, for which it has a fixed annual commission, and it is obliged to make a permanent statutory advance to the Government of £T1,000,000, against the deposit by the Government of marketable securities bearing interest at a rate agreed upon. The bank has the exclusive privilege of issuing bank notes payable in gold. Its central office is in Constantinople, and it is managed by a director-general and advisory committee appointed by committees in London and Paris.

Monetary System.—The monetary system presents a spectacle of perplexing confusion, which is a remnant of the complete chaos which prevailed before the reforms initiated in 1844 by Sultan Abdul-Medjid, and which are still far from completion. The basis of the system adopted was the double standard with a fixed relation of 1 to 15·09, and free coinage. The unit was the piastre (=2⅛d.), nominally subdivided into 40 paras. The gold pound (18s. 2d.) was equivalent to 100 piastres; the gold pieces struck were £T5, £T1, £T½, and £T¼; the standard is 0·916⅔ fine, and the weight 7·216 grammes. The silver coinage consisted of the medjidie (weight 24·055 grammes, 0·830 fine), equivalent to 20 piastres, and its subdivisions 10, 5, 2, 1, and ½ piastre pieces. The altilik, beshlik, and metallik currencies struck, the first and last in the reign of Mahmoud II. and Abdul-Medjid, and the second in the reign of Mahmoud only, were not included in the reform; these were debased currencies bearing a nominal value, the altilik of 6, 3, and 1½ piastres, the beshlik of 5 and 2½ piastres, the metallik of 1, ½, and ¼ piastres; they represented the last degree of an age-long monetary depreciation, the original piastre having had a value of about 5s. 7d., which had fallen to 2⅛d. The heavy depreciation in silver causing large losses to the Government, free coinage was suspended in 1880, and the nominal value of the medjidie was reduced by decree to 19 piastres (105·26 piastres thus =£T1), while in the same year the debased currencies were reduced, altilik, the 6-piastre piece, to 5 piastres, the 3-piastre piece to 2½ piastres, the 1½-piastre piece to 1¼ piastre; beshlik, the 5-piastre piece, to 2½ piastres, the 2½-piastre piece to 1¼ piastre; metallik, the 1-piastre piece to ½ piastre, the ½-piastre piece to ¼ piastre, the ¼-piastre piece to ⅛ piastre—these values representing approximately the intrinsic value of the silver, at medjidie standard, contained in the debased coins. The copper coinage (113,000,000 piastres) and the paper currency (kaïmé) (1,600,000,000 piastres) referred to in the preliminary sketch were withdrawn in 1880 by repudiation. The 20-piastre medjidie currency, in spite of the further enormous depreciation of silver since 1880, has scarcely varied in the Constantinople market, but has always remained at a discount of about 3 per cent. (between 108 and 109 piastres to the pound) under Government rate; this is doubtless due to the fact that the demand and supply of the coins are very evenly balanced. The fractional medjidie coins (5, 2, and 1 piastres) are quoted at a separate rate in the market, usually at a premium over the 20-piastre piece. Within the last twelve years of the 19th century the altilik currency was almost entirely withdrawn, and replaced by fractional medjidie; a large proportion of the beshlik has also been withdrawn, but the metallik has not been touched. These debased currencies are usually at a premium over gold owing to the extreme scarcity of fractional coinage. The standard of the altilik is about 0·440 fine, that of the beshlik is 0·185 to 0·225 fine, that of the metallik is 0·170 fine. Foreign gold coins, especially the pound sterling (par value 110 piastres) and the French 20-franc piece (par value 87½ piastres) have free currency. Throughout Arabia and in Tripoli (Africa) the principal money used is the silver Maria Theresa dollar tariffed by the Ottoman Government at 12 piastres. The Indian rupee and the Persian kran are widely circulated through Mesopotamia; in Bussorah transactions are counted in krans, taking as a fixed exchange £T1=34·15 krans. The general monetary confusion is greatly intensified by the fact that the piastre unit varies for almost every province; thus, while the pound at Constantinople is counted at 108 piastres silver, it is at about 127 piastres for one kind of transaction and 180 for another in Smyrna, 135 piastres at Adrianople, 140 at Jerusalem, and so forth, accounts being kept in "abusive piastres," which exist no longer. In some towns, *e.g.*, Adrianople, small change is often supplemented by cardboard tickets, metal discs, &c., put into circulation by private establishments or individuals of good credit. The amounts of Turkish gold, silver, and debased coinage in circulation are approximately £T16,500,000 in gold, £T8,700,000 (940,000,000 piastres at 108) in silver medjidies and fractions, and 200,000,000 piastres in beshlik and metallik.

Tenure of Property.—Real property is held in one of four various ways: either *mulk*, *emiriyé*, *vakouf*, or *khaliyé*. 1. *Mulk* is the absolute property of its owner, and can be disposed of by him as he wills without restrictions, save those enumerated lower down (general dispositions) as general for all the four classes. *Mulk* property is governed chiefly by the *Sheri* (sacred law). A duty of 10 per mille on its estimated value has to be paid on transfer by sale, donation, or testament; 5 per mille on transfer by inheritance; and a registration duty on expenses of transfer. 2. *Emiriyé* is practically "public domains." The State may grant land of this category to private persons on payment by the latter of the value of the proprietary right—the tithes, ground-rent (should there be private buildings upon it), and the land-tax. It is administered by imperial functionaries called *arazi-mémourou*; it is with the consent of the latter only that the proprietary rights can be sold. These rights are of simple possession, but they are transmissible in certain degrees to the heirs of the possessor. *Emiriyé* cannot be mortgaged, but can be given as security for debt on condition that it be restored when the debt has been repaid. The creditor may demand the *arazi-mémourou* to proceed to a forced sale, but the *arazi-mémourou* is not obliged to comply with that demand; no forced sale may take place after the decease of the debtor. *Emiriyé* is not transmissible by will, but may be transferred by donation, which returns to the donor should he outlive the beneficiary. Should a proprietor of *emiriyé* plant trees or vines, or erect buildings upon it, with the consent of the State, they are considered as *mulk*; an annual tax representing the value of the tithes on the portions of *emiriyé* thus utilized is levied. The *emiriyé* then becomes *mulk*, with certain restrictions as to transfer dues. A transfer duty of 5 per cent. on the estimated value of *emiriyé* is paid on transmission by sale, inheritance, or donation, of 2½ per cent. on the amount of the debt in case of mortgage or release from mortgage, and of 10 per cent. on expenses of registration. A different scale is established for *emiriyé* with *moukataa* (rent paid for *emiriyé* with *mulk* property established upon it). 3. *Vakouf* is "all property dedicated to God, of which the revenue is consecrated to His poor"; or "property of which the usufruct, such as tithe, taxes, and rents, is attributed to a work of charity and of public interest." When once a property has been registered as *vakouf* it can never be withdrawn. There are two classes of *vakouf*:—(*a*) Land so declared either directly by the sovereign or in virtue of imperial authority; (*b*) lands transformed by their proprietors from *mulk* into *vakouf*. The laws and regulations concerning *vakouf* are too intricate to be described; generally it may be said that they form a great obstruction to dealing with a large proportion of the most valuable property in Turkey, and therefore to the prosperity of the country. The *vak'oufs* are administered by a special ministerial department (*evkaf nazareti*), whose property, on behalf of the State, they theoretically are. The effect of the original system was that a *vakouf* property became the inalienable property of the State, and the original proprietor a mere tenant. All fundamental repairs thus fell to the charge of the State, which could not afford to effect them, and the *vakouf* revenues decreased so rapidly that already in the reign of Selim I. (A.D. 1511–1520) a serious effort was made to deal with the difficulty. But this resulted in so heavy a burden upon the public that the law had again to be altered to extend hereditary rights, and to admit a system of mortgage which was assimilated to that for *emiriyé;* but the evils were little more than palliated. The curious guilds called *guedik* must here be mentioned. They were established at a time when industry was not free, and the Government fixed the number of artisans of every kind of trade in each town, no one having the right to increase that number. The *guedik*, then, was the right to erect buildings on *vakouf* property and supply it with the tools, &c., necessary to exercise a trade. The ancient *guediks* have not been abolished, the Government not daring to deprive them of their privileges; but since the Tanzimat no new ones have been created, industry being declared free. The various special dues payable on *vakouf* form too long a list to be inserted; the highest is 30 per mille. 4. *Khaliyé*. This property is also styled *mevad*. It consists of uncultivated or rough lands, such as mountains, stony ground, &c., which are useless without clearance, to which no possession is claimed, and which are at such a distance from the nearest dwelling that the human voice cannot be made to reach them from that dwelling. Any one can obtain a gratuitous permit to clear and cultivate such lands; the laws governing ordinary agricultural lands then apply to them. The permit is withdrawn if the clearance is not effected within three years. If the clearance is effected without the necessary permit, the land is nevertheless granted on application, and on the payment of the *tapou* or sum paid by the proprietor to the State for the value of the land.

General Dispositions.—By the "protocol of the 7th Sefer 1284 A.H." foreigners may enjoy the rights of proprietorship on the same conditions as Ottoman subjects throughout the empire, save in the Hedjaz. The transmission of property from a foreigner to his heirs is therefore governed by the Ottoman laws, and not those of the country to which he belongs. The real property of a Mussulman does not pass by inheritance to non-Mussulman heirs, but may pass to his Mussulman heirs of a foreign nationality, and *vice versâ*. Property of an individual who has abandoned Ottoman nationality without legal authority so to do does not pass to heirs, whether Ottoman or foreign, but devolves to the State; if legal authority has been granted the Government under which the foreign heirs live must have accepted the protocol above cited. An heir who has voluntarily caused the death of the person from whom he should inherit loses all rights of succession. It is not proposed to trace the formalities of transfer and transmission of real property here; they will be found in vol. iii. of the *Destour* (Ottoman Code).

General Dispositions as to Mines and Treasure-trove.—On *emiriyé* property mines become the sole property of the State, as also in land of which the tithe or other taxes are *vakouf;* the original proprietor must, however, be repaid the surface value of such lands. In lands assigned to public use (roads, pasturage, &c.) one-fifth of the produce of the mines goes to the State, four-fifths to the discoverer of the mine; in property entirely *vakouf* the mine becomes the sole property of the *vakoufs*. Mines found on *mulk* property belong to the proprietor of the soil. Deposits of fuel or "fusible matters" on *arazi-i-eushriyé* (lands distributed at the conquest to the conquerors) or on *arazi-i-haradjiyé* (lands left in the hands of native non-Mussulmans at the conquest) belong to the State for one-fifth, to the proprietor of the soil for four-fifths; if they be not "fusible" they belong entirely to the proprietor of the soil. As to ancient coins, and all kinds of treasure of which the proprietor is unknown, reference must be made to the *Destour*, No. 4, p. 89. The latest law on mines is that of the 26th November 1306 A.H.

Conclusion.—It is beyond the scope of this article to discuss the problem of Turkish financial reorganization. The latent resources of the empire are enormous: in the greater part of Asia Minor the soil is fertile, water abundant, the climate admirable, while minerals of all kinds exist in plenty, and there are large stretches of forest land. All this natural wealth is only waiting to be turned to proper account. But the disease is too deep-seated to be cured by measures of a financial order only.

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Turks Islands. See JAMAICA.

Turnau, the chief town of a government district in North Bohemia, Austria, on the Iser river, 14 miles south by east of Reichenberg. It has considerable glass-cutting industry, and manufactures of imitation jewellery and articles in gold and silver, cutting and polishing of precious stones, together with important trade in corn, fruit, and the local staples. Population (1890), 5963; (1900), 6278 (including garrison of 554 men), chiefly Czechs.

Turnhout, a town of Belgium, in the province and 26 miles north-east of the city of Antwerp by rail. Its industries include lace-making, the manufacture of playing-cards, and tanning. Population (1880), 16,670; (1890), 18,747; (1900), 20,887.

Turnu Magurele, chief town of the district of Teleorman, Rumania, situated about 2 miles from the left bank of the river Olt, near its junction with the Danube, almost opposite Nicopoli, in Bulgaria. A large quantity of grain is shipped in lighters to ports lower down the Danube. There is a court of first instance. Much damage was done to the town in 1853 during the war between the Russians and Turks. Population (1900), 8668.

Turnu Severin, chief town of the district of Mehedinţi, Rumania, situated on the left bank of the river Danube, below the well-known Iron Gate cataracts. It is a modern commercial town, having a court of first instance, a school of arts and crafts, and several churches. There are also large Government yards for the building of river steamers, lighters, and tug-boats. Near Turnu Severin are the remains of the celebrated Trajan's bridge, built in A.D. 103 by the architect Apollodorus of Damascus. The river is about 4000 feet broad at this spot. The bridge was composed of twenty arches supported by stone pillars, several of which are still visible at low water. When the quays were constructed many interesting sarcophagi were found. There is a large trade in cattle and pigs. The town derives its name from an ancient tower of Severus, which stood on a small hill surrounded by a deep fosse. Population (1895) 17,000; (1900), 18,626.

Tuscaloosa, a city of Alabama, U.S.A., capital of Tuscaloosa county, on the Black Warrior river, and the Mobile and Ohio and the Queen and Crescent railways, in the western part of the state. It was at one time the state capital, and is now the seat of the State University, Central Female College, Tuscaloosa Female College, and the Institute for Training Coloured Ministers. It also contains the Alabama insane asylum. Population (1890), 4215; (1900), 5094, of whom 76 were foreign-born and 2508 negroes.

Tuscany, a territorial division of Italy, occupying the west part of the middle of the peninsula, and including the provinces of Arezzo, Florence, Grosseto, Leghorn, Lucca, Massa and Carrara, Pisa, and Siena, with an area of 9304 square miles, and a population (1881) of 2,208,869 and (1901) 2,548,154. The surface is for the greater part mountainous, though there are plains near Florence and Arezzo, and along the coast. This last is the malaria-haunted district of the Maremma, embracing an area of about 850 square miles. In the first half of the 19th century Grand Duke Leopold II. of Tuscany began an elaborate and extensive system of drainage, which was afterwards extended until it comprised nearly the whole of the district. The greater part of it is pasture-land; and on the drier parts corn is grown, the people coming down from the hills to sow and to reap. Wheat, maize, wine, olive oil, tobacco, chestnuts, and flowers are the chief products of Tuscany. But its real wealth lies in its mines and industries. Mules, sheep, and cattle are fed on the pastures. Iron (Elba), mercury (Monte Amiata), boracic acid, copper, salt, lignite, statuary marble (Carrara, Massa, &c.), alabaster, and Sienese earths constitute the mineral resources. Mineral and hot springs abound, and some are well known (Montecatini, Bagni di Lucca) Beeswax is extensively made. The industries are exceedingly varied and carried on with great activity. The most important towns are Florence, Leghorn, Lucca, Pisa, Siena, Pistoja, Prato, Arezzo, and Massa; Leghorn being the chief port. There are universities at Pisa and Siena. Leghorn and Viareggio are much frequented for summer sea-bathing.

Tuskegee, a town of Alabama, U.S.A., capital of Macon county, in the eastern part of the state, in a cotton region. It is noted chiefly for its educational institutions—the Tuskegee Normal and Industrial Institute, Alabama Conference Female College, and Alabama Military Institute. The first of these was founded in 1881 by Mr Booker T. Washington for the purpose of giving an industrial education to the coloured race. It possesses a property of 2300 acres, 800 of which are under cultivation; it has forty-five buildings, many of brick, all designed and constructed, even to the making of the bricks, by the teachers and students. No fewer than twenty-six trades are taught. In 1900 it had 88 instructors, and was attended by 1000 students. Population (1890), 1803; (1900), 2170.

Tuticorin, a seaport town of British India, in the Tinnevelly district of Madras, 149 miles by sea from Colombo, in Ceylon; terminus of the South Indian railway, 443 miles south-west from Madras. Population (1881), 16,281; (1891), 25,107. Municipal income (1897–98), Rs.38,850. It is an old town, long in possession of the Dutch, and has a large Roman Catholic population. Though only an open roadstead where vessels have to anchor 2½ miles from the shore, it has become, since the opening of the railway in 1875, the second port in Madras and the sixth in all India. In 1897–98 the number of vessels that entered and cleared for foreign trade was 1046, with an aggregate of 279,422 tons, having increased in fifteen years from 882 vessels of 97,505 tons. The total sea-borne trade in the district of Tinnevelly was valued in 1897–98 at Rs.3,08,03,307, being 10 per cent. of the entire trade of the province. The exports are chiefly rice and live stock to Ceylon, cotton, sugar, coffee, and spices. There are 7 factories for ginning and pressing cotton, and a cotton mill with 24,332 spindles, employing 1000 hands. The fishery of conch shells is important, but the pearl fishery has decayed. Caldwell College was closed in 1893. There are two high schools (Caldwell's and St Xavier's).

Tuttlingen, a town of Würtemberg, Germany, on the left bank of the Danube, 37 miles by rail north by east of Schaffhausen. The town is overlooked by the ruins of the castle of Honberg, and has a monument to Schneckenburger, the author of *Die Wacht am Rhein.* It is the seat of textile, shoe, cutlery, iron, and other industries, and of a trade in fruit. The site was inhabited in Roman times. Population (1885), 8659; (1895), 11,672; (1900), 13,465.

Tuxedo, a town of Orange county, New York, U.S.A., in a hilly country in the south-eastern part of the state, on the Erie railroad. Within the town is Tuxedo Lake, on whose shores and on the surrounding hills are beautiful villas erected as summer homes by business men of New York. The town was organized in 1889. Population (1890), 1678; (1900), 2277.

Tuy, capital of the district of Tuy, province of Pontevedra, Spain, on the right bank of the river Miño, opposite Valença de Miño, which stands on the left bank in Portuguese territory. It has a station on the Orense–Vigo line. The town is near Monte San Cristobal, whose far-spreading spurs constitute the fertile and picturesque Vega del Oro. Hard by is the river Louro, abounding in salmon, trout, lamprey, eel, and other fishes. Not far off are the springs of San Martin de Caldelas. The industries include soap factories, tanneries, and distilleries, and there is a brisk trade in agricultural products. The town is clean, with well-built houses, regular streets, and many gardens. The cathedral is of a massive and fortresslike architecture, with a noble eastern façade of the 14th century. It has four naves, nine chapels, and a well-preserved cloister. There are several large convents and a few ancient parish churches, an old episcopal palace, hospitals, good schools, a theatre, and a very handsome international bridge over the Miño. Alphonso el Catolico drove the Moors from Tuy, and Portugal and Spain fought frequently for its possession. Population (1887), 11,284; (1897), 10,983.

Tver, a government of Central Russia, on the upper Volga, to the north of Moscow. It has an area of 25,225 square miles; its population, which was 1,567,300 in 1872, numbered 1,812,825 (domiciled only) in 1897, 986,570 of whom were women, and 149,762 lived in towns. The high proportion of women (119 to 100) is explained by the fact that a large number of the men leave their villages in the winter (the season when the census was taken) to work in the factories at St Petersburg and Moscow. No less than 384,500 persons, of whom 77,000 were women and 26,000 children, left the province for this purpose in 1899. The population is almost entirely Great Russian, but includes about 115,000 Karelians. The government is divided into twelve districts, the chief towns of which are Tver, Byezhetsk (9000 inhabitants), Kalyazin (5497), Kashin (7468), Kortcheva (2379), Ostashkoff (10,457), Rzheff (21,397), Staritsa (5395), Torzhok (12,743), Vesiegonsk (3469), Vyshniy Volotchok (16,722), and Zubtsoff (2984). The distribution of landed property in 1896 was as follows:—The peasants owned 69 per cent. of the land, having since their liberation bought 2,660,300 acres from the landowners, in addition to their allotments, which made 50 per cent. of the land; the nobility owned 13 per cent.; other landowners, 6 per cent.; the Crown, 7 per cent.; and the Imperial family, 4 per cent. Only one-tenth of the land is considered as unavailable for culture. No fewer than 42,540 peasant families hold no land, while in addition to the land which they own the peasants rent 1,498,000 acres. Notwithstanding the very moderate fertility of the soil, which requires heavy manuring, and the great development of industries in the villages, the peasants hold under culture 80 per cent. of the total cultivable area of the province. Far from destroying agriculture, the village industries favour it by providing occupation and earnings in the winter. The crops are quite insufficient for the population, and grain has to be imported in large quantities, though 1,951,000 acres were under cereal crops in 1900. The average yield in 1895–99 was: rye, 4,543,000 cwt.; wheat, 19,000 cwt.; oats, 4,473,000 cwt.; and barley, 718,000 cwt.; also potatoes, 6,083,000 cwt. The sowing of grass is spreading, owing to the efforts of the *zemstvos*, and improved machinery is being introduced. Live-stock breeding is next in importance to the cultivation of the soil, there being in the province in 1899, 351,000 horses, 579,000 horned cattle, 476,000 sheep, and 60,000 pigs. Dairy-farming has developed, and dairy produce is exported. Manufactures have grown rapidly, the aggregate annual returns of all factories amounting to over 40,000,000 roubles, so that Tver occupies the seventh place among the governments of European Russia for manufactures. They employ over 25,000 persons (8400 women, 3430 children). Cotton-mills, flour-mills, tanneries, and distilleries are the chief industrial establishments. The government of Tver is also a great emporium for village industries, of which a remarkable variety is carried on, nearly every district and even every village having its own speciality. The principal of these domestic industries are weaving, lace-making, boat-building, and the making of boots, sacks, nets, all sorts of wooden goods, nails, locks, and other hardware and agricultural implements, and felt goods. Trade is very active, and its returns were estimated in 1899 at 76,500,000 roubles, which is much below the real figure. The river ports on the systems of the Volga, the western Düna, and the Msta represented an aggregate of 3680 vessels and 81,710 rafts cleared, and about as many entered, an aggregate of over 2,000,000 towns; while the railway stations represented a movement of 903,000 tons entered and 725,500 tons sent out. Owing to the efforts of the local county and district councils, and notwithstanding the opposition of the Government, education, as well as the organization of medical relief, mutual insurance against fire, co-operative dairying, and agricultural instruction are in a better position than in most provinces of Russia. There were in 1899, 2 gymnasia and progymnasia for boys and 8 for girls, 1 *real* school, 2 teachers' seminaries and 1 theological seminary, 4 agricultural and 3 lower technical schools, and 1557 primary schools—55 town schools (6547 pupils), 16 ministerial (2349 pupils), 704 of the *zemstvos* (52,381 pupils), 20 private (1534 pupils), and 762 schools of inferior grade of the synod (27,122 pupils). Consequently 76 per cent. of the young men taken for the army could read and write in 1899, as against 37 per cent. in 1875. There are 75 school libraries, in addition to 22 public libraries. Mutual insurance by the *zemstvos* is very successful in the village, representing an aggregate capital of 111,000,000 roubles. (P. A. K.)

Tver, the capital of the above government, 102 miles by rail north-west of Moscow, on the right bank of the Volga, opposite its junction with the Tvertsa river, which enters into the Vyshnevolotsk chain of canals, connecting the Volga with St Petersburg. This system having become less used than the Mariinsk route, Tver has lost its importance as a centre for trade in corn, its place in this respect having been taken by Rybinsk. But this loss is compensated for by the great development in its manufacturing industries, which now employ more than 10,000 workmen and show an aggregate annual return of more than 20,000,000 roubles. The chief works are cotton mills (16,500,000 roubles a year in one large factory employing 8200 persons) and flour mills, but there are also a number of machinery works, glass works, saw-mills, and tanneries; large railway carriage works and a steamer-building wharf have also been opened. The town is a considerable centre for the distribution of goods in a wide industrial region. It has an important river port, which was visited in 1899 by 1670 vessels and 47,700 rafts entered (420,000 tons), while the imports by rail reached 150,000 tons. The general aspect of Tver has much improved, and its population has nearly doubled since 1861, being 53,477 in 1897. Tver is well provided with schools, both for primary and secondary education, has a good museum, seven libraries, and free hospitals, and is in telephonic communication with Moscow and St Petersburg.

Twain, Mark. See CLEMENS, S. L.

Twenty-four Parganas, The, a district of British India, in the Presidency division of Bengal. It occupies part of the Gangetic delta, east of the Hooghly, surrounding (but not including) the city of Calcutta. It also excludes the unsurveyed and almost uninhabited Sundarbans. The administrative headquarters are at Alipur, a southern suburb of Calcutta.

Area, 2108 square miles; population (1881), 1,618,420; (1891), 1,892,033, showing an increase of 17 per cent.; average density, 898 persons per square mile. Classified according to religion, Hindus in 1891 numbered 1,187,667; Mahommedans, 690,815; Christians, 12,982, of whom 2010 were Europeans; "others," 569. In 1901 the population was 2,078,340, showing a further increase of 10 per cent. The land revenue and rates in 1897–98 were Rs.17,59,130; number of police, 1332; boys at school (1897–98), 67,679, being 45·6 per cent. of the male population of school-going age; registered death-rate (1897), 24·4 per thousand. The Twenty-four Parganas form the tract of which the *zamindari* or landlord rights were granted to the East India Company after the battle of Plassey, while the revenue arising therefrom was conferred upon Clive, upon whose death it reverted to the Company. The district is traversed by three railways, two of which terminate at the ports of Diamond Harbour and Matla, but numerous river channels are still the chief means of communication. Apart from the suburbs of Calcutta, there is hardly a single real town. The two principal industries are the pressing of jute and the weaving of gunny bags.

Twerton, a parish in the Frome parliamentary division of Somersetshire, England, 1½ mile west of Bath, with a station on the Great Western railway. There are lias quarries in the parish, and bricks and woollen cloth are manufactured. Population (1891), 7685; (1901), 11,098.

Twickenham, a parish and urban district in the Brentford parliamentary division of Middlesex, England, on the north bank of the Thames. The interior of the church of St Mary was decorated and its tower restored in 1897. Population (1891), 16,027; (1901), 20,991.

Twiss, Sir Travers (1809–1897), English jurist and civilian, son of the Rev. Robert Twiss, was born in London in 1809. At University College, Oxford, he obtained a first-class in mathematics and a second in classics in 1830, and was elected a fellow of his college, of which he was afterwards successively bursar, dean, and tutor. During his connexion with Oxford he was, *inter alia*, a public examiner in classics and mathematics, Drummond professor of political economy (1842), and regius professor of civil law (1855). After he had forfeited his fellowship by marriage, he was elected to an honorary fellowship of University College. He published while at Oxford an epitome of Niebuhr's *History of Rome*, an annotated edition of Livy, and other works, but his studies mainly lay in the direction of political economy, law, chiefly international law, and international politics. In 1840 he was called to the bar at Lincoln's Inn, and became an advocate at Doctors' Commons. In the ecclesiastical courts he enjoyed a large practice, and filled many of the appointments incidental thereto, such as Commissary-General of the City and Diocese of Canterbury (1849), Vicar-General to the Archbishop (1852), and Chancellor of the Diocese of London (1858). He was professor of international law at King's College, London (1852–55). In 1858, when the Probate and Divorce Acts of 1857 came into force, and the ecclesiastical jurisdiction of Doctors' Commons had passed away, Twiss, like many other leading advocates of Doctors' Commons, became a Q.C., and in the same year he was also elected a bencher of his Inn. His successful career continued in the civil courts, and in addition to his large practice he was appointed in 1862 Advocate-General to the Admiralty, and in 1867 Queen's Advocate-General, an office since obsolete, the occupant of which took precedence of the Attorney-General. In 1867 he was also knighted. He served during his legal career upon a great number of royal commissions, such as the Maynooth commission in 1854, and others dealing with marriage law, neutrality, naturalization, and allegiance. He was also one of the commissioners who sat to determine the boundaries of Canada and New Brunswick, while his reputation abroad led to his being invited by the King of the Belgians to draw up the constitution of the Congo Free State. In 1871 Twiss became involved in an unpleasant scandal, occasioned by allegations against the ante-nuptial conduct of his wife, whom he had married in 1862; and he threw up all his appointments and lived in retirement in London until his death in 1897, devoting himself to the study of international law and kindred topics. Among his more notable publications of this period were *The Law of Nations in Peace* and *The Law of Nations in War*, two works by which his reputation as a jurist will chiefly endure. (E. A. AR.)

Tyler, a city of Texas, U.S.A., capital of Smith county, in the north-eastern part of the state, at the intersection of lines of the International and Great Northern and the St Louis South-Western railways, at an altitude of 531 feet. It is in a cotton region, and contains cotton-gins and compresses, and has a large business handling that staple. It contains also repair works of the St Louis South-Western railway, and rolling-mills. Population (1880), 2423; (1890), 6908; (1900), 8069, of whom 286 were foreign-born and 2693 negroes.

Tylor, Edward Burnett (1832-——), English anthropologist, born at Camberwell on 2nd October 1832, was the son of Joseph Tylor, a brassfounder. Alfred Tylor the geologist was an elder brother. His parents were members of the Society of Friends, at one of whose schools at Grove House, Tottenham, he was educated. In 1848 he entered his father's manufactory in London, but at about the age of twenty he was threatened with consumption and forced to abandon business. During 1855–56 he travelled in the United States of America to recruit his health. Proceeding in 1856 to Cuba, he met Henry Christy the ethnologist, with whom he visited Mexico. Professor Tylor's association with Christy greatly stimulated his awakening interest in anthropology, and his visit to Mexico, with its rich prehistoric remains, led him to make a systematic study of the science. While on a visit to Cannes he wrote a record of his observations, entitled *Anahuac; or, Mexico and the Mexicans, Ancient and Modern*, which was published in 1861. In 1865 appeared *Researches into the Early History of Mankind*, which made Tylor's reputation. It showed great research, original insight, and much constructive power in the formation of systematic views. The chapters on early myths and their geographical distribution are especially valuable. The work reached a third edition in 1878. This book was followed in 1871 by the more elaborate *Primitive Culture: Researches into the Development of Mythology, Philosophy, Religion, Language, Art, and Custom* (3rd edit., 1891), which is still the standard general treatise on anthropology. Tylor's treatment of animism (ch. xi.–xvii.) is particularly elaborate, and he first determined the limits of that province of anthropology, intending it to include "the general doctrine of souls and other spiritual beings." In 1881 Tylor published a smaller and more popular handbook on *Anthropology*. His work had already met with recognition. In 1871 he was elected F.R.S., and in 1875 received the honorary degree of D.C.L. from the University of Oxford. He was appointed keeper of the University Museum at Oxford in 1883, and reader in anthropology in 1884. In 1888 he was appointed first Gifford lecturer at Aberdeen University, and delivered a two years' course on "Natural Religion." In 1896 he became first professor of anthropology at Oxford.

Tyndall, John (1820–1893), British natural philosopher, was born in county Carlow, Ireland, on 2nd August 1820, his father being the son of a small landowner and, though in poor circumstances, a man of more than ordinary ability. Tyndall himself for many years represented to ordinary Englishmen the typical or ideal professor of physics. To correct the exaggerated estimate common in the active part of his lifetime a certain amount of detraction naturally followed, and his memory came to be unduly depreciated. So far from being typical, he was in many respects unique, and he was chiefly remarkable for strong character, abundant energy, and scientific enthusiasm.

General characteristics.

His knowledge of physics was picturesque and vivid rather than thorough and exact, and never did it make any pretence at being encyclopædic. In amount it did not much exceed what any highly educated man of genuine all-round culture should aim at, though it was far in excess of what in England is commonly thought possible; but its vividness and colour and garnish of enthusiasm were his own. His strong, picturesque mode of seizing and expressing things gave him an immense living influence both in speech and writing, and disseminated a popular knowledge of elementary physics such as had not previously existed. Hence he has been styled a popularizer, and it has been thought that his function was to take some recondite matter in hand and expound it to the unlearned and the ignorant. But this idea of his function does him both more and less than justice. It is true that owing to prevalent scientific ignorance he, like many another man, found it necessary to expound elementary facts and fundamental doctrines in extremely simple language; it is true also that in this power of exposition to the unlearned he far excelled all his contemporaries, nor has there been another like him with his peculiar power of catching the popular imagination and riveting its attention. But one reason of his success was that he never attempted to expound anything specially recondite—he never hesitated to elaborate the simple and illustrate the easy—so that persons unaccustomed to scientific conceptions of any kind were able by his aid to experience the novel sensation of really comprehending something in a region perfectly new—a fact which fully accounts for the great popularity of his lectures and books. What these lectures attempted they achieved with the utmost success; they were works of art, and by them he was able to communicate something of his enthusiasm for science to others. His continued success sometimes led him to employ a popular style in regions where it was unsuitable—in scientific controversy, for instance, or at the Royal Society—and hence he attracted to himself a certain amount of criticism. For errors which were venial in popular exposition became deadly in discussion with equals or scientific superiors: there they became painfully obtrusive, and afforded opportunity for surprising rebuffs. Of these lapses the public always, and his youthful disciples at first, knew nothing, and his lectures had a marvellously stimulating effect. There are some who hold that perfect lectures should awaken in a beginner a sense of the infinitude of knowledge and of his own hopeless ignorance. If so, Tyndall's lectures were not in this sense perfect; they encouraged rather than discouraged; they gave one the satisfying feeling of complete comprehension, so that after an intelligent youth had attended and thoroughly absorbed six or ten lectures, on heat, for instance, he could for some years live under the impression that he knew the subject. So he did, up to a point—knew it far better than those he was likely to come across in ordinary life; and the feeling of thorough comprehension of one department encouraged him to enter upon a study of others with hope of similar satisfaction, though without Tyndall's guiding hand it was in many cases a comparatively slow and difficult process. Whatever may be the merits and demerits of this mode of beginning the study of physics, it is by no means clear that the orthodox modern portal of the quantitative physical laboratory constitutes anything like the same effective initial entrance, although if the first difficulties are overcome, a far more extensive interior is thus opened up. If the object of training be to enable a student to measure physical quantities and devote himself to the science as to a profession, there can be no question which is the best method; but if the object be to imbue the beginner with ideas, and assist him to a general grasp of the elementary principles and qualitative foundations of the science, then the method of Tyndall is the right one. In any case, at the beginning it is a right method; but the mistake should not be made of supposing that the knowledge so imparted is all, or even much. It is a sketch of the edifice, but the building, the foundations, and even the preliminary work of collecting the materials must come later. Had the faculty of exposition been all, there had been less to say. Tyndall was a true educator, but he was more than that: he was at heart a Naturalist, *i.e.*, an explorer of Nature, a physicist of the field. He had the instincts which usually accompany a proclivity for biology or geology or some other exploring science; he was one of the finest field physicists of his century. The aspects of Nature appealed to him strongly and emotionally, and it was in the domain of observation that his best and most characteristic work lay.

PROFESSOR TYNDALL.
(*From a photograph by Elliott and Fry, London.*)

His scientific life may be divided very roughly into periods, or at any rate into groups:—(1) The youthful period, dominated by study in Germany and by work in magnetism; (2) the slaty cleavage and Swiss glacier period; (3) the Royal Institution and radiant heat period; (4) the final period, including his work in connexion with lighthouses, dust and disease, and amateur theology.

Tyndall was to a large extent a self-made man; he had no early advantages, but with indomitable earnestness devoted himself to study, to which he was stimulated by the writings of Carlyle. He passed from a National school in county Carlow to a minor post (1839) in the Irish Ordnance Survey, thence (1842) to the English Survey, attending Mechanics' Institute lectures at Preston in Lancashire. He then became for a time (1844) a railway engineer and (1847) a teacher at Queenwood College, Hants. Thence with much spirit, and in face of many difficulties, he betook himself, with his colleague Edward Frankland, to the University of Marburg (1848–51), where, by intense application, he obtained his doctorate in two years. At this period he certainly learnt some mathematics, and his inaugural dissertation was an essay on screw-surfaces; but he had not the genuine mathematical instinct, and never looked at things from the point of view of a mathematician. Some curious instances of this will occur as we proceed.

Investigations in magnetism.

His early magnetic investigations, for instance (1850–1855), sadly lack the definiteness which was possible at their date, but they are characterized by the same free intrepidity and lack of deference to authority which distinguish nearly all his work. He endeavours to measure the law of decrease of force with distance by pulling a sphere of iron off a large magnetized pole-piece from which it was separated by various thicknesses of paper, and expends much experimental care upon the operation, not at all realizing that it must necessarily lead to nothing. He makes many experiments on diamagnetic polarity, of which one series, on a plan suggested by Weber, is recognized as satisfactory, giving a definite result; but he does not express it as a mathematician would. He does not connect polarity with the discontinuity to be expected when lines of force traverse the boundary of two media of different permeability. The result of his crucial experiment is most naturally and simply stated by asserting that the permeability of bismuth is less than that of air; and, regarded in this way, it is difficult to see how the fact of the so-called diamagnetic polarity could be doubted. His chief magnetic work was devoted to the qualitative examination of the magnetic deportment of crystalline bodies; and he constructed artificial substances which behaved similarly by subjecting bread and other soft substances to pressure so as to produce a laminated structure.

Shortly before the Ipswich meeting of the British Association in 1851 Tyndall made acquaintance and began a lasting friendship with Huxley. The two young men stood for chairs of physics and natural history respectively, first at Toronto, next at Sydney, but they were in each case unsuccessful. In February 1853, however, Tyndall gave a famous Friday evening lecture (on "The Influence of Material Aggregation upon the Manifestations of Force") at the Royal Institution, and was in the following May chosen its professor of natural philosophy, a post which exactly suited his striking gifts, and made him a colleague of Faraday, whom in 1866 he succeeded as scientific adviser to the Trinity House and Board of Trade, and in 1867 as superintendent of the Royal Institution. His reverent attachment to Faraday is beautifully manifested in his memorial volume called *Faraday as a Discoverer* (1868).

Alpine investigations.

In 1854, after the British Association in Liverpool, a memorable visit occurred to the Penrhyn slate quarries, where the question of slaty cleavage arose in his mind, and ultimately led him, with Huxley, to Switzerland to study the phenomena of glaciers. Here the mountains seized him, and he became one of the most intrepid and most resolute of explorers; he was the first to ascend the Weisshorn (1861), among other feats of climbing. The strong, vigorous healthfulness and enjoyment which permeate the record of his Alpine work are magnificent, and traces of his influence remain in Switzerland to this day. In some respects the Swiss period gives the dominant note of his life, and it represents him fairly both in his strength and weakness: strength in observation and description, and pertinacious—often dangerous—measurements, skill in recording his adventures also, and in collecting information on the subject; weakness in not clearly understanding the true physics of a process even when it had been discovered and laid bare by others. The problem of the flow of glaciers occupied his attention for years,—throughout the rest of his life, one may say,—and it excited a singular amount of controversy, some of it of a personal kind. Tyndall was a most fair-minded controversialist, but he revelled in guerilla warfare, and seldom or never realized the weight of armament which disciplined troops could bring to bear against him. Consequently his controversies were often personal, always buoyant and hopeful, and seldom ended in any misgivings. For though he sometimes expresses himself as unable to understand the argument of his antagonist, he clearly does not mean this to be understood as due to a defect on his own part. His side of the controversy is always simple, and beautifully stated up to the lights of the average listener; and any lights beyond that he strongly inclines to mistrust. This boyish or free-lance attitude sometimes irritated the masters of the heavy artillery of science, who were astonished at an attack with bows and arrows, slings and stones, and other well-aimed and curiously effective weapons. For there was a vein of wholesome rightness about Tyndall, as well as a notable lack of the theoretical instinct; he was in close touch with Nature, and often realized her processes in his own way. He speaks of the pleasure derived from actual observation even of a well-known fact, and likens his feelings to those of Antæus on touching his mother earth. But his was not the inspired rightness of Faraday; doubtless it aimed at that, but his genius fell short of his master's in this respect, and whereas Faraday was more often right than the mathematicians, Tyndall was very liable to be in some vital points wrong; and the fact that he stated his case clearly sufficed to exhibit his wrongness all the more plainly to the few who possessed the necessary knowledge. Many explorers must find their theories looked down upon by the learned men at home on their return, and wise are they who realize where their strength lies, and do not seek to argue on first principles as if on equal terms.

The controversy with Forbes and others about glacier motion.

It would be tedious to rake among the ashes of the dead controversy about glacier motion, in which the names of Agassiz, J. D. Forbes, Rendu, and Tyndall were intermingled, but it contains some permanent lessons which are better not overlooked. Every one knew that glaciers moved, but the questions were how they moved, for what reason, and by what mechanism. Some thought they slid like solids; others that they flowed like liquids; others that they crawled by alternate expansion and contraction, or by alternate freezing and melting; others, again, that they broke and mended. Thus there arose a chaos of controversy, illuminated by definite measurements and observations. The following summary of this part of the matter by Tyndall is as fair as possible:—

> The *idea* of semi-fluid motion belongs entirely to Rendu; the *proof* of the quicker central flow belongs in part to Rendu, but almost wholly to Agassiz and Forbes; the proof of the retardation of the bed belongs to Forbes alone; while the discovery of the locus of the point of maximum motion belongs, I suppose, to me.

But the chief bite of the controversy lay between Forbes and Tyndall. Forbes asserted that ice was viscous; Tyndall denied it. All agreed that ice flowed *as if* it were a viscous fluid: in every detail this came out from the measurements; as a description of the motion this statement is perfect, and gradually from the conflict this fact clearly emerged. But how came it so to flow? That was what none of the combatants could explain. Tyndall thought it was by regelation, but he did not understand regelation. Nor did Faraday. The textbooks of that period (*e.g.*, Balfour Stewart's) enter into an elaborate fiction about the coldness of the interior of ice. It seems to have been spoken of as a property "inherent to ice" to have a cold inside. "Never can a calorific ray pass the first surface of ice to raise the temperature of the interior."

Tyndall speaks of "liquid liberty" on the surface of ice, and says that when two moist surfaces are brought into contact the liquid liberty is destroyed and the surfaces freeze together. Forbes, on the other hand, said simply that ice possessed viscosity. Tyndall does not seem very clear what viscosity is, and in a characteristic passage says, "What then is the meaning of viscosity or viscidity? I have heard it defined by men of high culture as 'gluey tenacity.' . . . Viscosity then consists in the power of being drawn out when subjected to a force of tension, the substance, after stretching, being in a state of molecular equilibrium, or, in other words, devoid of that elasticity which would restore it to its original form." Forbes, however, must have known precisely what viscosity was, and in so far as he only asserted that ice behaved as if it had viscosity he was right; and where a glacier consists of a heterogeneous assemblage of crystals and fragments it may be really viscous like a crystalline metal; but if he meant, as undoubtedly he did mean, that a mass of homogeneous blue ice began to soften before it melted, and was really a viscous fluid (as glass is) a little below its melting-point, he was wrong; and Tyndall felt and said that he was wrong.

James Thomson's solution.

A sufficient reason for the curious behaviour of ice was discovered, quite independently of the controversy, by a classical thermodynamical investigation of Professor James Thomson (elder brother of Lord Kelvin), a man of the higher order of specific intellect, who developed by pure theory a result which explains this and vastly more, and opens a new chapter in physics—the application of the second law of thermodynamics to physical and chemical problems. The simple fact is that ice under sufficient pressure melts, without the supply of any heat, and the water instantly freezes again on escaping from the pressure. For this reason ice behaves as if it were viscous. It yields where the pressure is greatest, and migrates to where the pressure is least; but it does not flow as ice, for ice is not viscous but a rigid solid; it flows as water, but exactly simulates viscosity by reason of its potentiality for change of state. The only controversy which could remain is a logomachy as to how nearly any of the statements which had previously been made corresponded to reality—a worthless subject for discussion.

Tyndall's criticisms of Forbes and Thomson.

On one point Tyndall holds Forbes very neatly. If ice were really viscous it would not crevasse when under tension, at least not to the extent it does; and Tyndall clearly notes and explains the fact that the direction of the latteral crevasses, at 45° and slanting upstream from the retaining walls, is just the direction required by the actual shear, being due to the extension-component of the distortion caused by the more rapid flow in the middle and the retardation of the edges, though it is at right angles to the direction which a casual observer would expect from the direction of the flow. But James Thomson's theory of the apparent viscosity of ice he cannot grasp. When he tries to explain it in popular language he comes to grief. The fact itself he accepts, viz., that pressure lowers the melting-point of ice, as it raises the boiling-point of water, but in trying to state it he proceeds thus:—

> When a liquid is heated the attraction of the molecules operates against the action of the heat, which tends to tear them asunder. At a certain point the force of heat triumphs, the cohesion is overcome, and the liquid boils. But supposing we assist the attraction of the molecules by applying an external pressure, the difficulty of tearing them asunder will be increased; more heat will be required for this purpose; and hence we say that the *boiling-point* of the liquid has been *elevated* by the pressure.

Here the sentence "more heat will be required for this purpose" is careless. The fact is that less heat is necessary to evaporate water under high pressure with the boiling-point raised; but this does not sound right to the average man, while Tyndall's statement does. So again when he comes to ice or bismuth he repeats the same kind of error in other terms—four times on two pages. (*Glaciers of the Alps* [1860], 1896 edition, pp. 408, 409.) It is curious to read Tyndall's attempts to understand James Thomson's theory. His mode of approaching the matter is always fair and characteristic, and singularly unsuitable for the purpose in view: it was written after a second communication from James Thomson, in which that philosopher endeavoured to emphasize the needlessness for any further talk about glacier motion or for spurious explanations of regelation:—

> I confess that even now I do not understand the essential point of Mr Thomson's theory—that is to say, its application to the phenomena of glacier motion. Indeed, it was the obscurity in my mind in connexion with this point, and the hope that time might enable me to seize more clearly upon his meaning, which prevented me from giving that prominence to the theory of Mr Thomson which, for aught I know, it may well deserve. I will here briefly state one or two of my difficulties, and shall feel very grateful to have them removed.

An admirable attitude; but after another paragraph the *ad captandum* style of argument is resumed, showing no sense of proportion, not at all realizing the extraordinary and crushing magnitude of "the Messrs Thomson," considered as theoretical physicists:—

> I would invite Mr Thomson to imagine himself and me together upon the ice, desirous of examining this question in a philosophic spirit; and that we have taken our places beside a stake driven into the ice, and descending with the glacier. We watch the ice surrounding the stake, and find that every speck of dirt upon it retains its position; there is no liquefaction of the ice that bears the dirt, and consequently it rests on the glacier undisturbed. After twelve hours we find the stake 15 inches distant from its first position. I would ask Mr Thomson how did it get there?

Tyndall's attitude towards scientific fame.

Whereas, then, on the scientific side Tyndall had his weakness, on the human side he was superlatively strong. Scrupulous fairness up to his lights was his constant attitude, and he took pleasure in urging the claims of an unknown man or of a foreigner. So he acted for J. R. Mayer, physician of Heilbronn, and so also for Rendu, bishop of Annecy. Mr Ruskin permitted himself in *Fors Clavigera* to join in the ice controversy, and to accuse Tyndall of showing a carping and detracting spirit in his effort to link the name of Rendu with that of Forbes; but this was allowing his judgment to be biassed by friendship and respect for the memory of Forbes, also by a too ready acquiescence in a descriptive or superficial statement of the glacier problem as if it were the complete solution. But he made amends, for this misguided criticism of a man as fair as himself, by a note specially written for a translation of Rendu's *Glaciers of the Savoy;* this, being accessible only with difficulty, may be in great part here reproduced, as a statement for all time of the worthy attitude of scientific men in such matters; and we can well imagine Tyndall acclaiming with a vigorous handshake his agreement with the substantial sentiment of this fine passage[1]:—

> It seems to me that all these questions as to priority of ideas or observations are beneath debate among noble persons. What a man like Forbes first noticed, or demonstrated, is of no real moment to his memory. What he was, and how he taught, is of consummate moment. The actuality of his personal power, the sincerity and wisdom of his constant teaching, need no applause from the love they justly gained, and can sustain no diminution from hostility; for their proper honour is in their usefulness. To a man of no essential power, the accident of a discovery is apotheosis; to *him*, the former knowledge of all the sages of earth is as though it were not: he calls the ants of his own generation round him, to observe how he flourishes in his tiny forceps the grain of sand he has imposed upon Pelion. But from all such vindication of the claims of Forbes to mere discovery, I, his friend, would, for my own part, proudly abstain. I do not in the slightest

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[1] To a book called *Glaciers of Savoy*, being a translation of Monsieur Rendu's book on the same subject, made by George Forbes in memory of his father, in which there are quoted several extracts from *Fors Clavigera* of October 1873 (Letter 34), Mr Ruskin adds a special supplementary note on the proper attitude of men of science to questions of priority. Considered critically, it is not a complete statement, for it is not human to attempt to eradicate the last traces of individuality; and the greatest men of science, to whom all other rewards were as nothing, have always felt a human interest in the personal side of all good work, and have been careful to attribute credit justly when they could. For as an artist signs a picture and resents a forgery, so may a man of science justly demand reasonable historical accuracy in the labelling of discoveries. But inasmuch as the labelling is often complicated, and misunderstandings must occur, especially in the careless estimation of the public, the extract quoted in the text is a true representation of the only attitude worthy of the dignity of science.

> degree care whether he was the first to see this, or the first to say that, or how many common persons had seen or said as much before. What I rejoice in knowing of him is that he had clear eyes and open heart for all things and deeds appertaining to his life; that whatever he discerned, was discerned impartially; whatever he said, was said securely; and that in all functions of thought, experiment, or communication, he was sure to be eventually right and serviceable to mankind, whether out of the treasury of eternal knowledge he brought forth things new or old.
>
> This is the essential difference between the work of men of true genius and the agitation of temporary and popular power. The first root of their usefulness is in subjection of their vanity to their purpose. It is not in calibre or range of intellect that men vitally differ; every phase of mental character has honourable office; but the vital difference between the strong and weak—or let me say rather, between the availing and the valueless intelligence—is in the relation of the love of self to the love of the subject or occupation. . . . It may be felt in any single page of Forbes's writing, or De Saussure's [or Tyndall's either] that they love crag and glacier for their own sake's sake; that they question their secrets in reverent and solemn thirst: not at all that they may communicate them at breakfast to the readers of the *Daily News*—and that, although there were no news, no institutions, no leading articles, no medals, no money, and no mob in the world, these men would still labour, and be glad, though all their knowledge was to rest with them at last in the silence of the snows, or only to be taught to peasant children sitting in the shade of the pines.

Principal scientific work.

The remaining epochs of Tyndall's life need but short notice. He investigated the transparency and opacity of gases and vapours for radiant heat during many years (1859–71), and this is frequently considered his chief work. He definitely established the absorptive power of clear aqueous vapour—a point of great meteorological significance. He made brilliant experiments elucidating the blue of the sky, and discovered the precipitation of organic vapours by means of light. He called attention to curious phenomena occurring in the track of a luminous beam. He examined the opacity of the air for sound in connexion with lighthouse and siren work. And he finally clinched the proof of what had been already substantially demonstrated by several others, viz., that germ-free air did not initiate putrefaction, and that accordingly "spontaneous generation" as ordinarily understood was a chimera (1875, 1876). One practical outcome of these researches is the method now always adopted of sterilizing by a succession of gentle warmings, sufficient to kill the developed micro-organisms, instead of by one fierce heating attempting to attack the more refractory undeveloped germs of the same. This method of intermittent sterilization originated with Tyndall, and it was an important contribution to biological science and industrial practice.

For the substantial publication of these researches reference must be made to the *Transactions of the Royal Society;* but a popular account of many of them was incorporated in his best-known books, namely, *Heat as a Mode of Motion* (1863, and later editions to 1880); *The Forms of Water, &c.* (1872); *Lectures on Light* (1873); *Floating Matter in the Air* (1881); *On Sound* (1867; revised 1875, 1883, 1893). The original memoirs themselves on radiant heat and on magnetism were collected and issued as two large volumes under the following titles:—*Diamagnetism and Magne-crystallic action* (1870); *Contributions to Molecular Physics in the Domain of Radiant Heat* (1872).

His scientific achievements were none of them of the very first magnitude: it is not so much what he did as what he was that is of permanent interest; and in the pursuit of pure science for its own sake, undisturbed by sordid considerations, he shone as a beacon light to many a struggling youth—an exemplar of simple tastes, robust nature, and lofty aspirations. His elevation above the common run of men was conspicuous in his treatment of the money which came to him in connexion with his successful lecturing tour in America (1872, 1873). It amounted to several thousands of pounds, but he would touch none of it: he placed it in the hands of trustees for the benefit of American science—an act of lavishness which bespeaks a noble nature. That Mr Ruskin should have allowed himself to belittle such a man is a painful instance of the mistakes which can be made through half-knowledge. There was in truth much kinship between them, and had they known each other better they would have been friends. They differed much in culture, no doubt, and in amount of achievement as well as in analytic power. No comparison is intended, but they had features in common. Both of them rushed into subjects for which they had had no adequate training, and both, by their innate ability, critical faculty, and clear commonsense, exercised some revolutionary and wholesomely clarifying influence on any subject they touched.

Theological controversy.

Tyndall's incursions into theology were marked by the same crude fearlessness as we have noticed in the higher parts of physics or amid the forces of nature; and he laid down the law, on prayer, for instance, and on miracles, with easy assurance. These writings—*Fragments of Science,* as he calls them, "for unscientific people"—are wholesome and interesting, though naturally they do not add to our knowledge appreciably; nor did the more ambitious Belfast Address (1874), delivered as President of the British Association, make any serious contribution to philosophy, though it stated a form of the materialistic position with his usual trenchant vigour, and made a great stir among those who were then busy with the supposed conflict between science and religion. At bottom Tyndall frequently displayed a reverent and religious spirit, but he was led away by his conception of physics into an endeavour to simplify the universe to an extravagant extent; and his light-hearted exhilaration in this enterprise shocked many good people, who feared that he might succeed in uprooting their treasured convictions.

Tyndall was a vehement politician, with a characteristically Irish readiness and violence of expression; though a thorough Liberal, he split from Mr Gladstone on Irish Home Rule, and exhibited activity in opposing it. In 1876 he married Louisa, daughter of Lord Claud Hamilton. He built in 1877 a cottage on Bel Alp above the Rhône valley, and in 1885 a house on Hindhead, near Haslemere. At the latter place he spent most of his later years; his health was, however, no longer as vigorous as his brain, and he suffered frequently from sleeplessness. On 4th December 1893, having been accidentally given an overdose of chloral, he died at Hindhead. (O. J. L.)

Tyne, The, a great river of England, flowing past Newcastle and emptying itself into the North Sea at Tynemouth. Perhaps the great feature of the Tyne, commercially speaking, has been the amalgamation of the great shipbuilding and engineering companies, enabling single firms to build and engine ships of the largest size, viz., Armstrong, Whitworth and Company, Palmer's, and Swan and Hunter. Two yards in 1898 built vessels whose total tonnage exceeded 50,000, and two engineering firms made engines the total horse-power of which was more than 50,000. To enable this to be done the Tyne Commissioners have changed the river from a shallow stream into a river deep enough to allow a 5000-ton ship to proceed 14 miles up the river. In this work 100,000,000 tons of material have been dredged from the river, making the depth of water at Shields harbour 40 feet, and at Newcastle 31 feet at high-water spring tides. The amount spent on these works of improvement, and on the Tyne piers, is nearly £6,000,000. Of this sum more than £1,000,000 has been spent on the two piers at the mouth of the river. The length of the north pier, which in 1898 was partly destroyed by a great storm, is 3059 yards, and that of the south is 5317 yards. The dangerous rocks known as the Black Middens are all but removed, and the Tyne now is a very safe harbour of refuge. The Tyne, Northumberland, and Albert Edward docks, the Tyne Commissioners' and Dunston staiths, are the great depôts from which coal is exported. In 1894 more coal was exported from Tyne dock than from any other dock in the world. At North Shields are two pontoon docks capable of docking the largest steamers in half an hour. There are two also at Wallsend, as well as one of the largest dry docks in the United Kingdom.

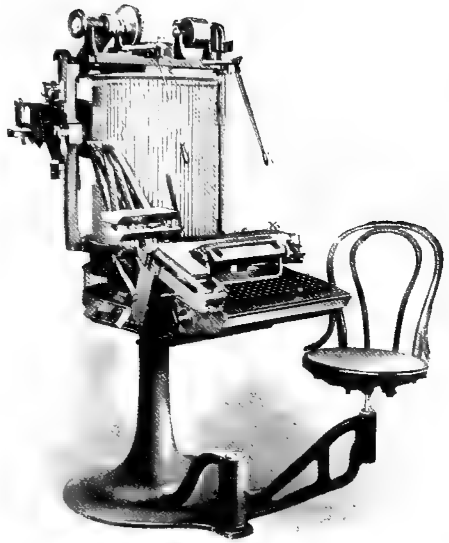
The following table gives some figures as to the progress of the Tyne:—

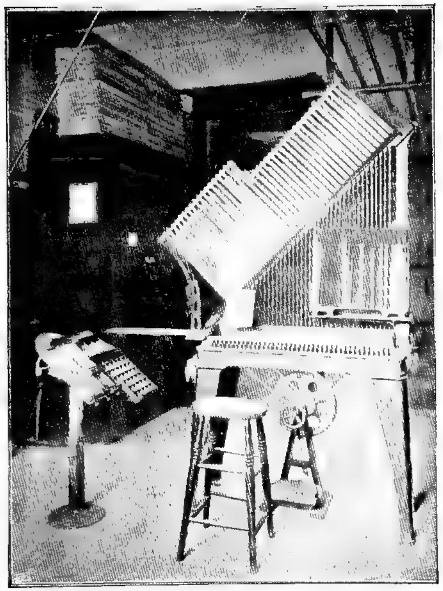
	1880.	1890.	1899.
Amount of coal exported, in tons	8,131,419	10,729,199	13,979,097
Average size of vessels using the port, in tons	$359\frac{1}{5}$	$476\frac{3}{5}$	$553\frac{2}{5}$

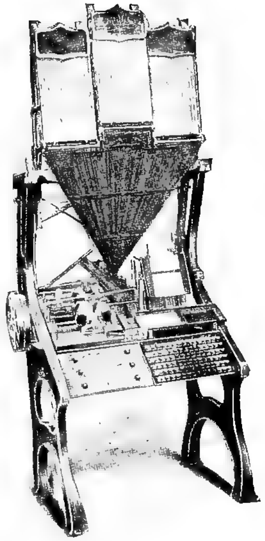
Tynemouth, a municipal and parliamentary borough (including the townships of the well-known watering-place Tynemouth, North Shields, Chirton, Preston, and Cullercoats), at the mouth of the Tyne, north bank, 8 miles east of Newcastle by rail. The borough (area 4300 acres) was divided in 1889 into six wards, and the town council acts as the urban sanitary authority. The old priory and castle now serve at the headquarters of the Tyne Submarine Engineers. The lighthouse on the cliff, to the north-east of the castle, is no longer used, but a new one has been built on St Mary's Island, 2 miles north. A fine parade (1893), on which are the aquarium and winter gardens (£120,000), and a small park stretch along the seashore. A free library and school of art, and a new infirmary, have been opened at North Shields, which is the largest part of the borough and is a port of great importance. The corporation have erected a covered market for general trade, and at the fish quay, which cost £81,000, 14,000 tons of fish are landed annually. The exports are coal and coke, of the value of £1,259,692 in 1899, and imports are corn, timber, and esparto grass, of the value of £486,700. In the same year 1091 British ships of 956,022 tons, and 1021 foreign ships of 539,260 tons cleared the port; 276 ships of 96,167 tons are registered at the port. Tynemouth returns one member to Parliament. Population (1891), 46,588; (1901), 51,514.

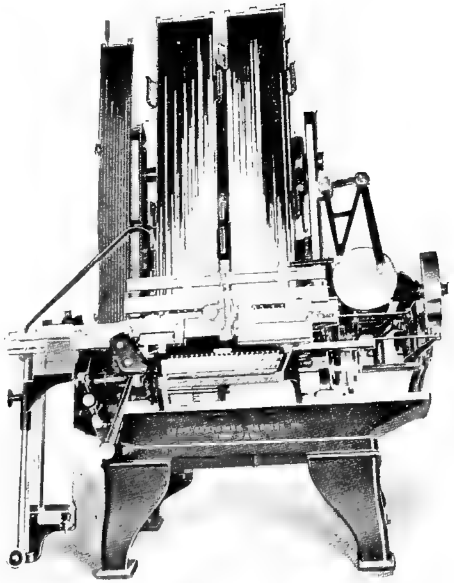
Type-setting and Type-casting Machines.—It has long been an object of inventors in connexion with printing to perfect a mechanical system by which hand-work may be done away with both in setting type and in distributing it after use. The first step in this direction was the construction of composing machines in which the compositor put together types in the required order, not by lifting them one after another from his "boxes" and placing them by hand in his "stick," but by operating a key-board which liberated them from magazines and assembled them in the order in which the keys had been struck. Such machines were followed as a natural correlative by distributing machines which performed the converse operation. Then the idea occurred of avoiding distribution altogether, by returning the printing surface to the melting-pot and using the metal over again to produce an entirely new printing surface as required, instead of sorting the types into their various kinds to be set up again either by hand or by machine. The forms of apparatus by which it was first sought to attain this end are in effect combinations of type-setting and type-casting machines, and may be divided into two broad classes: (*a*) those in which, by the operation of a key-board, letters are translated into metal types which appear as a product for use in the printing-press, not singly, but cast into complete bars or lines of type; and (*b*) those in which the final product is separate types, delivered made up into lines of the required length. The former class is exemplified by the Linotype, the Typograph, and the Monoline machines, the latter by the Lanston Monotype, the Tachytype, and the Goodson. Machines of the Linotype class all necessarily suffer from one important defect—the impossibility of making alterations in the bar of type after it has been cast. The smallest change, such as the addition of a comma, involves the resetting and recasting of a whole line, while, if two or three words have to be added or removed, the compositor may have to recast a considerable number of lines, perhaps a whole paragraph. Moreover, in regard to the quality of the letterpress obtained, the uneven contraction on cooling of the bar of metal is apt to produce irregularities in the "height to paper" of the surface, the result being an uneven impression. Again, should the matrices become worn or slightly bent in the course of working, or should particles of dirt get in between them, they no longer lie flush with each other when set up for casting, interstices are formed, and the metal flowing into these casts little projecting tags which rise to the level of the paper and print the thin black lines that may sometimes be noticed between the letters in newspapers set up on the Linotype. The Monotype and similar machines permit of corrections being made just as with hand-set type, but they too have disadvantages of their own when looked at as devices to save time and money. Each of them is in effect two machines, one of which punches holes, representing the letter it is desired to cast, in a long slip of paper, while the other takes this slip and, guided by the holes, performs the operation of casting the letters. Hence either two operators are required, or one operator must work the two portions alternately. A machine invented by Mr H. Gilbert-Stringer is designed to avoid the disadvantages mentioned as appertaining to both the Linotype and Monotype machines by casting at a single operation separate types properly arranged in lines and uniformly spaced. Up to the point where the matrices are ranged in a line ready for the bar of type to be cast, the mechanism may be identical with that of the Linotype; from that point each matrix is separately pushed into a mould which automatically varies in size to suit the size of the particular letter it is casting, and also casts the spaces between the words (determined by the use of a modified Schuckers wedge-space), so that when all the individual types and spaces in the line are assembled after casting they exactly fill the line. The machine requires only one attendant, and while one line is being cast the matrices which have formed the preceding one are being distributed to the magazine, as in the Linotype, and the following one is being set up. The matrices differ from those of the Linotype in that the face is impressed on their broad flat surface, not on the thin edge.

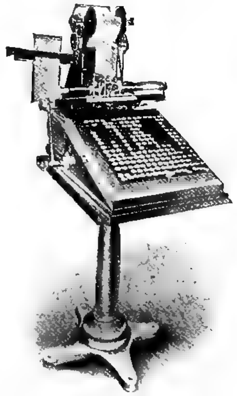
Composing Machines.—A very large number of machines for setting up ordinary foundry type have been invented since the early efforts of Church about 1820. In the machine of Young and Delcambre, which was used in London for composing the *Family Herald* in 1842, and was the forerunner of the Kastenbein machine employed in the *Times* office since 1869, the types are arranged in tubes placed either vertically or horizontally, and the lowest or endmost letter is, when wanted, ejected from the tube by a pusher actuated by a finger-key. It then passes down the channels of a guide-plate to a common point, whence it is pushed forward by a reciprocating motion to the line of previously composed matter and

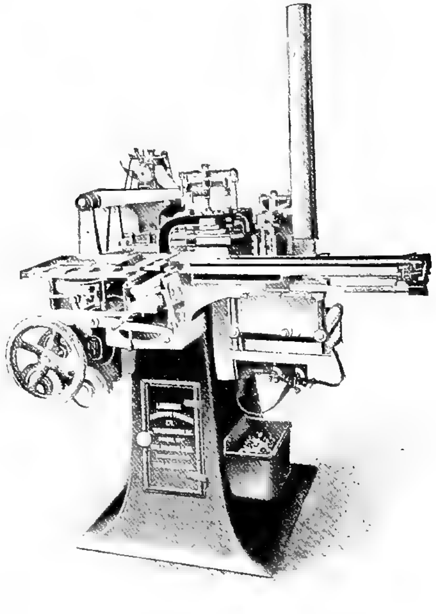

Simplex Composing Machine.


Wicks Composing Machine.


Empire Composing Machine.


Dow Composing Machine.


Lanston Monotype, Keyboard.


Lanston Monotype, Casting Machine.

Type-setting and Type-casting Machines.

divided into lines of the required length. To the same group belong the Fraser machine (described and illustrated in *Ency. Brit.* vol. xxiii. p. 701), the Hattersley, which has found a place in several English provincial printing offices, and the Empire, also known in America as the Burr. Another group of machines has been developed from the rotary composer, invented by Alexander Mackie of Warrington in 1871, and used in the office of the *Warrington Guardian.* In this the types were arranged in vertical tubes round a rotating disc, and the letters were automatically selected by a strip of paper previously punched with holes through which feelers passed and caused the desired type to be ejected upon a travelling band. This device of using a paper strip perforated in different positions to correspond to different letters was patented by Felt in 1860 (*U.S. Patent Spec.* No. 28,463), and he also utilized it for effecting distribution, the "dead" or used type being dealt with by another machine through which the paper strip was run in the reverse direction. This quality, however, was not so valuable as it might appear at first sight, since any correction, however simple, of necessity made the perforated paper ineffectual as a guide in distribution. The Thorne machine, exhibited in the Paris Exhibition of 1878, was a development of the principle of a rotating disc, but the types, which were contained in a vertical cylinder, were selected by touching keys in the ordinary manner. When liberated they fell upon a rotating table, whence they were deflected by a finger upon a travelling band and delivered into the composing race. The Simplex machine (see Plate), now being made in America, resembles the Thorne very closely. The Wicks composing machine (see Plate), again, adopts a different principle from both the above groups. The types are ejected upon a straight race set at an angle of 45°. Thus each has to travel a different distance from the other—a result which the inventors of the Delcambre group of machines were at pains to avoid; and when several keys are struck together so as to give a combination like "and," the several types delivered to the race follow each other in proper succession to the point of assembly, the letter whose key is nearest to the left side of the keyboard preceding those whose keys are more to the right.

The Paige composing, justifying, and distributing machine—an American invention—is one of the most remarkable pieces of mechanism ever put together. It contains 18,000 parts, and the patent specifications form an imposing volume. It is operated by keys in the ordinary way, but automatic mechanism advances the ejected letters in words, spaces them, and inserts the lines in the galley with leads if desired; at the same time other mechanism automatically distributes dead matter and refills the tubes which contain the supplies of types. Two machines were made, and are said to have done good work, but the cost of construction and the complicated nature of the mechanism made the apparatus impracticable commercially, and the two that were made are now on view as mechanical curiosities, the one in the Columbia Institute and the other in Cornell University. The Paige machine dispensed with the guide-plate of the Delcambre group, the letters being ejected on a plane along which a driver passed at intervals and swept the type into a receiving race on the left of the machine. The Dow composing and justifying machine (see Plate), a recent American invention, adopts this characteristic of the Paige, but has two drivers meeting at the centre of the plane which receives the letters. The types having been swept to the centre by these, a vertical driver forces them downwards into a vertical receiver. When a line has been set a justifying key is touched, the vertical line passes to a horizontal position, and is driven forwards to a point where apparatus measures it, and having removed temporary brass spaces, replaces them with others selected from a series of ten different thicknesses. The Empire machine (see Plate) has also been provided with an automatic justifier working on a plan similar in general conception to that adopted by Legerman in 1888 in a separate machine, which dealt with unjustified lines as an independent operation. The Paige, the Empire, and the Dow machines, each in its way, connect the apparatus with the composing machine and give it automatic operation. Another mode of automatic justification is presented by the Stringer and Wicks apparatus, the method of which is to insert two or more thin spaces between the words; the line is then composed in excess of the required length, but is reduced by automatic mechanism, which rejects as many spaces as are necessary, without the need for others to be selected and inserted. In another Stringer apparatus the words as they are composed are divided by an em quad, and the line having been automatically measured, the spaces are reduced as required by being passed in front of a cutter automatically adjusted for the purpose.

Distributing Machines.—There are two main classes of distributing machines. One, which is exemplified by the Delcambre or the Fraser (illustrated in *Ency. Brit.* vol. xxiii. p. 702), is operated by a keyboard; the compositor strikes the keys corresponding to the letters of the printed matter he wishes to distribute, and thus opens gates through which the types pass and find their way down a guide-plate to their proper tubes. The other comprises a number of machines which agree in requiring the type to be specially nicked for their use. Each type has its own particular combination of nicks, and the receptacles in which the type is collated are provided at their entrances with wards corresponding to these nicks, so that each type can only enter the one receptacle for which its nicks are arranged (Fig. 1). In some cases, as in the Empire and the Dow, the distributor is a separate machine; in others, as the Thorne and the Simplex, it is combined with the composing machine in such a way that the two work simultaneously.

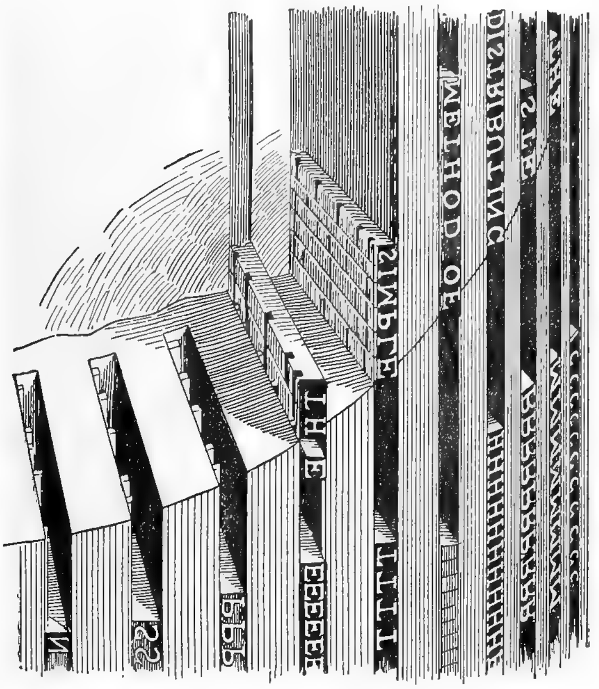


Fig. 1.—Nick System of Distribution (Simplex Machine).

Linotype.—An enormous amount of ingenuity has been expended on the Linotype, which was developed into a practical machine by Ottmar Mergenthaler, of Baltimore, though two of its elements—the solid bar of type and the wedge space—were invented by others, the former by T. W. Smith, of the Caslon Foundry, and the latter by Jacob W. Schuckers, of Washington. The following will give a general idea of its working:—In the magazine A (Fig. 2) are a series of matrices, formed with the characters in intaglio on one edge, which are discharged by gates, operated from the keyboard D into the chutes E, and thence upon the travelling belt F; this delivers them upon a revolving pusher wheel by which they are set up in proper order in the assembler block G. Above the assembler block is a space magazine, and from this the space key J releases a space bar, when desired, which drops into place in the line. As the matrices are forced into the assembler block they move to the left against the resistance of a sliding abutment, thus being held compactly in place in the line. As soon as a complete line is set up, the compositor operates a hand lever by which the assembler block and matrices are raised to the level of a horizontal slide, where the line is grasped between two jaws and carried to the left, and lowered into position opposite the mouth of the mould wheel K. Here the justification of the line is effected by means of an upwardly moving plunger which drives the wedge-shaped spaces, seen in Fig. 3, into the line, and thus expands it to the exact length required. The matrices are then locked firmly in a vice with the characters opposite the mouth of the mould. At this time the pump plunger in the melting pot M (Fig. 2) is forced downwards by mechanism actuated by suitable cams on the driving shaft, and a jet of molten type metal is ejected into the mould and against the characters on the matrices, thus casting the bar or "slug." The cast bar is next forced, by a revolution of the wheel K, between a pair of knives, by which it is trimmed, and into a galley, where it is pushed along by a packer arm and placed beside its fellows in a column ready for use.

It is next necessary to distribute the matrices to the magazines, in order that the operation of the machine may be carried on continuously. The matrices and spaces are raised from the vice and brought opposite a bar R, which carries on its under side a series of undercut ribs corresponding to the teeth which are shown at the edges of the V-shaped notch in the top of the matrices (Fig. 3), and the matrices are pushed on to this bar so as to be suspended by the ribs. They are next pushed still farther towards the right of the machine into a box having ribs engaging the notches in the side of the matrices, but with downwardly-inclined grooves crossing these ribs, by which the shoulders at the upper end of the space bars are allowed to descend, and the spaces are thus dropped out of line and fall through a chute into the space-box from which they originally came. The matrices are pushed still farther to the right, where their teeth slide along the distributor bar T, being carried by two screws which engage opposite sides of the matrices and keep them separated so that they hang loosely from the distributor bar. The ribs of the distributor bar are so arranged as to support each matrix by one or more pairs of teeth until it arrives opposite the mouth of its own magazine channel, where they are interrupted in such a manner that the matrix is unsupported and drops into the magazine for further use. It will thus be apparent that there is a constant circulation of the matrices through the machine, and the composing of one line, the casting of another, and the distribution of a third are all carried on at the same time, which adds greatly to the speed of the operation.

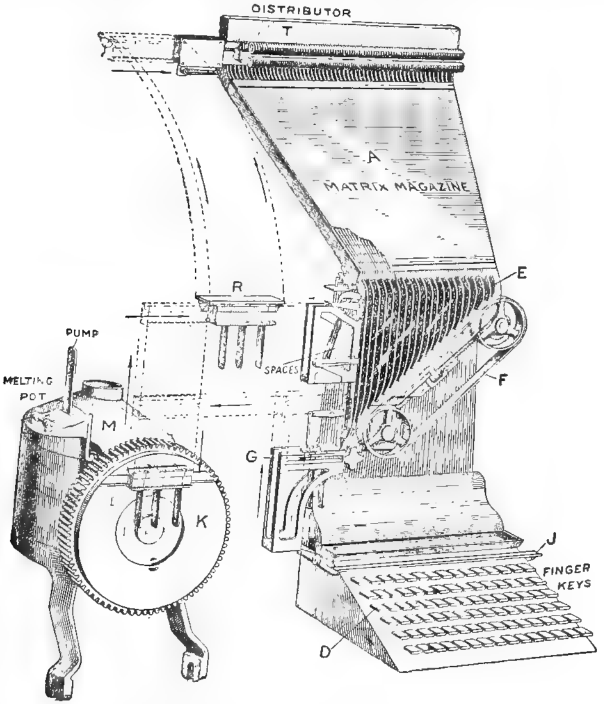


Fig. 2.—Diagram of Linotype Machine.

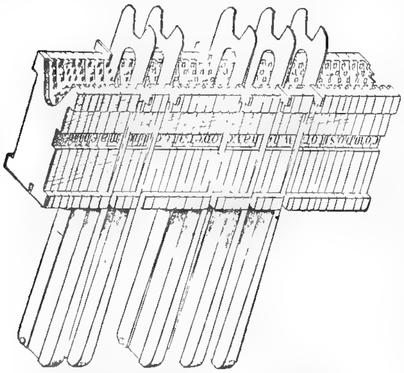


Fig. 3.—Line of Matrices with Spaces.

Several ingenious variations of the Linotype machine have been invented. In the United States patent to Rogers, No. 437,139 (23rd September 1890), the matrices consist of hooked bars which slide upon wires strung on a harp-shaped frame, with their outer ends spread out like a fan and their inner ends converging and brought into a vertical line at the composing point. The matrices are normally held at the outer ends of the wires by stops, and are released by the operation of keys, sliding down the wires and arranging themselves in line at the composing point. After the line is cast, the inner end of the frame is raised and the matrices all slide back by gravity, and are again retained by their stops. In the Mergenthaler patent (U.S.A.), No. 614,229 (15th November 1898), the matrices slide on wires as in the Rogers machine, but two magazine frames are carried on an inclined rotating shaft, which allows one frame to be brought into connexion with the keyboard while the matrices of the other are being returned to position by the inclination of the frame in its revolution with the inclined shaft. Another variation is found in the patent to Rogers, No. 534,917, in which the hooked-bar matrices are of various lengths and are supported, when in the reserve position, on a bar over which the hooks extend. As the keys are operated, they are pushed off one by one upon a travelling cord belt on which the hook catches, and are carried by it down to the composing position, where they are run off upon another guide rod and stopped. When the line is cast, they are all pushed off the rod upon their belts, and are returned by them to their original position.

Lanston Monotype.—In the Lanston apparatus there are two distinct machines, a ribbon-punching machine and a type-casting and composing machine. The first of these (illustrated on the Plate) is a small device resembling a typewriter, having a number of keys, 225 in all, corresponding to all the characters used in a font of type, with a few additions to represent certain movements to be performed by the composing machine. Each key, as it is operated, works two punches, which make two perforations in a strip of paper fed step by step through the machine. These perforations stand in a transverse line across the strip, as shown in Fig. 4, and their relative position in the line varies with the particular key operated. At the end of each word a spacing key is struck and suitable perforations are made in the strip, and as the end of a line is neared, a bell rings to warn the operator, who, by looking at a line scale facing him on the machine, is enabled to see how many units of space remain to be filled, and can then determine whether another word or syllable can be set up. If not, it then becomes necessary to provide proper space-type to justify or fill out the line, which is done by increasing the width of the normal space-types already provided for in the proportion which the number of units of space still vacant in the line bears to the number of space-types which the line contains. For example, if there are ten space-types and $\frac{1}{10}$th of an inch of space remains to be filled, each space-type must be increased in thickness just $\frac{1}{100}$th of an inch completely to fill the line. It is not necessary, however, for the operator to make this calculation, for he has only to consult the scales provided for this purpose, and is referred at once to the proper keys to punch the justifying perforations in the strip. The segmental scale on the front of the machine is divided by its radial lines to indicate the number of units of space in the line, and the pointer is moved by the action of each key over a space proportioned to the number of units of width of the type set. This scale is also divided by circular lines intersecting its radial lines and corresponding in number to the space-types which may occur in a line, and in the squares formed by these lines are placed numbers indicating the justifying keys which must be struck to effect the justification accurately. The pointer is graduated according to the possible number of space-types in a line, and on reading the number of space-types from the space counter and then noting the figures in the square on the justifying scale which lies opposite the proper space division on the pointer, the operator reads at once the number of the proper justifying key or keys. Having justified the line, the operator works a lever at the left side of the machine; this sets back all the counters to the zero mark, winds the springs which feed the paper, and punches the galley perforations which control the feed of the galley in the composing machine. These operations are then repeated for the next and all succeeding lines.

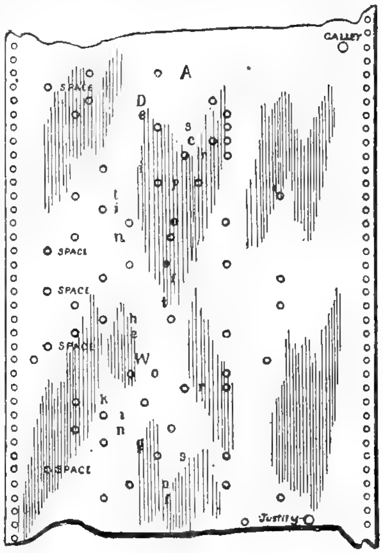


Fig. 4.—Perforated Strip.

The ribbon thus prepared in the punching machine is used to control all the movements of the casting or composing machine (see Plate). The matrices for forming the type faces are formed in a plate about 3 inches square, and any character is brought opposite the casting point by the movement of the matrix-carrier in two directions, or rather by the resultant of two such independent movements. As the perforations for controlling the galley movements and those for justifying the line are necessarily made after the others in the perforating machine, and these operations must be provided for in the composing machine before the line is set up, the latter machine is so organized that the ribbon is passed through and the types are set in the reverse order to that in which the strip was punched. The perforated ribbon is wound from one reel off to another, passing over the edge of a tracker board in which there are a number of holes corresponding to those which may occur in the ribbon, and each of these holes communicates by a tube with a small piston which controls some device for performing one of the various operations of the machine. As the ribbon passes over the tracker board, a jet of compressed air passes to the appropriate operating device whenever a ribbon perforation or any combination of them coincides with the proper holes. The two perforations on each transverse line control two stop pins which limit the movements of the matrix-carrier to bringing the proper matrix to the casting-point, while the justifying perforations set in motion devices which open the space mould to cast space type of the exact size to effect the proper justification of the line, and the galley perforation starts the feeding device which moves the galley for the next line of type. The matrix-carrier may be readily removed and another carrying a different style or size of type substituted therefor.

Type-casting.—While the Linotype and other matrix-composing machines have come into extensive use for the production of newspapers in various parts of the world, the great mass of printing is still done by the aid of movable types, which alone yield work of the highest finish and excellence. Hence these still form one of the most important parts of a printer's outfit and one of the heaviest items in his capital account. Their costliness is largely due to the comparative slowness with which, until a recent date, they could be turned out by the founders, and this again was a consequence of the fact that automatic machinery had not been applied in type-casting to anything like the extent that had been found advantageous in many industries, so that the cost of skilled and highly specialized labour remained a dominating factor. This was the case even in America, the home of automatic machinery and a country where type-founding has been made a special study. In his book on *The Practice of Typography* (New York, 1900), De Vinne says that the machine invented in 1838 by David Bruce, Junr, of New York (a Scotsman who migrated to America), or some modification of it, furnished nearly all the type made for more than forty years after its invention, and that though real improvements were introduced from time to time, the changes did not increase the productiveness of the apparatus, the great defect of which was that it did not make the type perfect, *i.e.*, various finishing operations had to be performed by hand. He goes on to say that though many machines had been designed to produce perfect type, none had been found entirely satisfactory by the type-founders of the United States, the nearest approach to success being that patented in 1888 by Henry Barth, of Cincinnati. The Barth machine casts the type, breaks off the jet, finishes the groove between the feet, rubs down the feather edge at the angles of the sides, and delivers the types in lines two feet long. It is claimed for it that not only is it more accurate, but that its output is one-half greater than the older machines: one of the latest forms is reported to be capable of yielding 70 ℔ of brevier-body type in one working day, or say 35,000 types. A notable advance in the adoption of automatic machinery was, however, made in England just at the end of the 19th century, when the Wicks rotary type-casting machine was developed into a practical apparatus. This machine is able to produce finished types, which can be despatched to the printer without any inspection or treatment beyond packing, at a continuous rate of 60,000 an hour. Essentially simple in design, it yet requires to be made with an accuracy which is far beyond that attained in ordinary mechanical fitting, and is to be measured in ten-thousandths of an inch. It consists of a horizontal mould wheel, 20 inches in diameter, contained in the casing D (Fig. 5), in which are cut 100 radial slots, each having a matrix at its inner end. These slots thus form moulds, and are of varying size according to the dimensions of the letter each has to cast, the width for a letter like *m* being much greater than for one like *i*. Each wheel can only produce type of the particular body for which it has been cut, but by changing the matrices the moulds can be made to cast any description of face capable of being received upon the body. The wheel is rotated once in every six seconds, so that the slots are successively presented to a jet of molten type-metal, which is pumped from the metal reservoir A by a pump B of special construction, and forced out at high pressure through a nozzle under the shield C. As soon as any particular slot has passed the jet and been filled with metal, a cam-action comes into play and gradually pushes out the formed type. This operation is completed in half a revolution, the ejected type being taken up by carriers mounted on a continuous chain E, which is moved along exactly in step with the wheel. The carriers, which are of different sizes according to the particular letters they have to hold, are raised by a cam-action as they come opposite the slots to receive the types, but fall again at the point F, depositing the letters at the end of the race G. Each successive type thus dropped pushes its predecessors farther along the race until when the row contains 200 types—the product of two revolutions of the wheel—an attendant lifts the whole series off and places them on the plate H, one row below the other. Since the sequence of the letters is of course the same in each revolution, the result is that each vertical line on the plate consists of the same character, and each sort can be easily removed and packed in any required form for despatch to the printer. As soon as each slot has been emptied of its type, another cam begins to draw in the matrix towards the centre of the wheel, so that it is in as far as it can go by the time the slot is again opposite the jet. To prevent a type from being drawn back with the matrix, the bead-cam K engages with the nicks which have already been formed on the front of the type-bodies by the operation of the machine. To ensure trueness and accuracy in the product, the conditions under which casting is conducted are maintained as uniform as possible. The composition of the type-metal alloy is kept constant; the temperature of the molten metal is carefully regulated by the aid of a pyrometer to about 800° F., so as not to volatilize the antimony it contains; the pumps work up to a pressure of 900 ℔ to the square inch, and by the interposition of a reducing valve deliver the metal at the nozzle at a constant pressure of 200 ℔; and the moulding slots are maintained at an equably cool temperature by an elaborate system of water circulation. The last particular represents a fundamental departure from established practice, in which it is regarded as possible to cast only from a mould heated to 200° F., and is held to be largely responsible for the accuracy and durability of the machines, one of which, attended only by one man and a boy, has during a continuous run of 20 months produced 207 million types (over 2 millions a week) without the product showing signs of depreciation through the wearing of the machine.

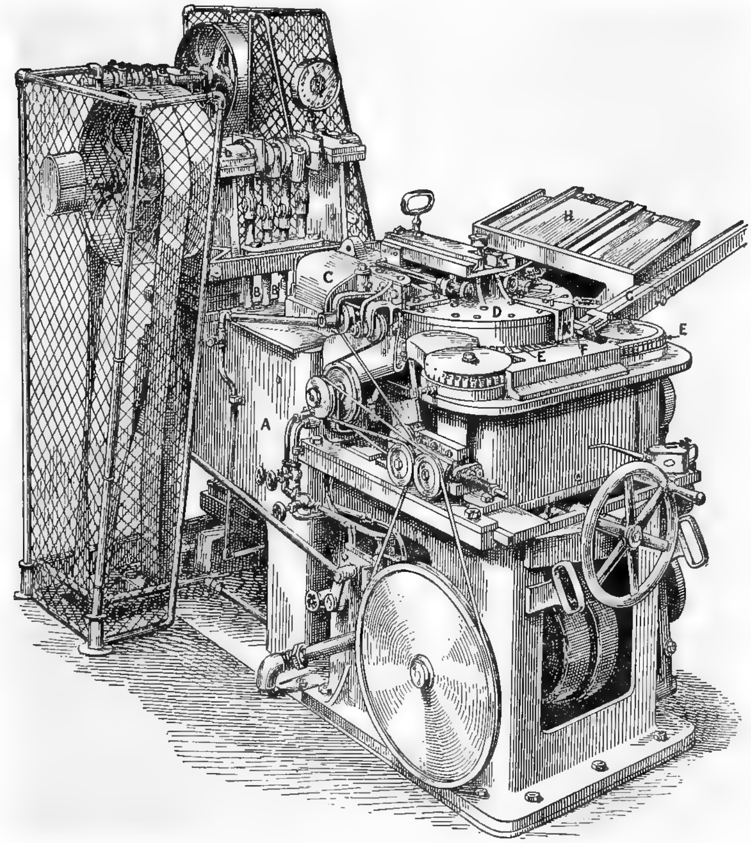


Fig. 5.—Wicks Rotary Type-casting Machine.

Such rapidity (and consequent cheapness) of production renders it not only economically possible, but profitable, for the type to be used for printing only once, and then returned straight to the melting-pot instead of being distributed. This practice was in fact adopted in 1900, as regards the greater part of its matter, by *The Times*, which, being thus printed from new type every day, secures the advantage of fresh unworn letters for each issue. The company owning the Wicks machine supply the printing-office of *The Times* with some 5 millions of types weekly, and these, after being set up by composing machines and used to make the stereotype plates required for the daily issues of that journal, are returned to the foundry to be melted and recast.

(F. C. S.; H. M. R.)

Typewriters.—Some historical details of the invention of typewriters will be found in the article on WRITING MACHINES (*Ency. Brit.*, vol. xxiv. p. 698). The earliest successful typewriting machines were placed upon the market in the United States about the year 1873. A British patent, No. 395 of 1714, was granted to Henry Mill for "An Artificial Machine or Method for the Impressing or Transcribing Letters, Singly or Progressively one after another as in Writing, whereby all Writing whatever may be Engrossed in Paper or Parchment so Neat and Exact as not to be distinguished from Print," but except by this title the patent gives no indication of the nature or construction of the machine. Other early patents on this subject are the U.S. patent to W. A. Burt, 23rd July 1829; the French patent to Progrin, No. 3748, 6th September 1833; and the U.S. patent to Thurber, No. 3228, 26th August 1843. A number of others were taken out later, but it was not until the issue to Sholes, Glidden and Soulé of U.S. patent No. 79,265, 23rd June 1868, supplemented by others to Sholes in 1868 and 1871, that the foundation was laid of a commercially successful machine. A few of these machines were sold in 1873 and the next two or three years, but in 1878 their manufacture was placed in the hands of E. Remington and Sons of Ilion, New York, and they became known as the Remington Typewriters. The great majority of modern machines are worked from a keyboard; the few which are not will be disregarded here, for although they are much less expensive in first cost than the others, they scarcely come into competition as practical instruments, on account of their slowness. Keyboard machines fall into two classes, according as the types which make the impressions are (*a*) carried at the end of levers or type-bars which strike the paper when the keys are depressed, or (*b*) are arranged round the circumference of a wheel, or segment, which is rotated by the action of the keys until the corresponding type is brought opposite the printing-point. The former of these arrangements is the more common; it may be seen in the Remington (Fig. 3), Densmore (Fig. 4), Fay-Sho (Fig. 5), New Century Caligraph (Fig. 6), Bar-Lock (Fig. 7), Williams (Fig. 8), Oliver (Fig. 9), Smith Premier (Fig. 10), Empire (Fig. 11), while the type-wheel is used in the Hammond (Fig. 12) and the Blickensderfer (Fig. 13). Another point of difference is in the inking device; in some cases, as in the Yost (Fig. 14), the Williams, and the Blickensderfer, the type is inked by means of an ink-pad before being brought down on the paper to make the impression, but more frequently an inked ribbon is drawn along by the action of the machine between the type-face and the paper. A third basis of classification may be found in the arrangement of the keyboard. In some machines there is one key for each character, in others each key does duty for two or more characters. For example, in the former class there is one key for the capital A and another for the small a, the keys being arranged in two banks corresponding to the upper and lower cases of a printer's type-case; in the latter, one key is capable of striking both the small and the capital letter, and it does one or other according as a subsidiary key is or is not brought into simultaneous use with it. In type-bar machines designed on this plan, each bar carries two or more letters (*cf.* Fig. 1), and the effect of the subsidiary key is to move the paper in such a way as to present it to the required letter.. This form of keyboard is also applied to type-wheel machines.

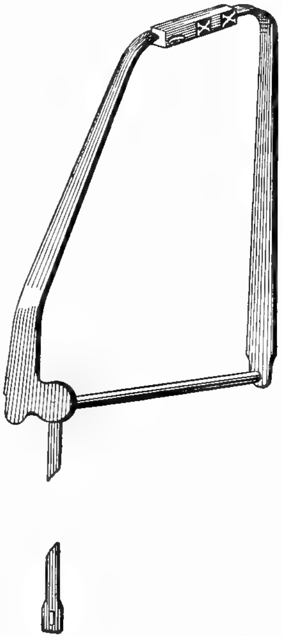


FIG. 1.—Type-bar of Oliver machine.

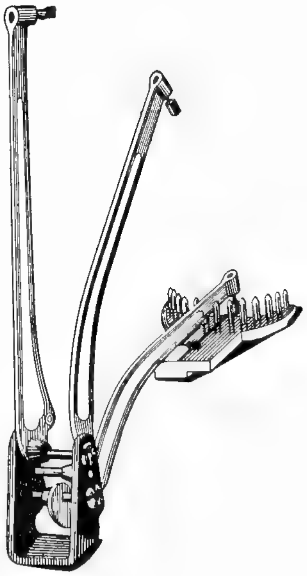


FIG. 2.—Type-bars of Bar-Lock machine.

Though there are numberless differences in detail, all typewriters bear a general resemblance to each other in their mechanical arrangements. The really essential operations may be reduced to two; the machine must print a letter when a key is struck, and it must have a device by which the paper may be moved a short distance to the left with each stroke in order that the letters may be printed separately, not one on top of the other. Of the many subsidiary appliances that are fitted—a bell to warn the operator that he is approaching the end of a line, a lock to prevent the machine from working after the end of the line has been passed, attachments for facilitating insertion of fresh paper, corrections, and tabulation, &c.—some are certainly of advantage, but others are more useful to the manufacturer in drawing up his advertisements than to the expert operator, whose first care often is to disconnect them from his machine. Similarly with the "visible writing," which is sometimes put forward as a recommendation of extraordinary importance; doubtless the novice who is learning the keyboard finds a natural satisfaction in being able to see at a glance that he has struck the key he was aiming at, but to the practised operator it is not a matter of great moment whether the writing is always in view or whether it is only to be seen by moving the carriage, for he should as little need to test the accuracy of his performance by constant inspection as the piano-player needs to look at the notes to discover whether he has struck the right ones. The one important desideratum, without which no typewriter can produce work of satisfactory appearance, is accuracy of alignment. For the attainment of this the use of type-bars has given wide scope to the ingenuity of inventors, who have been confronted with the problem of making a system of levers at once strong, rigid, and

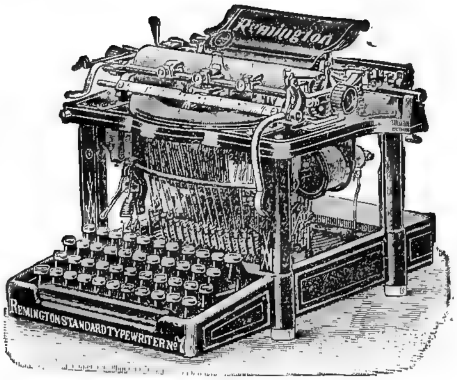


FIG. 3.—Remington.

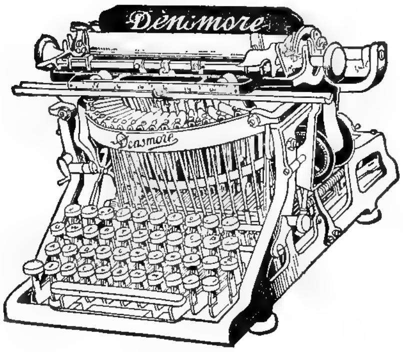


FIG. 4.—Densmore.

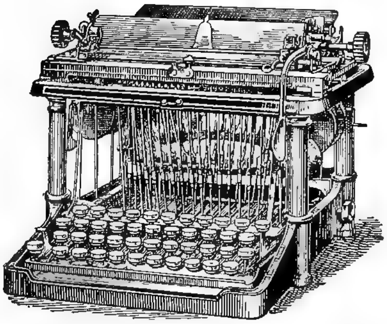


FIG. 5.—Fay-Sho.

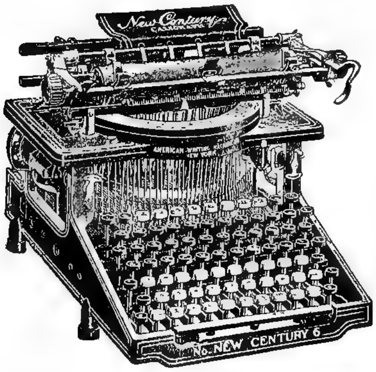


FIG. 6.—New Century Caligraph.

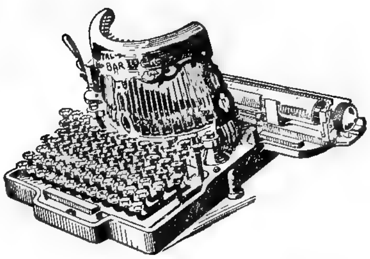


FIG. 7.—Bar-Lock.

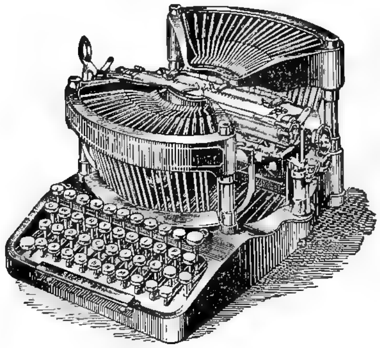


FIG. 8.—Williams.

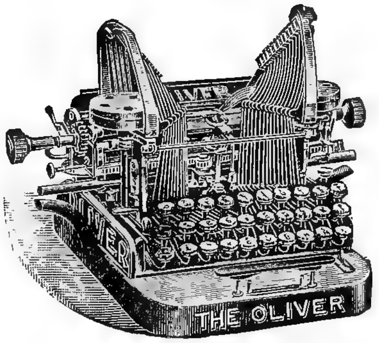


FIG. 9.—Oliver.

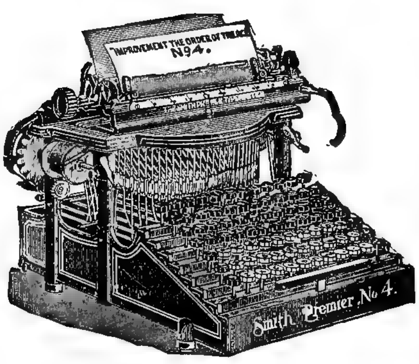

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FIG. 10.—Smith Premier.

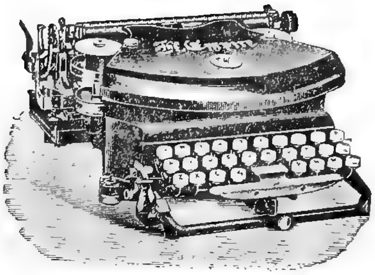

FIG. 11.—Empire.

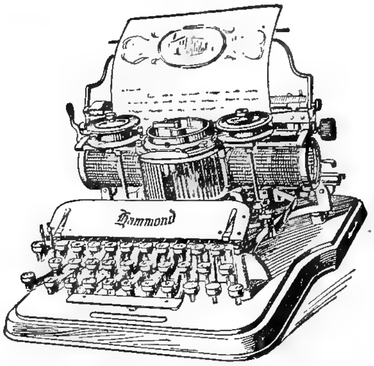

FIG. 12.—Hammond.

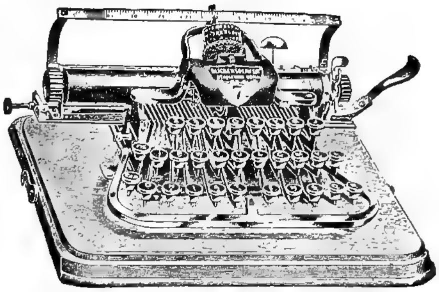

FIG. 13.—Blickensderfer.

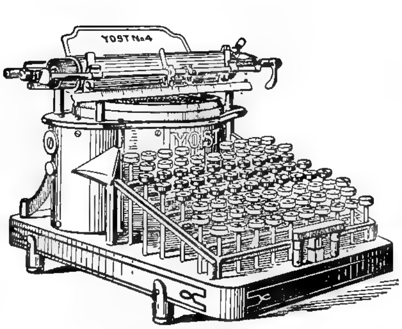

FIG. 14.—Yost.

light, and of supporting them on bearings which are steady and adjustable for wear in conditions where space is much restricted. In the Oliver machine the type-bar is of the form shown in Fig. 1, to secure stiffness and a double bearing. In the Bar-Lock, the type-bars are arranged three in one hanger, so that each has a bearing three times as wide as would be possible in the same space if each had a hanger to itself (Fig. 2); in addition the wear of the pivots can be taken up by the screws seen on the right of the bearings, and as a further precaution each type-bar is locked at the printing point by falling between a pair of conical pins, which centre it exactly in the required place. In the Yost and the Empire, the type-bars pass through guides. The centre guide of the former is shown at G in Fig. 15, the type being just about to strike the paper. Pressure on one of the keys works the lever and pushes up the connecting rod C, when the type leaves the ink-pad P and passes through the guide, which is slightly bevelled so as to guide it exactly to the printing point. In the Smith Premier the shafts upon which the type-bars swing are mounted tangentially on the ring (Fig. 16), so that long supporting bearings are obtained, while the shortness of the type-bars themselves renders it possible to make them very stiff. The rocking-shaft mechanism (Fig. 17), by which the power is transmitted from the keys to the type-bars, admits of each key having the same leverage and tends to uniformity of touch. This last quality is also aimed at by interposing an intermediate parallel bar between the key levers and the type-bar, as in the New Century Caligraph. In the Densmore, the friction of the movements is minimized by the employment of ball bearings for the type-bar pivots. Electrical typewriters, in which the depression of a key does not work a type-bar directly, but merely closes a circuit that energizes an electro-magnet, have been suggested as a means of obtaining uniformity of touch combined with ease and rapidity, but have not as yet displaced the ordinary machines to any extent.

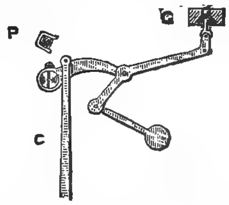

Fig. 15.—Central guide and type-bar of Yost machine.

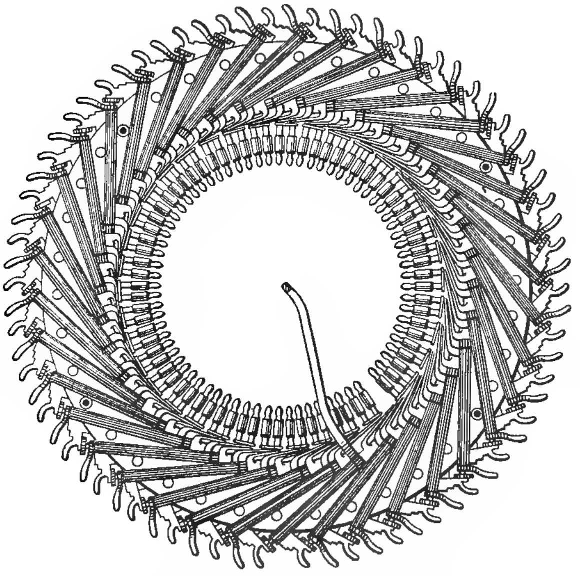

Fig. 16.—Type-bar bearings, Smith Premier.

One special form of typewriter, the Elliott and Hatch (Fig. 18), is designed to write in a book such as a ledger. One leaf is clamped between the platen and an open frame which holds the paper smoothly. The operative parts slide on this frame, and move up and down the page so as to space the lines properly, the key-board, with the type-bars, ribbon, &c., travelling step by step across the page.

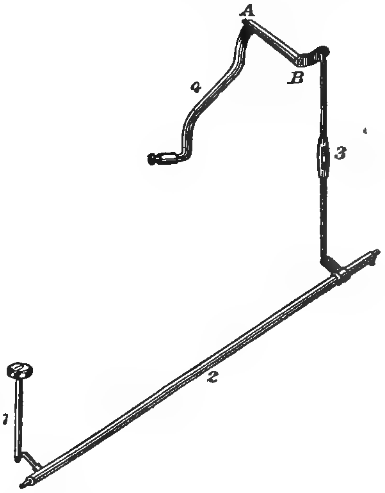

Fig. 17.—Rocking-shaft mechanism of Smith Premier.

1, Key with stem; 2, rocking shaft; 3, connecting rod; 4, type-bar; A and B, conical bearings, 1⅝ inch apart.

The United States, the country which first produced a practical typewriter, manufactures about 100,000 of such machines annually, and many are also made in Great Britain and Germany. The purchaser in Great Britain will not be able to buy a machine from most of the best-known makers for less than £20; this high price is partly justified by the care and accuracy required in manufacture, but probably the reason for its maintenance is rather to be sought in the existence of a typewriter trust.

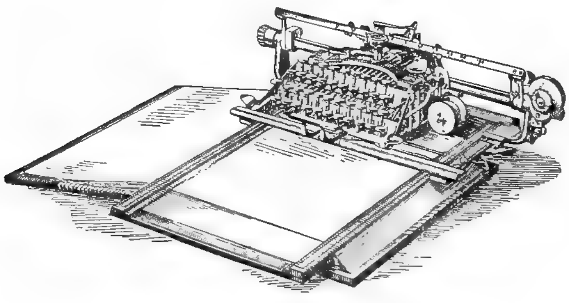

Fig. 18.—Elliott and Hatch Book Typewriter.

Typhoid Fever.—No disease has been more thoroughly studied in recent years than typhoid fever.[1]

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[1] The word "enteric" has been substituted for "typhoid" by the Royal College of Physicians in the nomenclature of diseases authorized by them, and the change was officially adopted by all departments of the British Government. Its advantages are doubtful, and it has been generally ignored by the English-speaking medical profession and by those foreign countries which used the word "typhoid." "Enteric" is preferable in that it cannot be confounded with "typhus" and bears some relation to the nature of the affection, the characteristic feature of which is a specific inflammation of the small intestine; but it is open to the serious objection of not being sufficiently distinctive. There are, in truth, several enteric fevers, and the particular appropriation of a term having a general meaning to one of them is awkward and cannot be sustained. Thus it is found

The chief points requiring notice are (1) causation and spread, (2) prevalence, (3) treatment, (4) prevention.

Causation.—The cause is the *bacillus typhosus*, discovered by Eberth in 1880 (see PATHOLOGY, *Parasitic Diseases*). This organism multiplies in the body of a person suffering from the disease, and is thrown off in the discharges. It enters by being swallowed, and is conveyed into the intestine, where it sets up the characteristic inflammation. It is found in the spleen, the mesenteric glands, the bile, and the liver, not infrequently also in the bone marrow, and sometimes in the heart, lungs, and kidneys, as well as in the fæces and the urine. It has also, though more rarely, been found in the blood. The illness is therefore regarded as a general toxæmia with special local lesions. The relation of the bacillus to the other numerous bacteria infesting the intestinal canal, some of which are undoubtedly capable of assuming a pathogenic character, has not been determined; but its natural history, outside the body, has been investigated with more positive results than that of any other micro-organism, though much still remains obscure. Certain conclusions may be stated on good evidence, but it is to be understood that they are all more or less tentative. (1) In crude sewage the bacillus does not multiply, but dies out in a few days. (2) In partly sterilized sewage (*i.e.*, heated to 65° C.) it does not multiply, but dies out with a rapidity which varies directly with the number of other organisms present—the more organisms the quicker it dies. (3) It is not found in sewer air. (4) In ordinary water containing other organisms it dies in about a fortnight. (5) In sterilized water it lives for about a month. (6) In ordinary soil moistened by rain it has lived for 67 days, in sewage-polluted soil for at least 53 days, in soil completely dried to dust for 25 days, and in sterilized soil for upwards of 400 days. (7) Exposed to direct sunlight it dies in from four to eight hours. (8) It is killed by a temperature of 58° C., but not by freezing or drying. (9) It multiplies at any temperature between 10° C. and 46° C., but most rapidly between 35° C. and 42° C. These conclusions, which are derived from experiment, are to a considerable extent in agreement with certain observations on the behaviour of the disease on a large scale.

The susceptibility of individuals to the typhoid bacillus varies greatly. Some persons appear to be quite immune. The most susceptible age is adolescence and early adult life; the greatest incidence, both among males and females, is between the ages of 15 and 35. The aged rarely contract it. Men suffer considerably more than women, and they carry the period of marked susceptibility to a later age. Predisposing causes are believed to be debility, depression, the inhalation of sewer air by those unaccustomed to it, and anything tending to "lower the vitality," whatever that convenient phrase may mean. According to the latest theories, it probably means in this connexion a chemical change in the blood which diminishes its bactericidal power. Typhoid is a common sequela of influenza. The lower animals appear to be free from it in nature; but it has been imparted to rabbits and other laboratory animals. The disease is conveyed by various channels. There is no evidence that it is infectious in the sense in which small-pox and scarlet fever are infectious; and even persons in attendance on the sick do not often contract it when sufficient care is taken. The recognition of these facts has led to a general tendency to underrate contagion, direct and indirect, from the sick to the healthy as a factor in the dissemination of typhoid fever, and to look too exclusively to other modes of conveyance; but it must be remembered that the sick, from whose persons the germs of the disease are discharged, are always an immediate source of danger to those about them. In some circumstances such personal infection may become a very important means of dissemination. There is evidence that this is the case with armies in the field; *e.g.*, the conclusions of the Commission appointed to inquire into the origin and spread of enteric fever in the military encampments of the United States in the Cuban campaign of 1898. Out of 1608 cases most thoroughly investigated, more than half were found to be due to direct and indirect infection in and from the tents (Childs: Sanitary Congress, Manchester 1902). A similar but perhaps less direct mode of infection was shown to account for a large number of cases under more ordinary conditions of life in the remarkable outbreak at Maidstone in 1897, which was also subjected to very thorough investigation. It was undoubtedly caused in the first instance by contaminated water, but 280 cases occurred after this cause had ceased to operate, and these were attributed to secondary infection, either direct or indirect, from the sick. A good deal of evidence to the same effect by medical officers of health in England has been collected by Dr Goodall, who has also pointed out that the attendants on typhoid patients in hospital are much more frequently attacked than is commonly supposed (*Trans. Epidem. Soc.*, vol. xix.). The reports of the medical officer to the Local Government Board contain several other instances of epidemic outbreaks in which personal contagion has played a part.

The other means of dissemination are polluted soil, food and drink, particularly milk and water. The precise mode in which polluted soil acts is not understood. The result of experiments mentioned above shows that the bacillus lives and multiplies in such soil, and epidemiological investigation has repeatedly proved that typhoid persists in localities where the ground is polluted by the leakage of sewage or by the failure to get rid of excrementitious matter. In some instances, no doubt, drinking water thus becomes contaminated and conveys the germs, but there appears to be some other factor at work, for the disease occurs under the conditions mentioned where the drinking water is free from suspicion. Exhalation is not regarded as a channel of communication. The recent researches of Majors Firth and Horrocks prove that dust, flies, and clothing may convey the germs. Another way in which food becomes the medium of conveyance is by the contamination of oysters and other shell-fish with sewage containing typhoid bacilli. This has been abundantly proved by investigations in Great Britain, America, and France. Uncooked vegetables, such as lettuces and celery, may convey the disease in a similar way. The most familiar and important medium, however, is water. It may operate directly as drinking water or indirectly by contaminating vessels used for holding other liquids, such as milk cans. Typhoid caused by milk or cream has generally been traced to the use of polluted water for washing out the cans, or possibly adulterating their contents. There is obviously no reason

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necessary to revert to the discarded "typhoid," which has no real meaning in itself but is convenient as a distinctive label, when speaking of the cause of the disease or some of its symptoms. We have the "typhoid bacillus," "typhoid stools," "typhoid spots," "typhoid ulcers," &c. The word "enteric" cannot well be applied to these things, because of its general meaning. Consequently both words have to be used, which is awkward and confusing. It has therefore been thought better to adhere to the older word, a course followed by recent medical publications of high standing, such as *Quain's Dictionary of Medicine* (third edition).

why this chain of causation should not hold good of other articles of food and drink. Outbreaks have been traced to ginger beer and ice-creams. Water sources become contaminated directly by the inflow of drains or the deposit of excretal matter; indirectly, and more frequently, by the leakage of sewage into wells or by heavy rains which wash sewage matter and night soil from ditches and the surface of the land into springs and water-courses. Water may further be contaminated in the mains by leakage, in domestic cisterns, and in supply pipes by suction. There is some reason to believe that the bacilli may multiply rapidly in water containing suitable nourishment in the absence of large numbers of their natural foes.

Prevalence.—Typhoid fever is more or less endemic and liable to epidemic outbreaks all over the world. It is more prevalent in temperate than in tropical climates. The following comparative death-rates show its relative prevalence in certain countries in 1890:—Italy, 658; Austria, 470; U.S.A., 462; Prussia, 204; England, 179. It has undergone marked and progressive diminution of late years in many countries coincidently with improved sanitation, particularly in regard to drainage and water-supply. Table I. gives the annual death-rates in England and Wales since 1869, when typhoid was registered separately from typhus and "simple" fever.

TABLE I.—*Annual Mortality per Million Persons living from Enteric Fever—England and Wales.*

Year.	Mortality.	Year.	Mortality.
1869 . . .	390	1885 . . .	175
1870 . . .	388	1886 . . .	184
1871 .	371	1887 . . .	185
1872 . .	377	1888 . . .	172
1873 . . .	376	1889 . . .	176
1874 . . .	374	1890 . . .	179
1875 . . .	371	1891 . . .	168
1876 . . .	309	1892 . . .	137
1877 . .	279	1893 . . .	229
1878 . . .	306	1894 . . .	159
1879 . .	231	1895 . . .	175
1880 . . .	261	1896 . . .	166
1881 . . .	212	1897 . . .	156
1882 . . .	229	1898 . . .	182
1883 . . .	228	1899 . .	199
1884 . . .	236	1900 . . .	160

The diminution is more clearly shown if quinquennial periods are taken, as in Table II.

TABLE II.—*Average Annual Mortality per Million in England and Wales, and in London.*

	1871-75.	1876-80.	1881-85.	1886-90.	1891-95.	1896-1900.
England and Wales .	354	278	218	180	176	176
London .	256	234	226	150	136	148

London shows less improvement than the country as a whole, but it started with superior sanitary conditions, and though the reduction has not been maintained in the last recorded quinquennium, the mortality is still much below the mean. The disease is more prevalent in Paris, but the diminution effected has been far greater in the time, the average annual mortality per million having fallen from 1430 in 1882 and 581 in 1883–88 to 293 in 1889–94 and 172 in 1895–1900. Other recorded instances of diminution are Berlin, Hamburg, Munich, Copenhagen, the Netherlands, Buenos Aires (from 1060 per million in 1890 to 140 in 1899). In all these and other cases the improvement is attributed either to drainage or water-supply, or both. The case of Munich is so instructive that it deserves special mention. For many years typhoid was excessively prevalent in that city. The prevalence was continuous, but aggravated by large epidemic waves, extending over several years. These gradually decreased in magnitude, and ceased towards the end of 1880. Since then the prevalence has still further diminished, the average annual mortality per million having fallen from 2024 in 1851–60, 1478 in 1861–70, and 1167 in 1871–1880, to 160 in 1881–90, and 52 in 1891–1900. It has been forcibly argued by Dr Childs (*Trans. Epidem. Soc.*, vol. xvii.) that drinking water had little, if anything, to do with the prevalence of the disease, and that its gradual reduction was due to purification of the soil by improved drainage systems and the abolition of slaughter-houses. The epidemic waves were found by von Pettenkofer to be associated with the rise and fall of the subsoil water; when the water fell the fever rose, and *vice versâ*. He did not, however, consider that the subsoil water exercised any influence itself; he merely regarded it as an index to certain conditions of moisture which exercised a favourable or unfavourable influence on the development of the disease. His theory, which has been much misunderstood, is to some extent corroborated by some facts observed in Great Britain. One is the seasonal prevalence of typhoid, which in England is an autumnal disease. The minimum occurs in May or June; in August a marked rise begins, which continues throughout the autumn and reaches a maximum in November, after which an abrupt fall sets in. These facts are in keeping with Pettenkofer's theory, for the subsoil water reaches its maximum height at the end of spring and falls throughout the summer and a great part of the autumn. The coincidence is further emphasized by the fact that in dry years, when the subsoil water sinks lower than usual, typhoid is more prevalent, and in wet years the contrary. A glance at the mortality table for England given above will show that the progressive improvement recorded down to 1892 was suddenly interrupted in 1893, when the rate rose abruptly from 137 to 229. That was an extraordinarily dry and hot year, and it was followed by a succession of dry and hot years, culminating in 1899, with two exceptions—1894 and 1897. In both the typhoid rate fell again, but in all the others it rose. One explanation has been suggested by Mr Matthew Adams of Maidstone. He points out that organic matter deposited on or in the ground passes in normal years gradually through several layers of soil, and undergoes a process of destruction or purification before reaching the underground water; but in hot summers the ground becomes baked and cracked, and there is no such percolation; when rain comes everything is swept suddenly away without any purification, and finds its way into the sources of drinking water. Whether this be so or not, there is no doubt that dangerous material does collect during the summer and is swept into water-courses by the autumnal rains. Perhaps this is sufficient to account for the seasonal prevalence and the annual variations noted. On the other hand, there is a great deal of typhoid which has no connexion with water-supply at all. Numerous cases of persistent prevalence have been investigated by the medical officers of the Local Government Board, in which drinking water has been exonerated and the mischief attributed to standing pollution of the soil—for instance, Mold, Middlesbrough, Southend, Swinton, and Pendlebury, &c. In such places the chronic prevalence is apt to swell at times to more epidemic proportions, as at Munich; and possibly the condition of the ground may be the cause. An examination of the relative incidence of typhoid on the counties of England and Wales (Bulstrode) goes to show that its prevalence, broadly regarded, is not capricious. The areas of maximum and minimum incidence remained practically the same throughout the twenty years 1871–90, though there was everywhere a large diminution. This fact suggests the reflection that standing conditions are more important factors than those accidental occurrences which attract public attention by causing sudden and explosive outbreaks. When these are on a small scale they may be due to milk; on a large scale they are always water-borne and caused by sudden contamination of a public supply. The classical example is Maidstone. That outbreak began towards the end of August 1897, and within six weeks some 1500 persons were attacked. The total number of cases was 1847, with 132 deaths, in a population of about 34,000. With the exception of 280 cases of secondary infection, which lingered on till the following January, they all occurred before October 18, and the whole thing subsided almost as rapidly as it arose. A mass of evidence of different kinds left no possibility of doubt that accidental contamination of a water-supply was the cause. Perhaps the most striking point was that Maidstone is supplied with water from three different sources, known as Cossington, Boarley, and Farleigh, and out of 1681 cases the respective incidence in these areas was—Cossington 29, Boarley 69, Farleigh 1583. Another great example of water-borne typhoid is furnished by Philadelphia, where 14,082 cases occurred in 1898–99.

Treatment.—Improved knowledge of the nature and causation of typhoid fever has not led to the successful introduction of a specific treatment; nor have means been found to cut short the illness, though its fatality has been reduced. It still goes through the classical stages, which broadly coincide with first, second, and third weeks. Attempts have been made to deal directly with the toxins produced by the bacilli, on the hypothesis that they are formed in the intestinal canal, by the use of internal disinfectants, such as mercury, iodine, carbolic acid, salol, &c., and these agents are sometimes beneficial; but the treatment remains essentially symptomatic, and follows the principles that were recognized before the discovery of the *bacillus typhosus.* The most important improvement is the regular use of sponging or bathing for the reduction of temperature. It has even been developed into a continuous bath, in which the patient is kept in water throughout the illness. The fatality of typhoid fever varies greatly. The mean of 28 years in the London fever hospitals is 17·79 per cent., the minimum for a single year being 13·20 and the maximum 24·68. At Maidstone it was only 7·14 per cent., and in the hospitals there 5·5 per cent. Age exercises a marked influence, the fatality rising steadily after the period 5 to 10 years. The importance of careful and intelligent nursing is undoubtedly great in this illness, but there is a tendency, encouraged by some nurses, on the part of the public to over-estimate that factor and to think that nothing more is needed. This is a grave mistake. No disease requires more vigilant attention or greater medical experience.

Prevention.—Broadly speaking, the problem of preventing typhoid fever is well understood. The difficulty lies less in want of knowledge than in the details of putting knowledge into practice. If house drainage were always perfectly carried out, sewage satisfactorily disposed of, water-supply efficiently protected or treated, patients segregated, and the typhoid material excreted by them effectually annihilated—if, in short, scientific cleanliness were completely attained, the disease would disappear, or be at least excessively rare. In some communities much has been done in the directions indicated, with the good results already noted; but in many others the lessons of experience are quite ignored, and even in the best practice lags behind theory. This is mainly due to apathy and reluctance to spend money, but there are certain real difficulties which stand in the way. To discuss them fully would involve a lengthy consideration of drainage, water-supply, and other matters, which are really separate subjects, and would be out of place here; but some points must be noted. The most important is undoubtedly water-supply. The substitution of public water-supplies for shallow wells and small streams liable to pollution is one of the greatest factors in the diminution of typhoid and other water-borne diseases; but it may give rise to danger on a far larger scale, for a whole community may be poisoned at one blow when such a supply becomes contaminated. Unfortunately, it is extremely difficult to prevent contamination with certainty in a populous country. Theoretically, water may be pure at its source, and may be distributed in that condition. Such is water derived from deep wells and springs, or gathered from uncultivated and uninhabited uplands. In the one case it has undergone natural filtration in the ground; in the other, it escapes all risk of pollution. These waters are generally pure, but the condition cannot be relied on. A tramp or a shepherd may pollute the most remote gathering-ground unless it be fenced in; deep wells may be similarly fouled by workmen, and sewage may find its way into them from the surface or through fissures. In an outbreak of enteritis and typhoid fever at Leavesden Asylum, investigated by the writer in 1899, the source of mischief was traced to contamination of the well, which was 250 feet deep in the chalk. The contamination did not take place from the surface, but from some underground source, and there were grounds—corroborated by subsequent observation—for believing that it occurred at irregular intervals, and was probably connected with the level of the deep underground water. At the same time the similar well of a

TABLE III.—*Occurrences of Typhoid according to Sources of Water-Supply.*

Source of Water.	Town.	Annual Typhoid Case-Rate per 100,000.								
		1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Deep wells in Red Sandstone	Wolverhampton	109	184	109	146	159	117	124	224	237
	Birkenhead	157	207	185	165	138	126	211	230	145
Deep wells in Chalk	Southampton	145	159	109	83	78	64	153	171	109
Upland surface water	Liverpool	152	275	267	190	168	160	129	149	115
	Manchester	120	120	90	96	92	90	118	78	78
	Plymouth	126	63	47	32	31	49	41	49	120
Rivers (filtered)	London	65	84	77	81	71	70	66	98	95
	Reading	30	35	28	53	30	67	32	48	41
	Worcester	155	145	110	36	43	45	31	50	26
Average of 219 towns		88	142	103	115	102	100	115	127	116

TABLE IV.—*Statistics of Anti-Typhoid Inoculation.*

No.	Group which was under Observation.	Number of Inoculated and Uninoculated in the Group.		Number of Cases of Typhoid Fever.		Percentage Incidence of the Disease.		Number of Deaths from Typhoid Fever.		Percentage Death-rate for Typhoid Fever.		Case Mortality—*i.e.*, Proportion of Deaths to Cases.	
		Inoculated.	Uninoculated.	In Inoculated.	In Uninoculated.	In Inoculated.	In Uninoculated.	In Inoculated.	In Uninoculated.	In Inoculated.	In Uninoculated.	In Inoculated.	In Uninoculated.
1	Nurses and Attendants, Barming Asylum.	84	116	0	4	0	1·34	...	...	...	...	...	...
2	Inoculated Regiments and other Units of the British Army in India.	4,502	25,851	44	657	0·98	2·54	9	146	0·2	0·56	1 in 4·9	1 in 4·5
3	15th Hussars, Wives of same, and Officers.	360	179	2	11	0·55	6·14	1	6	0·27	3·35	1 in 2	1 in 2·2
4	Garrison of Ladysmith.	1,705	10,529	35	1,489	2·05	14·14	8	329	0·47	3·12	1 in 4·7	1 in 4·5
5	British Garrison of Egypt and Cyprus.	720	2,669	1	68	0·14	2·55	1	10	0·14	0·37	1 in 1	1 in 6·8
6	British Garrison in India.	5,999	54,554	52	731	0·87	1·69	8	224	0·13	0.58	1 in 6·5	1 in 3·3
7	Patients in Tintown Hospital, Ladysmith.	...	...	30	265	...	...	2	5	...	...	1 in 15	1 in 53
8	Patients in Stationary Hospital, Harrismith.	...	...	263	947	...	...	18	135	...	...	1 in 14·6	1 in 7
9	Patients in Portland Hospital.	...	...	54	178	...	...	4	25	...	...	1 in 13·5	1 in 7
10	Patients in the Irish Hospital.	...	...	80	592	...	...	5	74	...	...	1 in 16	1 in 8
11	Patients in Scottish National Red Cross Hospital.	...	...	15	70	...	...	1	10	...	...	1 in 15	1 in 7
12	Patients in Imperial Yeomanry Hospitals.	...	...	47	301	...	...	4	26	...	...	1 in 11·9	1 in 11·8
13	Patients in a Variety of Military Hospitals.	...	...	764	3,374	...	...	63	510	...	...	1 in 12	1 in 6·6
14	Staff of the Portland Hospital.	28	13	7	3	25	23	0	1	0	7	0 in 7	1 in 3
15	Staff of Imperial Yeomanry Hospital, Deelfontein.	59	25	4	4	6·8	16	0	0	...	...	0 in 4	0 in 4
16	Staff of Imperial Yeomanry Hospital, Pretoria.	32	72	3	7	9·3	9·7	0	0	...	...	0 in 3	0 in 7
17	No. 8 No. 9 } General Hospitals (Staffs of). No. 10	21 87 } 108 0	110 47 } 276 119	5 } 16 11 ...	44 13 } 93 36	14·8	33·5	0 } 1 1 ...	8 2 } 16 6	0·9 ...	5·8	1 in 16 ...	1 in 5·8
18	Staff of Second Section, Scottish Red Cross Hospital.	70	12	2	4	2·8	33·3	1	1	1·4	8·3	1 in 2	1 in 4
19	Fifth Battalion, Manchester Regiment.	200	547	3	23	1·5	4·2	0	7	0	1·3	0 in 3	1 in 3·3
20	City Imperial Volunteers.	700	494	60	39	8·5	7·9	9	11	1·3	2·2	1 in 6·7	1 in 3·5
21	Patients in Richmond Asylum, Dublin.	339	298	6	30	1·8	10·0	1	4	0·3	1·3	1 in 6	1 in 7·5
22	Officers Invalided from South Africa (first series).	112	109	32	24	28·5	22·0	...	...	...	...	...	...
23	Officers Invalided from South Africa (second series).	102	85	34	28	33·3	32·9	...	...	...	...	...	...
24	7th Hussars, South Africa.	307	244	9	20	2·9	8·2	0	3	0	1·2	0 in 9	1 in 6·7

neighbouring poor-law school was found to be dangerously polluted, and it was ascertained that two others in the same locality had been condemned and closed in the past. The deep chalk in that neighbourhood was clearly unsafe, and this was thought to be due to the practice of digging holes called "dumb wells," but in reality cess-pits, as much as 40 feet deep, in the chalk for the reception of sewage. The same practice is common in all inhabited localities on a chalk formation, as it is an extremely convenient way of disposing of sewage, which percolates away and renders it unnecessary to empty the cess-pit. Several similar cases of deep well pollution have been recorded, notably those of Houghton-le-Spring in 1889 and Worthing in 1893. In order to secure purity, therefore, and prevent liability to outbreaks of typhoid and other intestinal disease, all gathering grounds should be fenced in, and water, even from deep wells, should be regularly examined, both chemically and bacterioscopically, in order that any change in composition may be detected. In the water-supplies of great populations such examination should be made daily. Further, all supplies which are not above suspicion should be filtered through sand or sterilized by boiling. The latter can be carried out by simple means in the case of individual domestic water, and attempts are being made to apply it by means of mechanical apparatus to supplies on a larger scale. It is not, however, applicable to the water-supply of large towns because of the liability of such apparatus to break down or get out of order. Sand filtration is at present the best mode of dealing with these supplies (see WATER SUPPLY). There is no purer water than that which has been properly treated by subsidence and sand filtration, even when it is taken from an impure source. So far as the prevention of typhoid and other water-borne disease is concerned, it is certainly safer than the unfiltered water which is taken from so-called pure sources. It cannot be a mere coincidence that London, Hamburg, Berlin, and other towns using well-filtered but originally impure river water should be generally freer from water-borne disease than many large towns drawing their supply from purer sources but neglecting to filter it, such as Manchester, Glasgow, and the American cities. Table III., prepared by Mr Caink, engineer to the city of Worcester, illustrates this fact, which has also been noted by Professor Saltet of Amsterdam as holding good of the Netherlands.

Of course, the amount of typhoid is dependent on other factors besides the water-supply, but the close connexion between the two and the influence of filtration are well attested by the experience of Worcester, where the great reduction recorded since 1894 coincided with new and improved filtration. The weak point about sand filtration is that it is apt to be imperfectly performed when the filters are frozen or newly cleaned, or when the process is too rapid. Filtration through porcelain is an efficient purifier, but it is not applicable to supplies on a large scale, and is liable to break down through clogging of the filters. Other portable filters are regarded as useless or worse. The best emergency treatment for suspected drinking water is boiling. Contamination of water in the mains is due to bad laying, and ought never to occur; that of supply pipes can be prevented by a constant service, and of domestic filters by providing them with covers.

Next to water-supply, and hardly less important, is drainage. The drying and cleansing of the soil by good household drainage and sewerage is essential to the prevention of typhoid. Cess-pits, leaking drains and privies, especially when there is only one to several houses, as in many industrial towns, are powerful allies of this disease. The drainage of all old houses is defective and dangerous. The ground about them is commonly honeycombed with cess-pits and saturated with sewage. The only way to discover and remedy such defects is to lay them bare with the pick-axe and shovel. Soil-pipes should always be trapped and ventilated. In short, no disease requires for its prevention more careful attention to house sanitation. The paving of yards and other spaces is also desirable in towns, on account of the liability of the unprotected soil to harbour moisture and filth. The other modes by which the disease is spread—such as shell-fish, milk, and uncooked vegetables—suggest their own remedy. The dissemination by dust and flies is less easily prevented. All that can be done is to segregate the sick and promptly destroy all dangerous matters proceeding from them. It should be remembered that the urine may be an even greater source of danger than the fæces. The same observation applies to the prevention of infection from person to person. There is no doubt that sufficient care is often wanting, even in hospitals, in handling patients, soiled linen and clothes, and in dealing promptly and effectually with their excreta. For the effectual segregation and treatment of persons suffering from typhoid prompt recognition is necessary; and this, unfortunately, is a matter of much difficulty on account of variation in the type and severity of the illness. Bacteriological science has here come to the assistance of the clinical physician with what is called the Widal or serum reaction, which has a great diagnostic value when carefully performed. (See BACTERIOLOGY: *Agglutinations.*) But obviously it can only be applied to persons in the position of patients; it is of no use in the case of those who do not proclaim themselves ill, but go about their business when suffering from the disease. Such "ambulatory" cases have long been recognized as an important factor in spreading the disease. Many of the most memorable epidemics have probably been caused by them, and it is difficult to see how they can be guarded against. Recent science, indeed, goes farther, and announces that the bacilli may live for years in persons who have had an attack, and may presumably be scattered far and wide by them. We need not, perhaps, be disturbed by this discovery. There are some grounds for supposing that the germs, or potential germs, of many parasitic fevers are virtually ubiquitous, but that they are not necessarily harmful.

The prevention of typhoid among armies in the field is a problem of the gravest practical importance, but of special difficulty, not in principle but because of the conditions. The water is generally polluted, and soldiers are too thirsty to wait while it is boiled or filtered, even if the means are at hand. The sanitary arrangements are such as to ensure the saturation of the ground with excreta; flies and dust abound; personal cleanliness is impossible, and men feed and sleep together in the closest proximity. No doubt a great deal might be done by efficient sanitary organization, which has hitherto been lacking, and by educating the men. Dr Leigh Carney in 1901 suggested a scheme for dealing systematically with the water-supply of an army.

One other point requires mention in connexion with prevention, namely, protective inoculation. This is performed with an anti-toxic substance prepared from dead cultures of bacilli, and has been tried on a fairly large scale, particularly on the British army in India and South Africa. It is notoriously difficult to prove the success of any protective treatment, and the reader will find some curious discrepancies in the foregoing statistical summary (Table IV.) published by Professor A. E. Wright of Netley (*Lancet*, 6th September 1902). Some of the results appear to be very satisfactory. (A. SL.)

Tyres.—The tyre of a wheel is the outer circumferential portion that rolls on the ground or the track prepared for it. When the track is smooth and level, as in a railway, the principal functions of the tyre are to give a hard, durable surface to the wheel, and to reduce to a minimum the resistance to rolling. Railway vehicle wheels are usually provided with hard steel tyres, this combination with the hard steel rail giving the maximum endurance and the minimum rolling resistance. For road vehicles also, in which durability is the prime consideration, the tyres are usually rings of iron or steel shrunk on the wooden wheels.

In bicycles, motor-cars, and other road vehicles in which freedom from vibration and shock from uneven road surface is desired, rubber or pneumatic tyres are employed. These elastic tyres are capable of absorbing small irregularities in the road surface without transmitting much vibration to the frame of the vehicle. Their range of yield is, however, too limited to absorb the larger irregularities met with on rough roads, so that their use does not obviate the necessity of spring support of the carriage body on the wheel axles. The pneumatic tyre has a very much smaller rolling resistance than a solid rubber tyre. Where the driving power is limited, as in bicycles, this consideration is by far the most important. A pneumatic-tyred bicycle requires less power to drive it at a given speed than does one with solid rubber tyres—in popular language, it is much faster; hence pneumatic tyres are now almost universally used on bicycles.

Rolling Resistance.—Professor Osborne Reynolds, in his investigations on the nature of rolling resistance, found that it is due to actual sliding of the surfaces in contact. Fig. 1 shows an iron roller resting on a flat, thick sheet of indiarubber. A series of equidistant parallel lines drawn on the indiarubber are distorted by the pressure, as shown in the figure. The distance between the marks on the periphery of the roller corresponds to that between the lines on the undistorted sheet of rubber. The motion of the roller being from left to right, actual contact takes place between C and D. The surface of the rubber is depressed at P, is bulged up in front at D, and behind at C. The vertical compression of the rubber at P causes it to bulge laterally, this causing a lateral contraction at D, which in turn causes a vertical extension at D. There is thus created a tendency to relative creeping motion between the roller and rubber. Between f and e there is no relative sliding, but over the portions eD and Cf there is slipping, with a consequent expenditure of energy. The action causes the actual distance traversed by the roller to be different from the geometric distance calculated from the diameter and number of revolutions of the roller. A certain amount of energy is expended in distorting the rubber between P and D; part of this energy is restored as the rear portion of the roller passes over this and the rubber gets back to its original unstrained state.

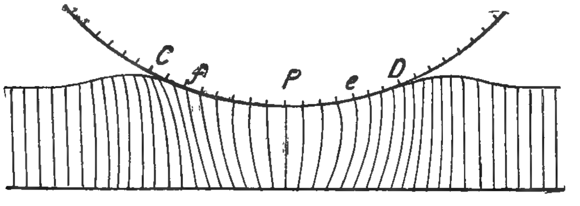

Fig. 1.

With an elastic tyre rolling on a hard, smooth surface the action is similar. Fig. 2 shows a portion of the tyre flattened out: p_1 and p_2 are the intensities of the pressures at points a_1 and a_2 at equal distances in front of and behind c, the geometrical point of contact: p_1 opposes, p_2 assists the rolling of the wheel. At usual speeds the opposing force, p_1, will be greater than the force of restitution, p_2, the difference being a measure of the elastic hysteresis of the material, H, at that speed. If the vertical compression cd of the tyre be denoted by y, the energy lost may be said to be proportional to Hy. Comparing three tyres of steel, solid rubber, and air respectively rolling on a smooth, hard surface, H is probably smallest for steel and largest for rubber, y is least for steel, greater for a pneumatic tyre pumped hard, greater still for solid rubber and for a pneumatic tyre insufficiently inflated. The rolling resistance of the steel tyre will therefore be least; next in order come the pneumatic tyre inflated hard, and the pneumatic tyre inflated soft, while the solid rubber tyre has the greatest resistance.

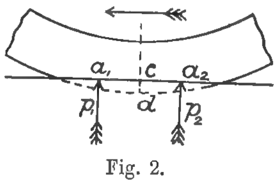

Fig. 2.

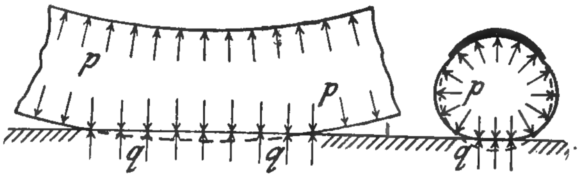

Fig. 3.

Pneumatic Tyres—Weight Supported.—Let a pneumatic tyre inflated to p lb per square inch support a load W lb. The portion near the ground is flattened (Fig. 3). If the tyre fabric is assumed to be perfectly flexible, then, since the part in contact with the ground is quite flat, the pressures p and q on the opposite sides must be equal; that is, the tyre presses on the ground with an intensity p lb per square inch. The area of the flattened portion is therefore W/p. Fig. 4 shows the shapes of the areas of contact of a bicycle tyre 28 inches by $1\frac{1}{2}$ inch, for various amounts of vertical flattening, the figures annexed to the curves in plan and to the corresponding lines in elevation indicating the amount of vertical flattening in sixteenth parts of an inch. Let y be the vertical flattening, x the semi-major axis, and h the semi-minor axis of the curve of contact. For small values of y, corresponding to a tyre pumped hard, the curves of contact may be considered plane sections of a circular ring. The area of the curve may be taken equal to that of an ellipse having the same axes, *i.e.*, πxz. But

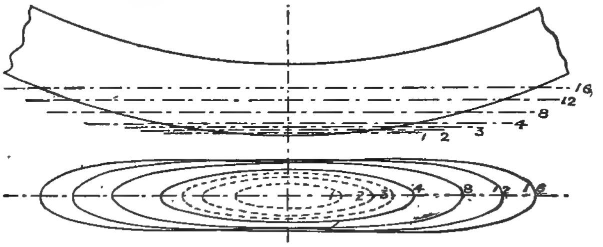

Fig. 4.

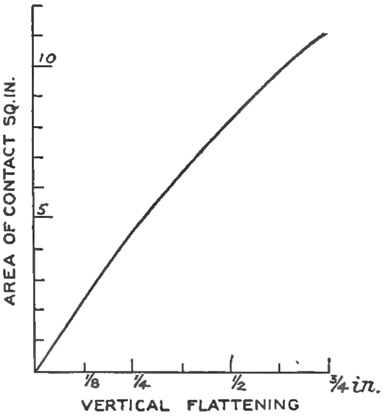

Fig. 5.

$$x = \sqrt{R^2 - (R-y)^2} = \sqrt{Ry - y^2} = \sqrt{y}\sqrt{2R-y},$$

and
$$z = \sqrt{r^2 - (r-y)^2} = \sqrt{y}\sqrt{2R-y},$$

R and r being the principal radii of section of the tyre longitudinally and transversely. Therefore, approximately,

$$A = \pi xz = \pi y\sqrt{2R-y}\sqrt{2r-y}.$$

For small values of y, y may be neglected in comparison with $2R$ and $2r$ respectively, and the above equation becomes

$$A = 2\pi y\sqrt{Rr},$$

and therefore
$$W = 2\pi yp\sqrt{Rr}.$$

For larger values of y, A is smaller than that given by the above formula, as shown in Fig. 5, which gives the areas of contact plotted with respect to the vertical flattenings for a tyre 28 inches by $1\frac{1}{2}$ inch. The same curve may serve to show values of W, thus corresponding to the load-deflection curve of a spring. The curve clearly shows the small value of the pneumatic tyre as a spring device. Thus, when pumped hard, so that the normal load is carried with $\frac{1}{8}$ inch vertical flattening, when the bicycle is travelling quickly a lump on the road equivalent to $\frac{1}{8}$ inch further flattening nearly doubles the upward reaction on the wheel. With the normal load carried with $\frac{3}{8}$ inch vertical flattening the same lump on the road increases the upward reaction by only 23 per cent., the area of contact of the tyre being increased from 6·5 to 8 square inches. The above brief investigation, involving a few approximations, is yet sufficiently accurate to afford a clear idea of the usual conditions of a tyre.

Outer Cover.—The outer cover has to be strong enough to withstand the air-pressure inside the tyre and to transmit the driving or the braking effort from the wheel to the road surface. For the latter purpose, the threads of the fabric are best disposed spirally, as shown in Fig. 6. While driving in the direction of the arrow the tension on the fibres *cc* will be slightly increased, that on the fibres *dd* decreased. The distortion of the fabric due to driving is thus reduced to a minimum. A woven fabric is sometimes used, but one made up of two or more layers of parallel threads embedded in rubber is better. This construction makes the outer cover more flexible, and consequently less energy is wasted in distorting the fabric as the tyre rolls on and off the ground, while greater durability is also secured. Fig. 7 shows a plain woven fabric, from which it is seen that each thread takes the form of a sinuous line. As the air-pressure inside the tyre is increased the threads tend to become straighter, thus pressing together with a cutting action. The total thickness is greater than that of two layers of parallel threads, while on the latter the threads can be placed closer together. The woven fabric is therefore stiffer, weaker, and less durable than that built up of parallel layers. The tensile stress per inch width, t_1, on the longitudinal section of the cover is given by the formula $pd=2t_1$; that on the transverse section, t_2, by $pd=4t_2$, d being the diameter of the tyre in transverse section; consequently the stress on the longitudinal section is twice that on the transverse. With the spiral disposition of the threads, as shown in Fig. 6, this inequality of stress in the two principal directions has the effect of tending to enlarge the transverse section of the tyre, while at the same time tending to contract the tyre on the rim.

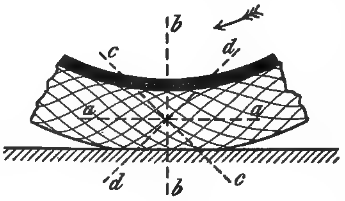

Fig. 6.

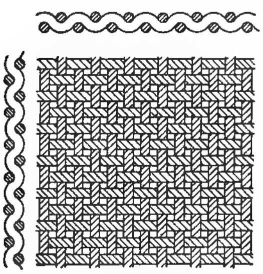

Fig. 7.

Single-tube, Double-tube, and Wireless Tyres.—A tyre, besides being strong enough to resist the stresses to which it is subjected, must be air-tight. In most tyres for cycles and motor-cars, an inner tube of indiarubber is made separate from the outer cover. In these double-tube tyres the outer cover is more or less easily detachable from the rim. The air under pressure is pumped inside the inner tube, which is supported by the outer cover. In case of puncture, the inner tube is repaired by cementing a patch of rubber on the outside of the inner tube, a solution of indiarubber in naphtha being the cementing agent employed. In a single-tube tyre, as its name indicates, the outer cover and the air-tight tube are vulcanized together to form a single hollow ring. To repair a simple puncture of a single-tube tyre it is not necessary to detach it from the rim; but as the air-tight tube is inaccessible, a different procedure is used. Instructions for repair, which need not be entered into here, are usually issued by the makers. A tubeless tyre, of which type the "Fleuss" (Fig. 8) is the best known, consists of the outer cover, as used in a double-tube tyre, to the inner surface of which an air-tight layer of sheet-rubber has been cemented. A continuous flap projects from one edge of the tyre, and when in position on the rim this flap is pressed against the other edge, forming an air-tight seal. A slight moistening of the flap with soft soap tends to remove any imperfection in the tightness of the air seal. The repair of a puncture of a tubeless tyre can be very quickly done. Since the inner surface of the air-tight layer is accessible, after placing the patch in position the tyre can be inflated and the bicycle ridden at once; whereas in the double-tube tyre, sufficient time must elapse between the patching and the inflation to allow the rubber solution to set.

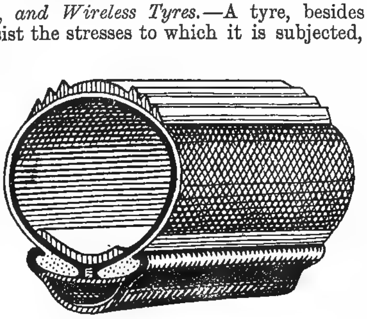

Fig. 8.

Methods of Attachment of Tyres to Rims.—A single-tube tyre can be cemented directly to the rim. For detachable double-tube tyres on bicycles, two methods, the Dunlop-Welch endless wire (Fig. 9) and the "Clincher" (Fig. 11), account for by far the greater proportion. The Fleuss tubeless tyre is attached like the Clincher. In the Dunlop-Welch tyre the endless wires are embedded in the two edges of the outer cover respectively, the transverse tension of the fabric being transmitted to them. Each endless wire is formed of three coils, so as to give flexibility to the edge of the cover. The ring formed by each endless wire is smaller in diameter than the edge of the rim. The middle portion of the rim is deepened, its diameter being less than that of the ring of endless wire. To detach the tyre, after deflation, one part of the edge of the outer cover is depressed into the bottom of the rim, the opposite part then projects slightly beyond the edge of the rim and is pulled outside; one portion being got outside, the rest easily follows. Fig. 10 shows the nature of the mutual action between outer cover C, rim R, and endless wire W in a Dunlop-Welch tyre. The transverse tension T on the outer cover is transmitted to the endless wire W, which is also subjected to the reaction N of the rim. The resultant Q must lie in the plane of the endless wire W, and constitutes a radially outward force acting at all points, which in turn causes a longitudinal pull, P, on the wire. Let d be the diameter of the inner air-tube, D the diameter of the ring formed by the endless wire W, p the air pressure, and θ the angle between T and Q. Then for each inch length of wire $T=pd/2$, $Q=T/\cos\theta$; while $P=QD/2$. Combining these results. we get $P=pdD/4\cos\theta$. If $\theta=30°$, $P=\cdot29pdD$, from which the section of wire for a tyre of any size can be calculated. In the "Clincher" fastening thickened edges on the outer cover take into corresponding edges formed on the rim, and are securely held therein when the tyre is inflated.

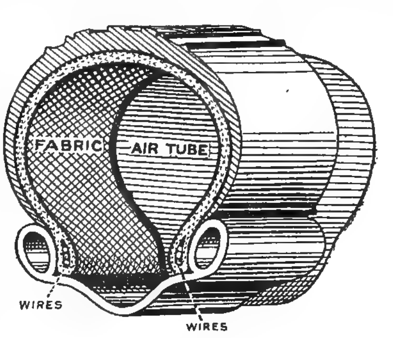

Fig. 9.

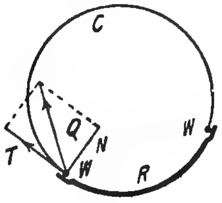

Fig. 10.

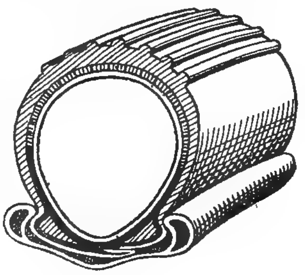

Fig. 11.

Prevention of Punctures.—The outside of the tyre is covered with a thick layer of rubber, which protects the fabric from injury by contact with the rough road surfaces. In full roadster tyres this outer layer of rubber is thinner at the sides than at the tread (the part which actually rolls on the ground), but still completely covers the fabric. In light roadster and racing tyres the sides are not covered, and an appreciable gain in speed or ease of driving is due to the greater flexibility of the cover thus obtained. Numerous puncture-proof bands and other devices have been tried with the object of absolutely preventing punctures, or making the tyre self-sealing after puncture; but since they increase the rolling resistance, and therefore the effort necessary to drive the bicycle at a given speed, it is questionable if they are at all necessary. The writer is of opinion that for the usual conditions of riding in England the chance of puncture of any first-class tyre inflated sufficiently hard is so small as to render undesirable any addition that makes the tyre slower in the running.

Valve for Pneumatic Tyre.—A non-return valve is permanently attached to the inner tube of the tyre, which allows the air forced from the inflater to pass inside the inner tube. The most commonly used, the Dunlop-Woods valve, consists of a short piece of rubber tubing mounted on a brass stem, which has a small hole communicating from its outer end to the inner surface of the rubber tube. Normally, the tubing closes the mouth of this hole, preventing the air from escaping from the tyre, but lifts freely when air is being forced from the inflater. The arrangement of the parts for deflating and for getting access to the rubber tubing is very simple and effective. The cyclist should be careful that the small piece of valve tubing, and the two fibre washers at the ends of the flexible connecter which serve to make air-tight the two joints between the latter and the pump and valve stem respectively, are always in good condition; if faulty, they should be at once renewed. If either of these seemingly small details is out of order, it may be impossible to pump the tyres hard enough; the bicycle being ridden, the tyres may be nipped in many places between the rim and sharp edges on the road surface, and practically ruined.

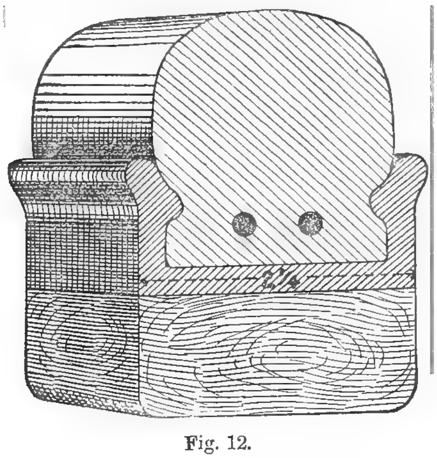

Fig. 12.

Tyres for Motor Cars.—Although the pneumatic tyre for bicycles is efficient, durable, and trustworthy, the tyre problem for motor cars is still unsolved. For a slow-speed vehicle an ordinary steel tyre is cheap, durable, and to be depended on, but the vibration communicated to the body renders it undesirable for private cars. At slow speeds the solid rubber tyre, being not liable to puncture like the pneumatic, is trustworthy if made of sufficient sectional area, but it is somewhat expensive, and lacks the comfort and easy running of the pneumatic. The thickness of the fabric of a pneumatic tyre is much greater, even in proportion to the diameter of its transverse section, than that of a cycle tyre. The stiffness increases very quickly as the thickness increases; consequently, even at the same speed of revolution as a cycle tyre the energy lost in bending and unbending is enormously greater. This energy appears as heat; the temperature of the cover rises until the heat carried away by the air is equal to that generated. At high speeds the rise of temperature is still greater, and the injurious action on the rubber and fabric shortens the life of the tyre. Unfortunately at high speeds the solid rubber tyre is still worse off in this respect, its elastic hysteresis, and therefore the heating effect, being greater than that of a pneumatic tyre. Fig. 12 shows a section of Challiner's cup tyre and rim for motor cars, the tyre being of solid rubber.

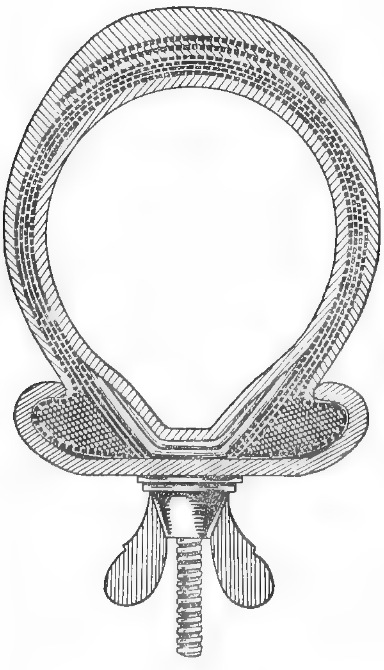

Fig. 13.

The methods of fastening motor car tyres to the rim are more elaborate than those of cycle tyres, mechanical fastening, such as screws, being largely used. Fig. 13 shows the Clipper Continental motor car tyre, the "Clincher" type of fastening being supplemented by the inner plates of trough section which, by means of thumbscrews, positively fasten down the beaded edges of the outer cover. Fig. 14 shows the Goodyear detachable double-tube tyre. Expanding wires are embedded in the base of the outer cover, which comes off sideways after removing the flanges when it is desired to repair a puncture. The same firm also make a single-tube tyre for motor cars. The Martin pneumatic tyre is of the tubeless variety, and is fastened to the rim by side flanges.
(A. Sp.)

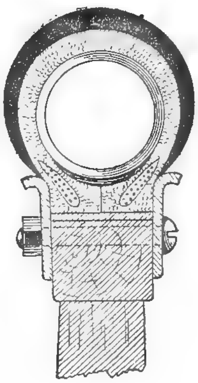

Fig. 14.

Tyrol. See Tirol.

Tyrone, a borough of Blair county, Pennsylvania, U.S.A., on the Little Juniata river, and lines of the Pennsylvania Railroad, in the central part of the state, at an altitude of 907 feet. It has manufactures, especially of iron and steel, flour, paper, and lumber. Population (1880), 2678; (1890), 4705; (1900), 5847, of whom 209 were foreign-born and 115 negroes.

Tyrone, an inland county of Ireland, province of Ulster, bounded on the N. by Londonderry, on the E. by Lough Neagh and Armagh, on the W. by Fermanagh and Donegal, and on the S. by Fermanagh and Monaghan.

Population.—The area of the administrative county in 1900 was 778,943 acres, of which 235,479 were tillage, 332,667 pasture, 463 fallow, 9658 plantation, 47,598 turf bog, 6843 marsh, 109,997 barren mountain, and 36,238 water, roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, is identical with the old judicial county. The population in 1881 was 197,719; in 1891, 171,401; and in 1901, 150,468, of whom 74,233 were males and 76,235 females, divided as follows among the different religions:—Roman Catholics, 82,425; Protestant Episcopalians, 33,740; Presbyterians, 29,722; Methodists, 3176; and other denominations, 1405. The decrease of population between 1881 and 1891 was 13·31 per cent., and between 1891 and 1901, 12·2 per cent. The average number of persons to an acre in 1891 was ·22, and of the total population 154,696 persons inhabited the rural districts, being an average of 173 to each square mile under crops and pasture.

The following table shows the degree of education in 1891:—

	Males.	Females.	Total.	Percentage.			
				Roman Catholics.	Protestant Episcopalians.	Presbyterians.	Methodists.
Read and write.	53,168	50,858	104,026	58·0	71·4	82·5	86·8
Read only . .	10,505	14,396	24,901	18·6	15·1	10·5	8·8
Illiterate . .	13,122	14,044	27,166	23·4	13·5	7·0	4·4

The percentage of illiterates among Roman Catholics in 1881 was 30·2. In 1891 there were 16 superior schools with 405 pupils (Roman Catholics 89, and Protestants 316), and 387 primary schools with 20,385 pupils (Roman Catholics 9752, and Protestants 10,633). The number of pupils on the rolls of the National schools on 31st December 1900 was 23,618, of whom 12,092 were Roman Catholics and 11,526 Protestants.

The following table gives the number of births, deaths, and marriages in the years specified:—

Year.	Births.	Deaths.	Marriages.
1881	4298	3482	713
1891	3415	3006	713
1900	3004	3133	685

In 1900 the birth-rate per 1000 was 20·0, and the death-rate 20·8; the rate of illegitimacy was 4·1 per cent. of the total births. The total number of emigrants who left the county between 1st May 1851 and 31st December 1900 was 134,446, of whom 71,487 were males and 62,959 were females. The chief towns in the county, with their populations, are Strabane, about 5000; Omagh, 4500; Dungannon and Cookstown, between 3000 and 4000.

Administration.—The county is divided into four parliamentary divisions—North, South, East, and Mid; the number of registered electors in 1901 being respectively 6992, 6975, 7534, and 8661. The rateable value in 1900 was £458,797. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the grand jury were transferred to a county council, urban and rural district councils were established, and under that Act the county now comprises three urban and seven rural sanitary districts.

Agriculture.—The following tables show the acreage under crops, including meadow and clover, and the amount of live-stock in 1881, 1891, 1895, and 1900.

Year.	Wheat.	Oats.	Barley, Rye, Beans, &c.	Potatoes.	Turnips.	Other Green Crops.	Flax.	Meadow and Clover.	Total.
1881	2088	108,005	377	43,248	14,815	3360	23,508	56,592	251,993
1891	1363	95,455	905	42,458	16,017	4418	12,636	75,258	248,510
1895	855	94,526	408	41,091	16,614	3095	17,241	76,616	250,446
1900	1545	91,323	307	38,067	16,633	3658	7816	76,130	235,479

In 1900 the total value of the cereal and other crops was estimated at £1,540,522. The number of acres under pasture in 1881 was 314,102; in 1891, 327,494; and in 1900, 332,667.

Year.	Horses and Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	23,823	1073	155,116	45,933	28,417	8995	716,315
1891	25,929	1532	177,505	88,991	48,001	11,021	850,589
1895	26,694	1321	176,181	68,733	46,961	9597	925,737
1900	23,508	1496	179,019	77,680	41,193	10,721	1,077,876

The number of milch cows in 1891 was 72,475; in 1900, 69,440. It is estimated that the total value of cattle, sheep, and pigs in 1900 was £2,404,543. In 1900 the number of holdings not exceeding 1 acre was 2262; between 1 and 5, 2400; between 5 and 15, 7850; between 15 and 30, 7727; between 30 and 50, 4039; between 50 and 100, 2461; between 100 and 200, 588; between 200 and 500, 158; and above 500, 40—total, 27,525. The number of loans issued (the number of loans being the same as the number of tenants) under the Land Purchase Acts, 1885, 1891, and 1896 up to 31st March 1901 was 3272, amounting to £825,442. The number of loans for agricultural improvements sanctioned under section 31 of the Land Act, 1881, between 1882 and 1901 was 274, and the amount issued £17,212. The total amount issued on loan for all classes of works under the Land Improvement Acts from the commencement of operations in 1847 to 31st March 1901 was £150,776.

Ubeda, a town of Spain, province of Jaen, on the Guadalquivir. The surrounding country is very beautiful, full of vineyards and olive plantations, producing much wheat, pod and other fruit. There are fine pastures for the rearing of live-stock, especially horses. The streets are clean and well-paved, with some good public buildings, theatre, bull-ring, schools, town hall and hospital. An important fair is held from 29th September to 5th October every year. The chief industries are concerned with oil, soap, esparto grass, and linen. There are some remains of the old walls of the Saracenic and Christian epochs. The church of San Salvador is a noble pile of the 16th century, San Paul and San Nicolas are Gothic churches. Population (1887), 18,713; (1897), 20,026.

Ucayali. See AMAZON.

Udaipur, or OODEYPORE, or MEWAR (Meywar), a native state of India, in the Rajputana agency. Area, 12,861 square miles. Population (1881), 1,443,144; (1891), 1,862,478, including 134,429 Bhils.; (1901), 1,021,664, showing a decrease of 45 per cent., compared with an increase of 29 per cent. in the preceding decade.

The estimated gross revenue is Rs.37,50,000, of which Rs.4,16,730 was expended on public works in 1897–98; tribute, Rs.2,50,000; number of children at school (1897–98), 3040. The chief, whose title is maharana, is the head of the Sesodia clan of rajputs, and claims to be the direct representative of Rama, the mythical king of Ajodhya. He is universally recognized as the highest in rank of all rajput princes. The dynasty offered a heroic resistance to the Mahommedans, and boast that they never gave a daughter to a Moghal Emperor. They are said to have come from Guzarat and settled at Chitor in the 8th century. After the capture of Chitor by the Emperor Akbar in 1568, the capital was removed to Udaipur by Maharana Udai Singh. During the 18th century the state suffered greatly from internal dissension and from the inroads of the Marathas. It came under British protection in 1817. The present maharana, Fateh Singh, G.C.S.I., was born in 1848, and succeeded by adoption in 1884. He is a rajput of the old school, devoted to field sports, and retains in his own hands all the powers of administration. A portion of the state is traversed by the Malwa line of the Rajputana Railway. A branch from Chitor towards Udaipur (60 miles) was taken over by the state in 1898, and is now being extended nearer to the capital (6 miles) at an estimated cost of Rs.2,54,000. Like the rest of Rajputana, the state suffered severely from famine in 1900. The ancient coinage is of great historical interest as being of the Sassanian or Persian type, copper issues of this type being still in circulation. Modern coins bear on the reverse the words "Friend of London." In 1897–1898, the value of the silver coined at the mint was Rs.83,422.

The city of UDAIPUR is 2469 feet above the sea. Population (1881), 38,214; (1891), 46,693; (1901), 45,595; death-rate (1897), 29·55 per 1000. Situated in a valley, amid wooded hills, on the bank of a large lake, with palaces built of granite and marble, it is perhaps the most picturesque place in India. In one of the palaces in the lake the European residents were sheltered during the Mutiny. In the neighbourhood is a collection of sculptured cenotaphs of former chiefs; and farther off, beside another lake, stands the tutelary temple of Siva. The city has two hospitals, one of which is for women, under an English lady, and a high school.

Uddevalla, a seaport town of Sweden, county of Göteborg and Bohus, 45 miles north of Gothenburg (107 by rail), at the head of a fjord which penetrates to within 13 miles of Lake Wener. It has butter and porcelain factories, joinery works, sugar refineries, and wood-pulp mills, and in the vicinity granite and felspar quarries. In 1894–95 the harbour was both deepened and widened; it is entered and cleared by shipping of about 100,000 tons annually. Population (1880), 7037; (1900), 9442.

Uddingston, a residential town, Lanarkshire, Scotland, on the Clyde, 7½ miles E.S.E. of Glasgow by rail. It has large preserve works and collieries. There is a public hall, a reading-room, and a grammar school. Population (1881), 3542; (1901), 7810.

Udine, a town, archiepiscopal see, and capital of the province of Udine, Venetia, Italy, situated between the Gulf of Venice and the Alps, 84 miles by rail north-east of Venice. The old castle is now converted into barracks.

One of the chief ornaments of the town is the bronze equestrian statue of Victor Emmanuel (1883), designed by Barzaghi, and there is also a monument (1887) of Garibaldi by Michieli. There are a technical institute and a school of the industrial arts (1880). Silks, velvets, and cottons are the staple industries. Population (1881), 27,090; (1901), 37,933.

Uelzen, a town of Prussia, province of Hanover, on the Ilmenau, to the east side of the famous Lüneburger Heide, at the junction of the Prussian state railways connecting Hamburg, Hanover, Bremen, and Stendal, and 52 miles south-east of Hamburg. The town is fairly well built, and in its vicinity are some interesting barrows and a whilom Benedictine monastery. Founded in the 10th century as Löwenwold, it became in the Middle Ages an active member of the Hanseatic League. Its principal buildings are the parish church and three chapels; one of the latter, dedicated to the Holy Ghost, has a valuable altar-piece dating from the 14th century. It has also a district court, a chamber of commerce, and a public school. The principal objects of its trade and industry are flax, tobacco, iron-works, gardening, and cattle. Population (1895), 8196; (1900), 8621.

Ufa, a government of south-east Russia, on the western slope of the Urals. It has an area of 47,112 square miles, and its population, which was 1,793,260 in 1882, in 1897 numbered 2,220,497 (domiciled only), of whom 1,108,317 were women, and 105,667 lived in towns. This considerable increase in the population is chiefly due to Russian immigration. In 1900 the population had grown to 2,420,652, of whom 116,708 lived in towns. The government is divided into six districts, the chief towns of which are Ufa, Belebei (5878), Birsk (8603), Menzelinsk (7542), Sterlitamak (15,538), and Zlatoust (20,973). Considerable towns have sprung up around the iron-works at Satkinsk, Yurezañ, and Katav-Ivanovsk. The Russian element in the population is rapidly increasing, and in 1899 represented 45 per cent. of the whole, as against 36 per cent. in 1865, the ethnographical composition being: Russians, 1,070,872; Bashkirs, Tatars, and Mescheryaks, 1,200,194; Tchuvash, Tehereniss, Votyaks, and Mordovians, 108,934; various, 3140. There were in the same year 1,070,555 Greek Orthodox, 23,761 Nonconformists (under-estimated), 1631 Catholics, 1038 Lutherans, 1,212,542 Mussulmans, 110,314 Buddhists, and 811 Jews. In 1899 nearly two-thirds of the land (*i.e.*, 20,123,000 acres) were owned by the peasants, 18,494,000 acres as their allotments, and 1,629,000 acres bought—chiefly by village communities and co-operative societies; 4,711,000 acres belonged to the nobility, and 1,151,700 acres to other private owners; 2,684,000 to the Crown, 456,000 to the Imperial family, and 208,000 to the towns, &c. Out of a total of 29,254,000 acres, 1,460,000 acres only were considered unfit for agriculture. Since the wholesale plundering of the Bashkir lands which took place under Alexander II. (see Remezoff's *Sketches from Wild Bashkiria*, 2nd edition, 1889), the land is now sold by the nobles, and bought chiefly by the merchant class. Large estates are common, one man owning 691,000 acres, 13 owning from 27,000 to 540,000 acres, and 326 from 2700 to 27,000 acres, although it is the peasants and the peasants' co-operative societies that cultivate 85 per cent. of all the area under crops. Agriculture has greatly developed, owing partly to the Russian immigration, and partly to the educational efforts of the local province and district councils; and in 1900 there were no less than 4,860,000 acres under crops and 9,780,000 acres under cultivation. The average yield in 1895–99 was 9,450,000 cwt. of rye, 1,567,000 cwt. of wheat, 4,836,000 cwt. of oats, 104,000 cwt. of barley—the total cereal crop, 19,240,000 cwt.; also potatoes, 1,885,000 cwt. The use of improved ploughs and machinery is becoming general, even among the Bashkirs, and grass sowing is practised. Peppermint and other aromatic herbs are cultivated. Cattle-breeding is extensively carried on, and there are excellent breeds of horses. There were in 1900 749,240 horses, 781,820 horned cattle, 1,751,000 sheep, and 138,800 pigs. Apiculture is also a valuable industry. The mining industry is very flourishing, the great iron works at Zlatoust belonging to the province. In 1897, 6360 cwt. of copper, 1,491,700 cwt. of pig iron, 355,300 cwt. of iron, 674,700 cwt. of steel, and 24,500 cwt. of iron chromates were obtained, and all industrial establishments showed an aggregate return of 14,000,000 roubles. Small trades in the villages are growing (weaving, wooden goods, hardware, agricultural machinery). There is a considerable export of grain, linseed, cattle, animal products, timber, metals and hardware. Owing chiefly to the efforts of the *zemstvos*, there are in the province 802 schools (35,050 boys and 12,370 girls) and about 1500 *medresses.* Medical assistance is also well organized. Owing to the excellent dry climate of the steppes, a considerable number of consumptive patients come to the Bashkir settlements to take there *koumiss* (mare's milk fermented); one large sanatorium was built for that purpose, and several small ones have been established. The government is rich in antiquities belonging to three different periods—the Finnish or Chud period, the period of the Bulgarian empire, and the period of Nogai domination. The burial mounds of the Chud contain brass implements and decorations, and in one of them near Ufa a coffin covered with sheets of silver was found. Remains from the Bulgarian empire are found at Menzelinsk. But it is the ruins of the Mongolian period which are of greatest value, the remains of a large town, with a mausoleum and a palace, which have been found near Ufa, covering several miles along the Byelaya river. (P. A. K.)

Ufa, the capital of the above government, situated at the confluence of the Ufa with the Byelaya, on the trans-Siberian railway, 326 miles by rail E.N.E. of Samara. It has several iron and copper works, two machinery works, and several saw-mills. A museum and a public library have been opened. It is an important river port and a rapidly-growing city, carrying on a considerable trade with the surrounding agricultural region. Population (1884), 25,660; (1897), 49,961.

Ufalei, Upper AND **Lower,** two iron-works of Russia, in the government of Perm, in the district and 65 miles south of Ekaterinburg, near the Ufalei railway station. Nearly 10,000 tons of pig iron are obtained at the Upper works, and all sorts of iron goods are fabricated at the Lower works. The population is over 6000 at the former and over 5000 at the latter.

Uganda, a British protectorate in East Central Africa, in the Equatorial regions. The boundaries of this protectorate in 1901 were as follows:—On the N., the 5th degree of N. latitude (conterminous with the southern frontier of the Egyptian Sudan); on the E., the river Omo, the *thalweg* of Lake Rudolf, and a line drawn from the south-east corner of that lake southwards along the edge of the Laikipia and Kikuyu escarpments to the frontier of the German possessions; on the S., the Anglo-German frontier in East Africa (for some distance coincident with the 1st degree of S. latitude); and on the W., the frontier of the Congo Free State (a line which crosses Albert

Edward Lake, follows the Semliki river for part of its course, and terminates near the north end of Albert Nyanza), leaving the main stream of the Nile as the present north-western limits of the Uganda Protectorate, though the actual limit of the British sphere north of Lake Albert is the line of the Nile–Congo water-parting.

Area.

The territory comprised within the above limits amounts to an approximate area of 150,000 square miles, but this area has since been reduced by the transfer of Uganda's eastern province to the administration of the adjoining East Africa Protectorate. This step will considerably modify the eastern boundaries of the Uganda Protectorate and diminish the extent of its territories by about one-sixth; but as the full extent and limits of the area thus withdrawn from Uganda administration have not yet been fully determined by the Foreign Office, it will be better for the purposes of this article to describe the Uganda Protectorate as it lay under the definition of boundaries recognized in 1901, the more so as there is a chance of these boundaries coming once more into force.

Administrative divisions.

In 1900 the Uganda Protectorate was divided into six provinces—Eastern, Rudolf, Central, kingdom of Uganda, Western, and Nile—and these again into a number of administrative districts. The kingdom of Uganda, which alone has a thoroughly efficient and recognized native government, was divided into no less than nineteen "counties" or districts, but the other provinces have as a rule only three or four subdivisions.

Administration and government.

This extensive protectorate grew by degrees from out of the native kingdom of Uganda, a powerful and once populous state on the northern and western shores of Victoria Nyanza. Uganda proper still continues to be the kernel, the headquarters of British dominion over the Nile sources. Whether it will remain so depends on the line followed by the British Government in its organization and government of the East African territories. It has been proposed to place all these territories—Zanzibar, East Africa, Uganda, Somaliland—under one general control, which should have its headquarters in the healthy Eastern province of the Uganda Protectorate.

At the present time the Uganda territories are governed by a commissioner and consul-general (under the Foreign Office) residing at Entebbe, on the north-western coast of Victoria Nyanza. He is assisted by a staff of officials differing little if at all from the functionaries of a Crown colony, and he himself is the equivalent of the governor of a Crown colony, though for some mysterious reason the British Foreign Office prefers to regard him as a member of the consular service. The natives are ordinarily under the direct rule of their own recognized chiefs, but in all the organized districts the commissioner alone has the power of life or death, of levying taxes, of carrying on war, of controlling waste lands and forests, and of administering justice to non-natives. In the case of Uganda proper special terms were accorded to the native king and people in the settlement dated 10th March 1900. The king was secured a minimum civil list of £1500 a year out of the native revenues; pensions were accorded to other members of the Uganda royal family; the salaries of ministers and governing chiefs were guaranteed; compensation in money was paid for removing the king's control over waste lands; definite estates were allotted to the king, royal family, nobility, and native landowners; the native parliament or "Lukiko" was reorganized and its powers were defined; and many other points in dispute were settled. The king was accorded the title of "His Highness the Kabaka of Uganda," and his special salute was fixed at eleven guns. By this agreement the king and his people pledged themselves to pay hut and gun taxes to the administration of the protectorate. Somewhat similar arrangements on a lesser scale were made with the king of Ankole, the kings of Toro and Unyoro, and with the much less important chieftains or tribes of other districts. The expenditure for 1902–03 was fixed at about £210,000, of which about £170,000 is furnished by an Imperial grant-in-aid and the balance from local revenue.

Expenditure and revenue.

Trade.

Trade is mainly conducted by native (*i.e.*, Arab, Somali, and Negro) traders, by British Indians, and by Germans. The value of the trade during 1901–02 was approximately £500,000 in imports (two-thirds from Great Britain, India, or British colonies) and £50,000 in exports. The articles exported were ivory, indiarubber, skins and hides, and live stock (for consumption in East Africa).

Population.

The protectorate is inhabited at the present time by about 3,900,000 negroes and negroids (natives), 700 British Indians (including 400 Indian soldiers), 100 Arabs, the same number of Somalis, and 300 Europeans (British, French, Germans, Italians, and Maltese).

Physical geography: climate.

The Uganda Protectorate, lying in Eastern Equatorial Africa, with a singularly diversified surface of lofty plateaux, snow-capped mountains, vast swamps, dense forests, and regions of desolate aridity (valley of Lake Rudolf), offers a remarkable variety of climates—samples, as it were, of all the climates in the habitable world. Eastern province (Naivasha, Mau, Nandi, Baringo, and Sūk) has, except on the extreme north and south, a mainly temperate climate, singularly agreeable and healthy, with a rainfall of from 20 to 60 inches per annum. Eastern province is hot and arid only in the country north of Lake Baringo and south of Lake Naivasha. Rudolf province lies low—an average altitude of not more than 2000 feet—is extremely hot, and has a very poor rainfall. In some of its districts no rain may fall for two years at a time, elsewhere scarcely as much as 10 inches per annum. Central province is abundantly well watered near Victoria Nyanza and around Mount Elgon and the Sūk Hills (about 20 to 100 inches annually); elsewhere the rainfall lessens to about 20 inches. Busoga and the western part of the Elgon districts in this province have a regular West African climate—hot, moist, and not overhealthy. These are the conditions of Uganda proper, a country with an annual rainfall of from 40 to 60 inches, a regular West African climate, and severe and frequent thunderstorms. Much the same may be said about Western province, except for the delicious cooling influence of the Ruwenzori snow range, which pleasantly affects Toro and northern Ankole. The rainfall on Ruwenzori and the central Semliki valley is quite 100 inches per annum. Along the Ruwenzori range are glaciers and snowfields nearly 30 miles in continuous length and some 5 miles in breadth. Nile province is perhaps the hottest part of Uganda. Like the districts round Rudolf, the average altitude (near the Nile) is not more than 2000 feet, but the rainfall is far more abundant than in the terrible Rudolf region, being an average of 30 inches per annum.

The surface of the protectorate is very diversified. There is the celebrated Rift valley running nearly north and south through Eastern province. This is a broad (perhaps 30 miles in width) trough lying between mighty cliffs, the tilted edges of elevated plateaux. There is a great deal of volcanic activity about the Rift valley—

Mountains, lakes, and rivers.

an active volcano near the Sugota swamps, cracks in many places through which steam pours, innumerable extinct craters and beds of lava. In the Rift valley, between Rudolf and the German frontier, are the fresh and salt lakes of Sugota, Baringo, Hannington, Nakuro, Naivasha, and smaller lakelets tedious to enumerate. West of the Rift valley lies that magnificent Nandi–Mau plateau, which stretches from the German frontier in the south to Mount Elgon and the Sūk hills on the north. Here there are altitudes between 6000 and 10,000 feet, the general height above sea-level being 8000 feet. West of the Mau and Nandi heights the land slopes gently (with here and there an isolated mountain) to the general level of the shores of Victoria Nyanza and the Uganda Protectorate—4000 feet. Mount Elgon, in Central province, is one of the leading physical features of the Uganda Protectorate. It consists of the vast crater—some 10 miles in diameter—of an extinct volcano, the rim of which rises in several places to over 14,000 feet. Terraces and buttresses extend and ramify in all directions from the central crater, so that the giant volcano and its surrounding heights form a mountain country (notable for its innumerable cascades and dense forests) the size of Montenegro. The mass of Elgon can be seen from the north-east coast of Victoria Nyanza, from near the main Nile stream, from the heights overlooking Lake Rudolf and from the Kikuyu escarpment. The remainder of Central province consists of well-forested, undulating land (Busoga) on the coast of the lake, a vast extent of marsh round the lake, like backwaters of the Victoria Nile (Lakes Kioga, Kwania, &c.), and a more stony, open, grain-growing country (Bukedi, Lobor, Karamojo). The Turkana country west of Lake Rudolf has been of late years terribly arid. A little vegetation is met with in the stream valleys, but most of the rivers marked on the map have ceased to show running water in their lower courses. A good deal of high land—rising in some peaks to near 10,000 feet—is found in the eastern part of Nile province, and these heights attract moisture and nourish permanent streams flowing Nilewards. But much of the lower ground is stony and poor in vegetation, while the lowland near the main Nile is exceedingly marshy.

The Nile sources.

The ultimate source of the Nile is usually held to be the springs of the river Kagera (rising near the north end of Lake Tanganyika, in German territory). The Kagera is the most important stream flowing into Victoria Nyanza (midway down its western coast). Something like a distinct current (checked sometimes by northerly winds) sets across the lake from the mouth of the Kagera to Ripon falls. Ripon falls, in the centre of the northern coast, at the head of the exquisitely beautiful Napoleon Gulf, mark the exit of the fully-born Nile from Victoria Nyanza. The Victoria Nile tumbles over 50 miles of cascades and rapids (descending some 700 feet in that distance) between Ripon falls and Kakoge. Here it broadens into Lake Kioga (in reality a vast backwater of the Nile), and continues navigable (save for sudd obstacles at times) right through Lake Kioga and thence northwards for 100 miles to Foweira and Karuma falls. Between Karuma and Murchison falls the Victoria Nile is unnavigable. At Fajao the navigation can be resumed into Lake Albert.

The Albertine Nile is a very important contribution to the main stream. It may be said to rise far to the south in the Ruchuru river (near Lake Kivu) and flows northwards through Lake Albert Edward and the Semliki into Albert Nyanza, joining the Victoria Nile at the north end of that lake. The main Nile stream when it quits Lake Albert continues navigable as far north as Nimule (3° 40′ N.). Between Nimule and Fort Berkeley the river flows through a deep gorge and falls nearly 1000 feet. Navigability really only begins again at Gondokoro on the Sudan frontier, from which point steamers now ply to Khartum. North of Gondokoro the formidable obstacle of the sudd—a dense growth of papyrus and other water vegetation—completely blocked Nile navigation as far north as Fashoda for many years together, from the time of the ancient Egyptians to our own, occasionally disappearing under the stress of exceptional floods. The sudd was cut through successfully by Anglo-Egyptian expeditions under the leadership of Major Malcolm Peake and others in 1900–01.

The geography of Western province includes many interesting features, the in many ways peculiar Albert Nyanza, the great snowy range of Ruwenzori, the dense Semliki, Budonga, Mpanga, and Bunyaraguru forests, the salt lakes and salt springs of Unyoro and western Toro, the innumerable and singularly beautiful crater lakes of Toro and Ankole, the volcanic region of Mfumbiro (where active and extinct volcanoes rise in great cones to altitudes of 13,000 and 10,000 feet), and the healthy plateaux of Ankole, which are in a lesser degree analogous in climate and position, and the Nandi plateau on the east of Victoria Nyanza. Ruwenzori is a snowy range, and not a single mountain. Its greatest altitude—Stanley's "Saddle" mountain—is possibly above 20,000 feet, and therefore the highest point on the African continent. Uganda Protectorate is a land of great lakes, and includes, or partially includes, the water areas of Victoria Nyanza (about 27,000 square miles), Lake Rudolf (about 3500 square miles), Lake Kioga-Kwania (800 square miles), Albert Nyanza (2700 square miles), and Lakes Albert Edward and Dweru (1500 square miles), besides the smaller lakes of the Rift valley, Lake Ndo in the Elgeyo valley, Lakes Salisbury and Kirkpatrick in Central province, Wamala in Uganda, and Kachera in Ankole. The water of Lake Victoria is perfectly fresh. This is the case with all the other lakes except Rudolf, Sugota, Baringo, Nakuro, Albert Nyanza, and Albert Edward, in which the water ranges from salt to slightly brackish.

Petrology and mineralogy.

The rocks in Eastern province are mainly volcanic (basalt, tuff, lava, kenyte). West of the volcanic region, nearer to Lake Victoria and Central province, ironstone, granite, gneiss, and schistose formations predominate, with phonolite in places, and a small but valuable deposite of limestone in the Nyando valley. Opals have been found near Lake Nakuro, and there are indications of precious stones in the Kamásia hills. Iron ore (hæmatite) is abundant. In Central province the rocks are mainly quartz, gneiss, and granite, with sandstone in Busoga, basalt round Mount Elgon, slate (Busoga) and ironstone (Busoga and Bukedi). In Rudolf province there are the basalt, lava, tuff, and kenyte of the volcanic Rift valley, overlying a formation of granite, gneiss, and quartz. Gold—in some cases alluvial—is found in the mountainous country to the north-west of Lake Rudolf. Gneiss, granite, and quartz—the decomposed granite giving the red "African" clay—are the leading features in the formations of Nile province, of Uganda proper, and of Western province, with some sandstone in the littoral districts of Uganda and in Ankole, and eruptive rocks and lava in south-western Ankole and on the eastern flanks of Ruwenzori. There are indications of copper in Busoga, of gold in Unyoro. Iron is found nearly everywhere. Graphite is present in Uganda and Unyoro.

Flora.

The vegetation of this protectorate is luxuriant except in the Rudolf region, which has the sparse flora of Somaliland. In Western province, Busoga, and the Elgon district the flora is very West African in character. The swampy regions of the Nile and of Central province are characterized by an extravagant growth of papyrus and other rushes, of reeds and coarse grass. There are luxuriant tropical forests in the coast region of Uganda, in Busoga, West Elgon, West Nandi, western Unyoro, eastern Toro, the central Semliki valley, and north-west Ankole. The Nandi plateau, the upper regions of Mount Elgon, Mount Debasien, and Mount Agoro are clothed with forests of conifers—juniper and yew—and witch-hazels (*Trichocladus*). There are also giant yew-trees on the flanks of Ruwenzori and the Mfumbiro volcanoes between 7000 and 9000 feet, but no junipers. The alpine vegetation on all these lofty mountains is of a mixed Cape and Abyssinian character—witch-hazels, senecios, lobelias, kniphofias, everlasting flowers, tree heaths, and hypericums. The really tropical vegetation of Uganda is nearly identical with that of West Africa, but there is no oil-palm.

Fauna.

The fauna also has many West African affinities in the hot, forested regions. In Eastern province, even, there is one West African mammal, the broad-horned tragelaph. As a rule, however, the fauna of the Upper Semliki valley, of parts of Ankole, Uganda and Unyoro, of Nile, Rudolf, and Eastern provinces, is of that "East African" "Ethiopic" character, which is specially the feature of South and East Africa and of the Sudan right across from Abyssinia to the river Senegal. Among notable mammals the chimpanzee is found in Unyoro, Toro, and north-west Ankole, and has only recently become extinct in Uganda; the newly-discovered okapi inhabits the Semliki forests on the Congo frontier; the giraffe (the male developing five horn cores) is common in Nile, Central, Rudolf, and Eastern provinces; there are three types of buffalo—the Cape, the Congo, and the Abyssinian; two species of zebra (one of them Grévy's), the African wild ass, the square-lipped ("white") and pointed-lipped ("black") rhinoceroses, the elephant, hippopotamus, the water tragelaph ("Speke's antelope"), the Cape ant-bear, the aard-wolf (*Proteles*), hunting-dog, and nearly every genus and most of the species of African antelopes. The birds are more West African than the mammals, and include the grey parrot, all the genera of the splendidly-coloured touracoes, the unique "whale-headed" stork, and the ostrich.

Ethnology.

The human races indigenous to the protectorate are mainly of the Negro species (with slight Caucasian intermixture), and may be divided into the following categories:—

I. *Pigmy-prognathous* (so called "Congo" pigmies of Semliki forest, of Kiagwe in Uganda, and of the western flanks of Mount Elgon).

II. *Pigmy*, of the Hottentot-Bushman type (lingering in a much modified form in the Sūk and Turkana countries and among the nomad Andorobo of Eastern province).

III. *Bantu negroes* (Banyoro, Baitu, Basese, Basoga, Bakonjo, Baganda, Kavirondo, and Karamojo).

IV. *Nile negroes* (Aluru, Bari, Madi, Acholi, Lango, Kedi, and South Kavirondo).

V. *Masai* (Masai, Gwas Ngishu, Burkeneji, Nandi, Sūk, Turkana, Elgumi, &c.).

VI. *Hamitic* (some tribes on islands and the north coast of Lake Rudolf; and the remarkable "Hima" or "Huma" aristocracy in Unyoro, Uganda, Toro, and Ankole).

The pigmies of the first class are generally known as Bambute or Batwa in the Semliki forests. They are both reddish-yellow and brownish-black (according to individual variation) in skin colour, with head hair often tending to russet, and body hair of two kinds—black and bristly on the upper lip, chin, chest, axillæ and pubes; and yellowish and fleecy on the cheeks, back, and limbs. Their faces are remarkable for the long upper lip and the depressed broad nose with enormous alæ. Associated with these pigmies is an apish type (Lendu, Lega, Baamba, Banande) of normal human stature, but short-legged and unusually prognathous. The Andorobo and some of the people in the Sūk mountains are of very mixed type, but tend towards dwarfishness of stature, and occasionally produce individuals strongly resembling the South African Bushmen.

The Bantu negroes probably represent the future ruling race of the protectorate, and include the remarkable Baganda people. These last, prior to the arrival of Arabs and Europeans, displayed a nearer approach to civilization than has as yet been attained by an unaided Negro people. Their dynasty of monarchs can be traced back with tolerable certainty to a period coincident with the reign of Henry IV. of England. The first Uganda king was probably a Hamite of the Hima stock (from Unyoro). Until recent years the Baganda and most of the other Bantu peoples of the protectorate worshipped ancestral and nature spirits who had become elevated to the rank of gods and goddesses. The Baganda are now mainly Christian. There is also a "totem" system still in vogue. All the Baganda belong to one or other of twenty-nine clans or "Biká," which are named after and have as totem familiar beasts, birds, fish, or vegetables. The Baganda are not a very moral people, but they have an extreme regard for decency, and are always scrupulously clothed (formerly in bark-cloth, now in calico). As a general rule, it may be said that all the Bantu tribes in the western half of the protectorate, including the Basoga, are careful to consider decency in their clothing, while the Kavirondo and Karamojo are often completely nude in both sexes.

More or less, absolute nudity is characteristic of the Nile negroes, of the Masai and Andorobo, and even of the Bahima (Hamites). Such clothing as there may be is either worn by married women or (for warmth) by elderly men.

The Nile negroes, Masai, and Hamites are tall people. The Nile negroes are seldom handsome, owing to their flat faces and projecting cheek-bones. The Masai are nearly always comely, but the Bahima are often markedly handsome even to European eyes. In the Bahima the proportion of Caucasian blood is about $\frac{1}{2}$; in the Masai $\frac{1}{8}$ to $\frac{1}{16}$; and in the Nile negroes and Bantu from $\frac{1}{32}$ to none at all. The aboriginal stock of the Uganda Protectorate is undoubtedly the pigmy-prognathous, which has gradually been absorbed, overlaid, or exterminated by better developed specimens of the Negro species, or by Negro-Caucasian hybrids from the north and north-east.

The languages spoken in the Uganda Protectorate belong to the following stocks:—I. *Hamitic* (Murle and Rendile of Lake Rudolf); II. *Masai* (Bari, Masai, Elgumi, Turkana, Sūk, &c.); IIA. *Nandi;* III. *Nilotic* (Acholi, Aluru, Jaluo, &c.); IV. *Madi* (spoken on the Nile between Aluru and Bari, really of West African affinities); V. *Bantu* (Lu-Ganda, Runyoro, Lu-Konjo, languages of West Elgon and Kavirondo, &c.); and lastly, the unclassified *Lendu* and *Mbuba* spoken by the pigmy-prognathous peoples.

History.—The countries grouped under this protectorate were invaded at some relatively remote period—say, four or five thousand years ago—by Hamitic races from the north-east (akin to the ancestors of the ancient Egyptians, Gallas, Somalis), who mingled extensively with the Nile negroes first, and then the aboriginal inhabitants of Uganda, Unyoro, and Nandi. These Hamites brought with them a considerable measure of Egyptian civilization. There was probably no direct intercourse with Egypt by way of the Nile, but an overland trade with Somaliland (the Land of Punt) *viâ* Mount Elgon and the Rudolf regions. In course of time even this intercourse with the non-Negro world died away, and powerful kingdoms with an aristocracy of Galla descent grew up in Uganda, Unyoro, and Ankole. The kingdom of Uganda especially dominated the lands of Victoria Nyanza in the 19th century.

In the 'forties and 'fifties of that century Egyptian officials, Austrian missionaries, and British, Dutch, Italian, and German explorers had carried our knowledge of the Nile beyond Khartum as far south as Gondokoro. In the same period of time the Zanzibar Arab traders were advancing on the Bahima kingdom of the western Victoria Nyanza and on Uganda from the south. King Suna of Uganda (great-grandfather of the present king) first heard of the outer world of white men in 1850 from a runaway Baluch soldier of Zanzibar. Captains Burton and Speke, on their Tanganyika expedition, heard of Uganda from the Arab traders in 1857. Captain Speke in 1862 reached Uganda, first of all Europeans to enter that country. In the late 'sixties Sir Samuel Baker (who had discovered Albert Nyanza) extended the rule of the Egyptian Sudan (of which he was governor-general) as far south as the Victoria Nile. General Gordon, who succeeded Baker, and who had Dr Emin Bey (afterwards Emin Pasha) as lieutenant, attempted not only to annex Unyoro but also Uganda to the Egyptian dominions, and thoroughly established Egyptian control on Albert Nyanza. But owing to the indirect influence of the British Government, exercised through Sir John Kirk of Zanzibar, the Egyptian garrison south of the Victoria Nile were withdrawn.

Suna, the powerful king or emperor of Uganda, who was the first to hear of a world beyond Negroland, had been succeeded in 1857 by his still more celebrated son, Mutesa (*Mutesa* means "the measurer"). Mutesa had received Speke and Grant in a most friendly manner. Subsequent to their departure he had opened up relations with the British agent at Zanzibar. In 1875 he received an epoch-making visit from the greatest of African explorers—Sir H. M. Stanley. Stanley, in response to Mutesa's questions about religion, obtained from that king an invitation to Anglican missionaries, which he transmitted to London through the *Daily Telegraph.* Having made the first survey of Victoria Nyanza and confirmed Speke's guesses as to its shape and area, Stanley passed on (half discovering Ruwenzori on the way) to the Congo.

Meanwhile the Zanzibar Arabs had reached Uganda in ever-increasing numbers as traders; but many of them were earnest propagandists of Islam, and strove hard (with some success) to convert to that religion the king and chiefs of Uganda and adjoining countries.

Christian missions, 1877-1879.

In 1877 the Rev. C. T. Wilson, one of a party of missionaries sent in answer to Stanley's appeal, though not on the lines suggested by him, arrived in Uganda, and towards the end of 1878 was joined by Mackay. In 1879 another party arrived by the Nile route; and Wilson, after thirteen months' actual residence, left for England with Felkin, who had arrived only three months before, taking with him envoys from Mutesa. In the same year the French Roman Catholic mission of the White Fathers of Algeria was inaugurated, and thus from 1879 dates the triangular rivalry of the creeds of Protestantism, Roman Catholicism, and Islam.

Mutesa succeeded by Mwanga, 1884.

In 1882 Islam gained an ascendancy, and the French withdrew for a time. In the autumn of 1884 Mutesa died. A great change had been wrought in Uganda during the latter years of his reign. Linen, firearms, and jewelled swords had replaced the primitive bark-cloth and spear, while under the teaching of the engineer Mackay the native artisans had learnt to repair arms and use European tools. Mutesa was a clever man of restless energy, but regardless of human life and suffering, and consumed by vanity. He was succeeded by Mwanga, a cruel, vain, and weak youth. Encouraged by the intrigues of the Arabs, his suspicions and fears of the missionaries, and their influence over the growing numbers of their adherents, led him to attempt to stamp out the new creed.

In the early 'eighties the thoughts and aspirations of several European Powers turned towards Eastern Africa as a field for commercial and colonial expansion. The restless Arabs of Zanzibar had since 1857 steadily advanced Zanzibar influence to Tanganyika, Nyasa, and even through the Masai countries to the north-east coast of Victoria Nyanza and the "back door" of Uganda. In 1882 the Royal Geographical Society despatched the great explorer Joseph Thomson to discover through Masailand the direct route to Victoria Nyanza. Thomson succeeded (he also discovered Lake Baringo and Mount Elgon), but turned back from the frontier of Busoga in order not to provoke the suspicious Mutesa to hostilities. Mr H. H. Johnston was despatched on a scientific mission to Kilimanjaro, and concluded treaties on which the British East Africa Company was subsequently based. The vague stir of these movements had perturbed Mutesa, and they were regarded with deep suspicion by his successor, Mwanga.

Murder of Bishop Hannington, 1885.

Religious feuds.

French and British factions.

The annexations of Emin on Albert Nyanza, the visit of Thomson to the closed door of Busoga, the opposition of the Europeans to the slave trade, and, lastly, the identification of the missionaries with political embassies and their letters of introduction from secular authorities, added to Mwanga's fears, and early in 1885, simultaneously with the return of the French Fathers, the long smouldering hostility broke out, and the Christian converts were seized and burnt at the stake. Bishop Hannington, who attempted to enter Uganda by the forbidden route from the east, was murdered, and Ashe and Mackay only redeemed their lives by presents. The Waganda Christians showed great heroism, and in spite of tortures and death the religion spread rapidly. Mwanga now determined to rid himself of Christians and Mahommedans alike by inducing them to proceed to an island in the lake, where he meant to leave them to starve. The plot was discovered, and Mwanga fled to the south of the lake, and Kiwewa, his brother, was made king. The chiefs of the rival creeds—English, French, and Ba-Islamu, as they were called—divided the chiefships. The Mahommedans now formed a plot to oust the Christians, and treacherously massacred a number of their chiefs, and then defeated their unprepared adherents. Kiwewa, refusing to submit to circumcision, was (after reigning three or four months) defeated, and expelled by the Ba-Islamu, who placed another brother, Kalema, on the throne, and began a fanatical propaganda, forcing the peasantry to submit to the hated circumcision. The British and French factions, who had taken refuge in Ankole, could not agree even in their common exile, and nearly came to blows, but on the spur of threatened famine they agreed to combine and to take back Mwanga as their king and strike a blow for supremacy in Uganda. Mackay opposed the return of Mwanga, but the priests supported it. In May 1889 Mwanga, aided by the trader Stokes, approached Uganda by water, and after several bloody battles captured the capital, but shortly afterwards was again defeated, and Kalema and the Ba-Islamu reoccupied Mengo. Appeals for help were sent to Mr Jackson, who had arrived on the east of the lake with a caravan of some 500 rifles, sent by the newly-formed East African Chartered Company. He replied saying he would come if all expenses were guaranteed and the British flag accepted. Père Lourdel, who was Mwanga's chief adviser at this time, counselled acceptance of these terms, but Jackson only sent a flag and marched northwards. Returning three months later, he found that Dr Peters, a German in command of a filibustering expedition, had passed through his camp, read his letters, and, acting on the information thus obtained, had marched to Uganda, arriving in February 1890, where with the aid of Lourdel he concluded a treaty which was kept secret from the British party, who repudiated it. The Baganda Christians before the arrival of Peters had again engaged the Mahommedans and driven them to the frontiers of Unyoro, where Kabarega gave them an asylum and aid. The posts of honour had been divided between the rival factions. Peters' Treaty had given fresh offence and added to the disputes arising in the division of the offices of state, and the factions were on the point of fighting. Jackson arrived in April with 180 guns (the remainder of his undisciplined rabble having mutinied), and presented a new treaty, which was refused by the French. Feeling ran high, and Jackson withdrew his treaty, and, taking a couple of envoys who should bring back word whether Uganda was to be French or British, he left the country, Mr Gedge remaining with a score or so of mutinous porters.

Lugard's arrival, 1890.

While these events were happening in Uganda, the Anglo-German treaty of July 1890 had assigned Uganda to Great Britain, and in October 1890 Captain Lugard, then at Kikuyu, half-way between the coast and the lake, received instructions to go to Uganda. He had with him Messrs De Winton and Grant, some 50 Sudanese soldiers, and about 250 porters, armed for self-defence with cheap Snider carbines. Marching with hitherto unprecedented rapidity, he entered Mengo on 18th December. Lugard, by introducing the names "Protestant" and "Catholic"—till then unknown—and by insisting that all religion was free, endeavoured to dissociate it from politics, and urged that as Uganda was now under Great Britain, there could be no hostile "French" faction. This attitude was welcome to neither. The French party were unwilling to acknowledge British suzerainty, even though religion were quite free, for the divergence between the factions was more political than religious, while the British faction were disappointed that Lugard would not help them to crush their rivals. For some days the position of the new arrivals on the little knoll of Kampala was very precarious, and an attack in force was nightly expected. Lugard's first object was to obtain a treaty which would give him a right to intervene in the internal affairs of the country. The hostile French faction was much the stronger, since at this time the king (whom the whole of the pagan party followed) was of that faction; but after some critical episodes the treaty was signed on 26th December. Lugard then endeavoured to settle some of the burning disputes between the two factions relative to the division of lands and chiefships, &c., and to gain the confidence of both parties. In this he was to some extent successful, and his position was greatly strengthened by the arrival in January 1891 of Captain Williams, R.A., with a small force of Sudanese and a Maxim. The position, however, remained extremely critical, and the difficulties were increased by the attitude of the missionaries of both factions. In April Lugard, hoping to achieve better results away from the capital, led the combined factions against the Mahommedans, then raiding the frontier, whom he defeated. Seeing that the situation in Uganda was impossible unless they had a strong central force, which the Company could not provide, Lugard and Williams had formed the idea of enlisting the Sudanese who had been abandoned by Emin and Stanley at the south of the Albert Lake. Taking with him Kasagama, the rightful king of Toro, he traversed the north of Ankole, with which country he made a treaty, and passing thence through southern Unyoro, along the northern slopes of Ruwenzori, reached Kavalli at the south end of Lake Albert, defeating the armies of Unyoro who opposed his progress. He brought away with him 8000 Sudanese men, women, children, and slaves. Some of these he left at the posts he established along southern Unyoro. After an absence of six months from Uganda Lugard reached the capital at the end of the year (1891) with 200 or 300 Sudanese soldiers and two or three times that number of followers. Meanwhile Williams, amid endless difficulties, with a mere handful of men had managed to keep the two factions from civil war, though fighting had actually occurred in Buddu and in the islands, which Ashe asserts to have been in pursuance of a plan to bring on war before the return of Lugard and the simultaneous arrival of a large caravan from the coast. This plan miscarried, owing to the bravery of the Protestants and the indefatigable efforts of Williams.

Civil war, 1891.

After Lugard's return a lull occurred till the coast caravan left, when lawlessness again broke out and several murders were committed. On 22nd January the killing of a Protestant at the capital (Mengo) produced a crisis. Lugard appealed to the king to do justice, but he himself was treated with scant courtesy, and his envoy was told that the French party would sack Kampala if Lugard interfered on behalf of the murdered man. Both sides rushed to arms, and in spite of strenuous efforts on the part of the British administrator to avert war (which at one time appeared to have succeeded), the French party, confident of victory, determined to fight, and committed fresh outrages, and finally attacked the British who had assembled round Kampala. Williams led a charge and had a narrow escape, but the king and French party were defeated and fled to the islands. The king and chiefs (except two ringleaders) were offered reinstatement, and they appeared anxious to accept these terms, but the French bishop joined them in the islands, and from that day all hopes of peace vanished. Fighting was recommenced by a "French" attack on "English" canoes, and Williams thereupon attacked the island and routed the hostile faction. After this the "French" slowly concentrated in Buddu in the south, the Protestants migrating thence. In this exodus the Buddu missionaries and a Sudanese garrison, as well as Mr Bagge, who had gone south by water, had narrow escapes, but fortunately all arrived safely. Williams then led a successful expedition against the Sese islanders, and went on to the south of the lake to obtain one of the young princes—heirs to the throne—who were at the French mission there. But the Fathers were hostile, and though Mwanga was eager to accept Lugard's offers of reinstatement, he was a prisoner in the hands of his party. He succeeded eventually in escaping, and arrived in Mengo 30th March (1892). A new treaty was made, and the British flag flew over the capital, while the French party were given a proportion of chiefships and assigned the province of Buddu. These conditions they themselves said were liberal, nor could they have dared to assume their old positions throughout Uganda.

The Mahommedans had all this time refrained from attacking the capital as had been expected. They now clamoured for recognition, and Lugard went to meet them, and after a somewhat precarious and very difficult interview, he succeeded in bringing back their king Mbogo to Kampala, and in assigning them three minor provinces in Uganda.[1]

The question of evacuation, 1892.

Lugard on his return to Uganda at the end of 1891 had received orders to evacuate with his whole force, as the Company could no longer maintain their position in the country. A reprieve till the end of 1892 followed, funds having been raised by the Church Missionary Society and friends. The lives of many Europeans were at stake, for anarchy must follow the withdrawal, and it seemed impossible to repudiate the pledges to Toro, or to abandon the Baganda who had fought for the British. In June 1892, therefore, Lugard determined to leave for England to explain the position of affairs and appeal against the decision for abandonment. Williams remained in Uganda, where the outlook was now fairly promising, and every effort was made to reduce expenses. On arrival in England Lugard found that the British Government had decided not to come to the help of the Company, and Uganda was to be left to its fate. A strong movement was set on foot for the "retention of Uganda," and on 10th December Lord Rosebery despatched Sir G. Portal to report on the best means of dealing with the country, and a subsidy was given to the Company to enable them to retain their troops there till 31st March 1893. Captain Macdonald, who had been in charge of a railway survey to Uganda, was directed to inquire into the claims put forward by France for compensation for the priests. His report was set aside by the Government, who, however, in order to close the controversy with France, agreed to pay a sum to the French priests without admitting liability, and the Foreign Office published a categorical reply by Lugard to the accusations made. Portal and his staff reached Uganda in March, and Williams left soon afterwards with the original troops of the Company, leaving Selim's Sudanese and Portal's large escort in Uganda. By his tact, fearless bearing, and freedom from bias he had, as before, during Lugard's absence prevented any fresh disturbances, though the Protestants had quarrelled among themselves. The country on Portal's arrival bore every mark of prosperity and revival. By increasing the territory of the Roman Catholics, and giving them estates on the road from Buddu to the capital, Portal gave effect to projects which the Protestants had violently opposed. He added also to their chiefships, and on 1st April hoisted the British flag, made a new treaty with Mwanga, and sent Major Owen to enlist 400 Sudanese from the Toro colonies. He recommended to Government the retention of Uganda, the abandonment of Unyoro and Toro, and the construction of a railway half-way only to the lake. He departed after two and a half months' residence, leaving Macdonald in charge.

Portal's mission.

Under Macdonald's régime the Sudanese under Selim Bey began to conspire against the British control. Selim Bey was deported to the coast.

Colvile's occupation of Unyoro.

In November 1893 Colonel Colvile arrived to take charge, and at once led the whole of the Baganda army against Kabarega of Unyoro. Captain "Roddy" Owen defeated the hostile army, first in the south and later in the north, and the Uganda chiefs scattered the main body, while Colvile occupied the capital and built a line of forts from Uganda to Lake Albert, of which he left Major Thruston in command. This officer fought a number of brilliant actions, and aided by Cunningham, Vandeleur, Grant, and others, he overran Unyoro and broke down all resistance. In August 1894 Uganda was declared a protectorate, and at the end of the year Colvile was invalided. Mr Jackson now took temporary charge, pending the arrival in June 1895 of Mr Berkeley, the first Administrator.

At this time also it was decided to construct a railway to Uganda, but work was not actually begun till December 1896. Peace seemed assured in Uganda: territorial limits to religious teaching were abolished, English Catholic priests were added to the French Fathers, and the material progress of the country was very marked. European traders settled in the country, good permanent houses were built, roads were made and kept in repair, and many new industries introduced, chief among which were the expression of oil from various oil-seeds and the cultivation of coffee. Trees were imported and land set aside for planting forests. The success of these efforts at progress was largely due to Mr G. Wilson, C.B. The grant to the protectorate stood at £49,000, and the staff, both civil and military, had been largely increased.

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[1] Since reduced to one.

Rebellion of 1897.

Sudanese mutiny.

In the middle of 1897, however, this era of peace was rudely interrupted. Colonel Ternan was acting commissioner, and Macdonald had returned to East Africa in command of an exploring expedition, for which Ternan had been ordered to supply 300 Sudanese. In June Wilson discovered a plot to revolt, and in July Mwanga fled to the south of Buddu and raised the standard of rebellion. The rebels were defeated by Ternan, and finally dispersed by Grant, while Mwanga was made a prisoner by the Germans. Ternan, apparently ignorant of the disaffection of his men, now sent three companies to Macdonald, selecting those who had been continuously fighting in Unyoro, Nandi, and Buddu. This caused great discontent, which was increased by the fact that their pay was six months in arrears and their clothing long overdue. The men too resented the fact that their pay was but a fifth of that given to Zanzibari coolies and to those of their own body enlisted in the adjoining protectorate. They were sore at again being sent on service without their wives, and complained of harsh treatment from their officers. Necessaries had been delayed in the foolish attempt to import steamers from the coast before the railway was made. At this moment Ternan left for England, and the civil charge devolved upon Wilson, while Thruston became commandant of the troops; but it was already too late to save the situation. The three companies had joined Macdonald and at once put forward their grievances, which they stated were unheeded; and it is probable that the steps taken to effect a solution were purposely misrepresented to the men by their native officers. Thereupon they left in a body to state their case to the acting commissioner at the "Ravine Station." Here they were fired upon by order of Captain Kirkpatrick, one of Macdonald's officers, who had ridden after them, and from that moment the insubordination became mutiny. Disregarding Jackson's efforts to bring them to reason, they marched towards Uganda, looting as they went. Macdonald and Jackson followed with a force of Zanzibaris. Meanwhile Thruston—a man justly loved by his soldiers, in whom he had complete confidence—hurried to the garrison at Luba's on the Nile, relying on his personal influence to control the men, and risking his life in the heroic attempt. He and two other Europeans were seized and made prisoners. On 19th October a battle was fought between the mutineers and Macdonald's force, in which the former were defeated, while Fielding was killed and two officers wounded. The same night the Sudanese leaders, fearful lest their men might submit, murdered their prisoners, and sent letters to Uganda to incite their comrades to mutiny. Wilson, however, had already disarmed the troops in Kampala, who remained loyal, as also did Mbogo, the ex-king of the Baganda Mahommedans. A large Protestant army now went to the assistance of Macdonald, and from 19th October to 9th January the siege of Luba's continued, with constant skirmishes, in which the Rev. G. Pilkington and Macdonald, junior, and many Baganda lost their lives. Early in January Mwanga escaped from the Germans, and declaring himself a Mahommedan reached Buddu with a large force, which Macdonald defeated with the aid of the Baganda army. He then disarmed the Sudanese garrisons in Buddu. The garrisons in Unyoro (about 500) and in Toro remained loyal. Meanwhile the Sudanese at Luba's (numbering 600, with 200 Mahommedan Baganda) escaped in a Government dhow which they had seized, the containing force under Woodward being powerless to stop them since Macdonald had taken the steamer to Buddu. The mutineers proceeded up the east bank of the Nile and crossed the river, making their way to Muruli. It appeared probable that if they reached that point the Sudanese garrisons in Unyoro would revolt as well as the Baganda Mahommedans, and the last hope of the Europeans would be lost. Leaving a small column to deal with Mwanga's force in the south, and another with Kabarega, Macdonald joined Woodward's force, now reinforced by 100 rifles under Harrison and by 150 Indian troops, as well as by Captain Austin's contingent. Lieutenant Scott was sent ahead to disarm the Unyoro garrisons, which he successfully did. Macdonald came up with the enemy in the swamps of Lake Kioga, and after a couple of successful skirmishes returned to Kampala, leaving Harrison in command. That officer, crossing a swamp supposed to be impassable, attacked the rebel stockade at Kabagambi, and carried it with great gallantry. The brave Maloney was killed and Lieutenant Osborne wounded, but the crisis was past. A large number of Indian troops arrived early in 1899, and in May Colonel Martyr inflicted another heavy defeat on the mutineers at Muruli, while Fowler, Price, and Sitwell broke up the Mahommedans in the south. Mwanga, however, managed to get through and join Kabarega and the rebels in the north. These were dealt with in a series of victories, but it was not until June 1899 that Colonel Evatt, I.S.C., had the good fortune to capture Mwanga and Kabarega, who were deported to the coast. Martyr at the close of the year undertook an expedition up the Nile, and extended the limits of the protectorate in that direction. The year had been a costly one, £329,000 being voted in aid. In the autumn of 1899 Sir Harry Johnston was sent out as Special Commissioner to Uganda, being also given the rank of commander-in-chief. By extensive reorganizations, and in spite of having to cope with a rising in Nandi, his commission resulted in reduction of expenditure and increase of local revenue. He gave the kingdom of Uganda a definite constitution, settled the land question throughout the protectorate, and also the question of native taxation. By agreements entered into with the Special Commissioner the natives of all the administered districts now pay hut and gun taxes as their contribution towards the upkeep of the protectorate. The armed forces and police of the protectorate were reorganized by Sir Harry Johnston, Colonel (afterwards General) Evatt, and Colonel A. H. Coles. The marine department (Government steamers on lakes and rivers) was placed under Mr C. W. Fowler, R.N. Mr J. F. Cunningham, who was secretary to the Special Commission, was appointed secretary to the Uganda Protectorate. Sir Harry Johnston's special commission terminated in the autumn of 1901, and he was succeeded as commissioner by Colonel Sadler.

In 1902 the Uganda railway, commenced in 1896, was finished. Its terminus is on Kavirondo Bay, Victoria Nyanza. It is some 580 miles long, ascends in places to altitudes of 7000 and 8000 feet (highest point 8300 feet), but has only one tunnel. Its cost was about £5,000,000.

Authorities.—Speke. *Discovery of the Sources of the Nile.*—Stanley. *Through the Dark Continent*, and *In Darkest Africa.*—Wilson and Felkin. *Uganda and the Egyptian Sudan.*—Ashe. *Two Kings of Uganda.*—Colvile. *The Land of the Nile Springs.*—Kollmann. *The Victorian Nyanza.*—Lugard. *Our East African Empire.*—Scott-Elliott. *A Naturalist in Mid Africa.*—Thomson. *Through Masailand.*—Keltie. *Partition of Africa.*—Dr Ansorge. *Under the African Sun.*—Sir Richard Burton. *Lake Regions of Central Africa.*—Sir Samuel Baker. *Albert Nyanza.*—Emin Pasha. *Journals* (1886 edition : Sampson Low).—Count Teleki and Lieut. Höhnel. *Lakes Rudolf and Stéphanie.*—Sir Harry Johnston. *The Uganda Protectorate.*—Government Blue-books (Africa) between 1885 and 1901. (H. H. J.; F. D. L.)

Uglich, a district town of Russia, in the government of Yaroslavl, on the right bank of the Volga, 45 miles south-west of Rybinsk railway station. It was here that Prince Demetrius, son of John the Terrible, was killed in 1591 by order of the Regent Boris Godunoff. The palace of Demetrius, two very old monasteries, and a cathedral dating from the 13th century, are still in existence. It has several steam flour-mills and paper mills, and manufactures of corn sacks and tea urns are common domestic industries. Sausages and hams are exported in large quantities, and there is otherwise an active trade. Population (1897), 12,000.

Uist, North and South, are two islands of the Outer Hebrides, Scotland, lying between Harris and Barra, in the county of Inverness. North Uist is 75,431 acres in extent, and South Uist 70,400 acres. Both are crofting islands, and contain a considerable proportion of good soil. North Uist contains the village of Lochmaddy, which is the centre of a large trade, having a fine natural harbour, and is the seat of a sheriff court-house and of the Long Island combination poorhouse. The parishes of North and South Uist embrace a number of other inhabited and uninhabited islands, of which the principal is Benbecula (in South Uist parish), lying directly between them. Population (1891), 10,008; (1901), 9377.

Uitenhage, a town of Cape Colony, 20 miles north-west of Port Elizabeth, with which it is connected by rail. This place, which was originally settled by the Dutch farmers spreading eastwards from Swellendam, has now become completely English, and is a thriving centre of agricultural industry, with a population which increased from 3500 in 1887 to 5330 in 1891. A large number of the natives find employment in the mills scattered over the district, where vast quantities of wool from the sheep farms of the eastern provinces are cleansed by machinery and forwarded for shipment at Port Elizabeth. The neighbourhood, which is pleasantly laid out with running waters and shady avenues, attracts many summer visitors and wealthy permanent residents.

Ujain, a city of India, in the native state of Gwalior, on the left bank of the river Sipra and a branch of the Rajputana railway from Ratlam, which has been extended to Bhopal (114 miles west) at the coast of Sindhia. It was the capital of Malwa in Hindu and Mahommedan times, being traditionally famous as the residence of Vikramaditiya. It is now a centre of the opium trade. In 1897–98 the exports of opium amounted to 3712 chests, paying a duty of Rs.20,58,800. Besides the Madhava College, there is a high school and a dispensary. Population (1881), 32,932; (1891), 34,691.

Ujvidék (German, *Neusatz*), a municipal town of Hungary, in the county of Bács-Bodrog, on the left bank of the Danube, opposite Petervárad. Among its educational establishments the most important are two upper gymnasia, a commercial academy, an upper girls' school, and the Servian educational society, "Matica Srbska." Its inhabitants carry on a brisk trade in fruit, vegetables, wine, and corn. There is a silk spinning-mill, which employs 500 hands. There are twenty-four credit institutes. Population (1891), 25,180; (1901), 29,296.

Uleåborg (Finnish, *Oulu*), a government in the grand duchy of Finland, including a wide territory to the north of Kuopio and nearly reaching Varangerfjord, taking in the high dreary plateau of Laponia (16,000 square miles) and the fertile plains of Österbotten. It has a total area of 63,970 square miles, and its population, chiefly agricultural in Österbotten and nomadic in Laponia, was, in 1899, 273,290 of whom 136,462 were women, and 22,126 lived in towns. The bulk of the inhabitants (99 per cent.) are Finnish. Immense spaces are covered with forests, and only 0·4 per cent. of the area is under culture. The capital of the government is ULEÅBORG, a seaport on the Gulf of Bothnia, now connected by railway with Helsingfors (498 miles). Its population in 1898 was 15,042, and it had a few tanneries, as well as some export trade in pitch, timber, butter (200 tons), leather, and hides. The other towns of the government are quite insignificant.

Ulm, a fortified town and bishop's see of Würtemberg, Germany, on the Danube, 58 miles by rail south-east of Stuttgart. The tower of the west façade of the cathedral was completed in 1877–90 by Professor August Beyer, according to the original plans of Böblinger, and is with its 528 feet one of the loftiest towers in the world. There are new law courts, a hydropathic, a library, and an agricultural school. Being a river port, at the head of effective navigation on the Danube, Ulm has a brisk trade. Population (1895), 39,304; (1900), 42,860.

Ulverston, a parish and market town of the North Lonsdale parliamentary division of Lancashire, England, on the Furness railway, 22 miles N.W. of Lancaster. It has, through its connexion with Morecambe Bay by a ship canal of 1 mile in length, a thriving shipping trade in iron and slates. It has manufactures of hardware, boots, and paper. Population (1891), 10,015; (1901), 10,064.

Ulwar. See ALWAR.

Umballa, or AMBALA, a city and district of British India, in the Delhi division of the Punjab. The city is 3 miles east of the river Ghaggar, 902 feet above the sea. It has a station on the North-Western railway (1077 miles north-west of Calcutta), with a branch line to Kalka at the foot of the hills (39 miles), which is now being continued up to Simla. Population (1881), 67,463; (1891), 79,294; municipal income (1897–98), Rs.49,929; death-rate (1897), 28 per 1000. Umballa owes its importance to a large military cantonment for all three arms, which was first established in 1843. The cantonment, which lies 4 miles south-east of the native town, is well laid out, with broad roads shaded by trees. It contains a church, a club-house, several hotels, and English shops; two high schools; four printing-presses; Hindu, Sikh, and Mahommedan literary institutions. A municipal water-supply has been constructed by means of a loan.

The district of UMBALLA has an area of 2754 square miles. Population (1881), 1,032,744; (1891), 1,033,427; average density, 375 persons per square mile. In 1901 the population was 816,110, showing a decrease of 21 per cent. The land revenue and rates in 1897–98 were Rs.9,83,402, the incidence of assessment being 14 annas per acre; cultivated area, 716,060 acres, of which only 83,149 were irrigated, including 2759 from Government canals; number of police, 867; number of schools (1896–1897), 246, attended by 9628 boys, being 10·2 per cent. of the boys of school-going age; death-rate (1897), 30·3 per 1000. The principal crops are wheat, maize, pulse, millet, rice, cotton, and some sugar-cane. It has one factory for ginning and pressing cotton. Two opposite corners of the district are watered by the Sirhind and the Eastern Jumna canals. A portion is crossed by the main line of the North-Western railway and by the Delhi–Umballa–Kalka railway, which have their junction at Umballa city. The district suffered from drought in 1896–97, the maximum number of persons in receipt of relief being 5279 in March 1897.

Umbria, a territorial division of Italy, situated in the middle of the peninsula, between Tuscany and the Marches on the north and Rome and the Abruzzi on the south, and comprising the one province of Perugia, with an area of 3748 square miles, and population (1881) of 572,060, and (1901), 644,367. The surface is mountainous, but affords good pasture, and there are numerous fertile valleys, yielding wheat, maize, leguminous plants, vines, olives, and fruits. Lignite, colouring earths, pottery clay, and marble are the more important minerals. The industries embrace the manufacture of silk, jute, and paper, iron-works and engineering shops, the preparation of olive oil, sugar-refining, the breeding of silkworms, and the manufacture of majolica, woollens, and glass. Modern Umbria formed down to 1860 a part of the States of the Church, and since that date has belonged to the kingdom of Italy. The most important towns are Perugia, Foligno, Terni, Spoleto, Orvieto, Rieti, Gubbio, Narni, and Assisi. Perugia is the seat of a free university.

Umeå, a town of Sweden, capital of the county of Vesterbotten, 8 miles from the mouth of the Ume river, and 231 miles north by east of Stockholm by rail, being connected with the trunk line to the north by a branch railway (19 miles) to Vännäs. The town has been almost entirely rebuilt since a fire in 1888, its chief buildings being the residence of the provincial governor (1894), a fine church (1894), a handsome town hall (1892), a museum of antiquities, higher slöjd school, seminary for female teachers, seamen's house, and saw-mills. The port —vessels unload and load at Sandvik, near the river mouth—is entered and cleared by some 200,000 tons annually. Population (1880), 2818; (1900), 3883.

Umrawattee. See AMRAOTI.

Umritsar. See AMRITSAR.

Unalaska, more correctly UNALASHKA, the largest of the Fox Islands, of the Aleutian chain, Alaska, U.S.A., and also, colloquially, the name of the principal settlement on the island, on the shores of Captain's Bay, in the north-east portion. The name is derived from two Aleut words meaning "next to the continent," referring to the position of the island. There was originally a large population of Aleuts, and numerous village sites can be recognized which have been depopulated for more than a century. The situation of the settlements was determined by the necessity for protection for shipping, as Captain's Bay contains several good harbours. The most accessible is Dutch Harbour, with its village of Udakhta on Amaknak Island. The oldest, settled in 1760–75, is Iliuliuk, which has a custom-house, Greek church, Methodist mission, and orphanage; it is situated in 53° 53′ N. and 166° 32′ W. The mean temperature is 38·3° F., and the annual rainfall about 38 inches. The island is mountainous and treeless, but with luxuriant growth of herbage. The active volcano of Makushin (5691 feet) is visible from Iliuliuk, and the volcanic islets Bogosloff and Grewingk, which rose from the sea in 1796 and 1883 respectively, lie about 30 miles west of the bay. The latter is still active. Unalaska is the principal port of Bering Sea, and enjoys a brisk trade, which has greatly increased since the gold discoveries. Many light-draught steamers have been built here for the Yukon, and it is the port of call for all the northern commerce of these waters. The population of Unalaska is small, comprising about 575 civilized Aleuts and 66 whites. In 1890 the population of the village of Unalaska was 317; in 1900 it was 428.

Unao, a town and district of British India, in the Lucknow division of Oudh. The town is 9 miles north-east of Cawnpore, and has a railway station. Population (1881), 9509; (1891), 12,931; municipal income (1897–1898), Rs.6928; no octroi is levied; incidence of taxation, R.0 : 5 : 7 per head; death-rate (1897), 66·5 per thousand.

The district of UNAO, north of the Ganges, between Cawnpore and Lucknow, has an area of 1778 square miles. Population (1881), 899,069; (1891), 953,636; (1901), 975,855. The land revenue and rates are Rs.13,93,531, the incidence of assessment per acre being R.1 : 6 : 8 on the temporarily settled and R.0 : 14 : 5 on the permanently settled estates; cultivated area (1896–97), 517,351 acres, of which 202,074 were irrigated from wells, &c.; number of police, 993; vernacular schools, 109, with 4440 pupils; registered death-rate (1897), 42·7 per thousand. The principal crops are barley, pulse, rice, wheat, millet, cotton, sugar-cane, and opium. The district is crossed by the main line of the Oudh and Rohilkhand Railway. It has no Government canals.

Underground Railways. See RAILWAYS.

Ungava. See LABRADOR and NORTH-WEST TERRITORIES.

Union, a town of Hudson county, New Jersey, U.S.A., just north of West Hoboken, a short distance from the west bank of the Hudson river, in the north-eastern part of the state. It partakes of the characteristics of Hoboken in its large foreign element, which consists chiefly of Germans. Population (1880), 5849; (1890), 10,643; (1900), 15,187, of whom 5179 were foreign-born.

Union, a town of South Carolina, U.S.A., capital of Union county, on the line of the Southern Railway, in the northern part of the state. Population (1890), 1609; (1900), 5400, of whom 15 were foreign-born and 1701 negroes.

Union Islands. See POLYNESIA.

Uniontown, a borough of Pennsylvania, U.S.A., capital of Fayette county, in the south-eastern part of the state, on the Pennsylvania and the Baltimore and Ohio railways, at an altitude of 990 feet. It is in the coking coal and natural gas region, and has glass-works and iron and steel manufactures. Population (1880), 3265; (1890), 6359; (1900), 7344, of whom 449 were foreign-born and 803 negroes.

UNITED KINGDOM.[1]

Extent and administration.

THE United Kingdom of Great Britain and Ireland has an area of 120,677 square miles, and at the date of the census of 1891 had a population of 37,957,133, and in 1901 of 41,454,621. If the islands in British seas are included, the area is increased to 120,979 square miles, and the population to 41,605,220.

Houses of Parliament.

England and Wales, Scotland, and Ireland are politically united under a Parliament consisting of the King, the House of Lords, and the House of Commons, the prerogatives of the Crown being exercised through responsible ministers. The House of Lords in January 1902 consisted of 590 members, viz., 4 members of the Royal family, 2 archbishops, 22 dukes, 22 marquises, 144 earls, 36 viscounts, 24 bishops, and 336 barons. The number comprised 16 Scottish peers (9 earls, 1 viscount, and 6 barons), representing the Scots peerage during the continuance of the Parliament, and 28 Irish peers (10 earls, 5 viscounts, and 13 barons), representing the Irish peerage for life. The number of old peerages is steadily decreasing, but the House is maintained and increased by the creation of new peerages, while the holders of existing ones are frequently promoted to titles of higher rank. Of the peerages existing in 1902, 2 dukedoms, 3 marquisates, 15 earldoms, 6 viscounties, and 110 baronies had been created since 1877. Among the barons are included 5 life peers who either were or had been Lords of Appeal in Ordinary. The number of seats appropriated to the lords spiritual has not been increased with the growth in the number of bishops in England and Wales. Of the 26 seats possessed by these dignitaries, 2 are always held by the archbishops, and 3 by the bishops of London, Durham, and Winchester; the remaining 21 are divided among 29 bishops in order of consecration as vacancies occur. The bishop of Sodor and Man has a seat but no vote. The privilege of voting by proxy, formerly allowed in the House of Lords, was abolished by standing order of the House in 1868.

The constitution of the House of Commons was modified by the Representation of the People Act, 1884, which conferred a "service" franchise on persons occupying, in virtue of their employment, dwellings not occupied by their employers; extended to householders and lodgers in counties the suffrages conferred in 1867 on householders and lodgers in boroughs; and also placed the three divisions of the United Kingdom on a footing of equality as regards electoral qualification. Further changes were introduced by the Distribution of Seats Act, 1885, which divided the country anew into county and borough constituencies, and increased the total number of members to 670.

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[1] This article includes only what is common to the three Kingdoms. For information as to Justice, Pauperism, Religion, Education, Agriculture, Railways, &c., see the articles on ENGLAND AND WALES, SCOTLAND, and IRELAND; and for matter relating to the Empire, see BRITISH EMPIRE, and the special articles on the COLONIES and PROTECTORATES.

The number of members of the House of Commons representing county, borough, and university constituencies respectively, and the number of registered electors in each class of constituency, according to a Return dated 20th February 1902, were as follows:—

	Members.	Electors.
ENGLAND (465) AND WALES (30)—		
Counties	253	3,097,516
Boroughs	237	2,348,840
Universities . . .	5	17,875
Total .	495	5,464,231
SCOTLAND—		
Counties	39	389,404
Boroughs . . .	31	295,772
Universities . . .	2	20,027
Total .	72	705,203
IRELAND—		
Counties . . .	85	597,676
Boroughs . . .	16	119,491
Universities . . .	2	4,492
Total .	103	721,659
Grand total .	670	6,891,093

The dates of first meeting and of dissolution, and the duration of recent Parliaments, have been as follows:—

When met.	When dissolved.	Duration. Years.	Months.	Days.
Victoria.				
5th March 1874	23rd March 1880	6	0	19
29th April 1880	18th November 1885	5	6	20
12th January 1886	26th June 1886	0	5	15
5th August 1886	28th June 1892	5	10	24
4th August 1892	8th July 1895	2	11	5
12th August 1895	25th September 1900	5	1	14
3rd December 1900	...		...	
Edward VII.				
14th February 1901	...		...	

The Speaker of the House of Commons is appointed by vote of the House; he holds office for the duration of the Parliament, but in a new Parliament the Speaker of the former is usually re-elected.

Government.

The Executive Government is carried on under the supervision of ministers of state, the heads of departments, and other dignitaries, the more important of whom are united in the Cabinet. This body is unknown to the law, and neither the number of its members nor their offices are definitely fixed. In recent years their number has varied from sixteen to twenty, holders of various offices having been included or excluded at the discretion of the head of the Administration. The first minister of the Crown, or Prime Minister, whose position as such has no official recognition, is appointed by the King, usually on the advice of the retiring Prime Minister, to some dignified office, and he, having made choice of his colleagues, recommends them for appointment. The offices which, either singly or in various combinations, have been held by prime ministers in recent years are those of First Lord of the Treasury, Lord Privy Seal, Lord President of the Council, the Chancellor of the Exchequer, and the Secretary of State for Foreign Affairs.

The First Lord of the Treasury is nominally at the head of the Treasury Board, but takes no part in its work. Under him is the Chancellor of the Exchequer, who is in fact Minister of Finance, representing his department in the House of Commons and providing for the adjustment of revenue and expenditure. Other Treasury officials with political duties are the Financial Secretary, the Patronage Secretary, called the senior "whip," and three Junior Lords of the Treasury, called assistant "whips." The office of Lord President of the Council is mainly an office of dignity. The Privy Council, of which he is titular president, is a body usually containing about 230 members. They are appointed for life, or for the life of the sovereign, so that at the accession of a new sovereign the Council must be reconstituted. The duty of the Council is to advise the King on affairs of State, the Lord President being required "to manage the debates in Council, to propose matters from the sovereign at the Council Table, and to report to the sovereign the resolution of the Council thereon." There are, in fact, no debates in Council, but the King by Orders in Council expresses his pleasure with respect to various administrative matters, such as government of colonies, grants of charters, the bringing of treaties into effect, and the regulating of departmental business. The Council has, besides, duties of a judicial or *quasi*-judicial nature which it performs by committee or commission. For Ireland there is a separate Privy Council. Within the Cabinet also is the Lord Chancellor, who has both political and judicial duties, is Speaker of the House of Lords by prescription, and Keeper of the Great Seal. The holder of this office must belong to the Church of England and abjure the doctrine of Transubstantiation. For Ireland there is a different Lord Chancellor, who also has a seat in the Cabinet. Other Cabinet ministers are the five Secretaries of State. Foremost among these is the Home Secretary, whose duties have a wide scope. He attends to the administration of criminal justice, police, and prisons, and through him the King exercises his prerogative of mercy. Within his department is the supervision of lunatic asylums, reformatories, and industrial schools, and it is his duty to see to the health of the community, especially of the classes employed in dangerous occupations. The Secretary for Foreign Affairs is concerned chiefly with the policy of the country with respect to foreign countries. He conducts negotiations with other states, his intercourse being carried on either through the representatives of foreign states in Great Britain, or through representatives of Great Britain abroad. The Secretary of State for War is responsible for the efficiency of the army. The heads of departments in the War Office advise him, and require his approval for every change. In Parliament he has to ask annually for the continuance of the standing army and for the money necessary for its maintenance. The Secretary for the Colonies, besides being the official medium of communication with colonial governments, has administrative duties respecting Crown colonies, and on his advice the Crown may veto an act of a colonial legislature. The Secretary of State for India appoints the members of the Council of India, which under his direction conducts the business of the Indian Government transacted in the United Kingdom, and, sitting in Council, controls the expenditure of the Indian Government. In questions of policy towards foreign Powers or native states, and in matters requiring secrecy, he may proceed on his own authority and is responsible to Parliament alone for his action. [For the functions of all officers of state not described herein, *vide* art. STATE, GREAT OFFICERS OF, vol. xxii. p. 458 of 9th edition.]

Within the Cabinet is the First Lord of the Admiralty, who has the general direction and supervision of all naval business. He is advised by four naval lords and a civil lord, each of whom, as the head of a separate department of naval administration, is responsible to him. The presidents of three boards which never meet have also seats in the Cabinet. The Board of Trade is technically a committee of the Privy Council, consisting of certain high dignitaries, but the president, who is assisted by a parliamentary secretary, is practically Minister of Commerce. The Board has a wide range of duties relating to trade, labour, shipping, harbours, railways, canals, fisheries, bankruptcy, and the preparation of statistics. The Local Government Board consists of the Lord President of the Council, the Secretaries of State, the Lord Privy Seal, the Chancellor of the Exchequer, and a president, who, as the Board never meets, is in fact the head of his department. The duties of the Board relate to the administration of the poor law, sanitary works, vaccination, adulteration of food, pollution of rivers. It has control over the finance of the various local authorities, and it audits their accounts. For Scotland there is a separate Local Government Board, of which the Secretary for Scotland is president, and another for Ireland, under the presidency of the chief secretary to the Lord-Lieutenant. The Board of Agriculture, formed in 1889, consists of the Lord President of the Council, the principal Secretaries of State, the First Lord of the Treasury, the Chancellor of the Exchequer, the Chancellor of the Duchy of Lancaster, the Secretary for Scotland, and any others whom His Majesty may appoint. The Act which created the Board transferred to it certain powers and duties from the Privy Council and from the Land Commissioners for England. The Board exercises powers under Acts relating to tithe-rent charges, copyhold, enclosure of commons, allotments, and drainage and improvement of land. It is concerned also with diseases of animals, destructive insects, and the muzzling of dogs. It promotes agricultural study, and collects and publishes agricultural statistics and information. The Board of Works and Public Buildings consists of a First Commissioner, the Secretaries of State, and the President of the Board of Trade, but it never meets. The First Commissioner is sometimes included in the

Cabinet. The duties of the Board are to see to the palaces and parks and such public buildings as are not assigned to the care of other departments. The Postmaster-General is responsible for the working of the postal and telegraph systems, and for the various financial systems managed by his department. The Lord-Lieutenant of Ireland represents the King and maintains the formalities of government in that island, the business of government being entrusted to the department of his Chief Secretary, who represents the Irish Government in the House of Commons, and may have a seat in the Cabinet. In theory, Ireland is governed through the Home Office, but in fact the details of Irish administration do not pass through that office. The Chief Secretary occupies an important position, and in every Cabinet either the Lord-Lieutenant or he has a seat. The first Secretary for Scotland was appointed in 1885, when the Scottish Office was created. To this department were transferred duties formerly discharged by the English Home Secretary and by the Scottish Lord Advocate. The Secretary for Scotland is not a secretary of State, but has a seat in the Cabinet. With the office of Chancellor of the Duchy of Lancaster there are nominally associated certain judicial and administrative duties, but this office is really a dignified sinecure, reserved for statesmen whose presence may be desirable at the deliberations of the Cabinet. The Education Board, formed in 1900, has supervision of educational matters in England and Wales only. (See ENGLAND AND WALES.)

Finance. The Imperial revenue, which for the financial year 1880–81 amounted to £81,872,354, reached for the year 1898–99 the sum of £108,336,193, showing an increase of about 32 per cent. This increase did not take place with perfect regularity, but the fluctuations were within comparatively narrow limits. In 1886–1887 the revenue amounted to £90,772,758, a sum which was not again reached till 1891–92, when the Exchequer receipts amounted to £90,994,786. The following year there was a fall of about £600,000, but since then the increase has been continuous.

The following table shows the Imperial revenue and expenditure (Exchequer receipts and issues), with the amount of revenue per head of population of the United Kingdom, for various years :—

Year ending 31st March.	Revenue.	Expenditure.	Revenue per Head of Population.
1881	£81,872,354	£80,938,990	£2 7 1
1886	89,581,301	92,223,844	2 9 9
1891	89,489,112	87,732,855	2 6 2
1896	101,973,829	97,764,357	2 12 2
1899	108,336,193	108,150,236	2 13 11
1900	119,839,905	133,722,407	2 18 7
1901	130,384,684	183,592,264	3 2 10
1902	142,997,999	195,522,213	...

During the thirteen years 1887–99 there was, as a rule, a large annual surplus, amounting in the aggregate to £21,150,441. The largest surplus was that of 1895–96, amounting to £4,209,472, and the only year in which there was a deficit was 1893–94, when the revenue receipts of the Exchequer were less than the issues for expenditure by £169,436. In each of the years 1899–1900 to 1901–02, however, owing to military operations in South Africa, there was a deficit.

The following statement shows the net receipts and the Exchequer receipts from the principal sources of revenue during the financial year ending 31st March 1902 :—

Sources of Revenue.	Net Receipts.	Exchequer Receipts.
Customs	£31,046,869	£30,993,000
Excise	31,597,961	31,600,000
Estate duties, &c.	14,250,827	14,200,000
Stamps (not fee stamps)	7,772,423	7,800,000
Land tax	775,219	725,000
House duty	1,726,676	1,775,000
Income and property tax	35,378,700	34,800,000
Total tax revenue	£122,548,675	£121,893,000
Post Office	£14,228,906	£14,300,000
Telegraph service	3,490,598	3,490,000
Crown lands	439,379	455,000
Interest on Suez Canal shares, &c.	869,634	869,634
Miscellaneous (fee stamps, Mint, &c.)	2,004,350	1,990,365
Total non-tax revenue	£21,032,867	£21,104,999
Total revenue	£143,581,542	£142,997,999

In the same year the Exchequer issues for expenditure chargeable against revenue to meet all requirements of the various services were as follows :—

Branches of Expenditure.	Expenditure Issues.
National Debt services—	
Interest of funded debt	£15,076,023
Terminable annuities	2,754,424
Interest of unfunded debt	314,751
Management of debt	173,617
Interest on war debt	3,366,716
Total Debt services	£21,685,531
Other Consolidated Fund services—	
Civil list	£487,746
Annuities and pensions	258,708
Salaries, &c.	78,916
Courts of justice	515,428
Miscellaneous	302,992
Total Consolidated Fund services	£23,329,321
Payments to local taxation accounts	£1,153,892
Supply services—	
Army	£92,542,000
Navy	31,030,000
Civil services	30,500,000
Customs and Inland Revenue	2,955,000
Post Office	9,240,000
Telegraph service	4,010,000
Packet service	762,000
Total Supply services	£171,039,000
Total expenditure	£195,522,213

The gradual increase in the amount of revenue (Exchequer receipts) derived from customs, excise, estate, &c., duties (mainly "death duties"), and stamps, is shown in the subjoined table. The death duties (probate, legacy, succession, &c., duties), formerly included under the head of stamps, became an important source of revenue in 1894–95, when a new estate duty, payable on the property of persons dying after 1st August 1894, was imposed. The revenue from estate, &c., duties given below is exclusive of the large share paid annually to local taxation accounts :—

Year ending 31st March.	Customs.	Excise.	Estate, &c., Duties.	Stamps.
	£	£		
1881	19,184,000	25,300,000	£11,078,481	
1886	19,827,000	25,460,000	11,590,000	
1891	19,480,000	24,788,000	13,460,000	
1896	20,756,000	26,800,000	£11,600,000	£7,350,000
1898	21,798,000	28,300,000	11,100,000	7,650,000
1899	20,850,000	29,200,000	11,400,000	7,630,000
1900	23,800,000	32,100,000	14,020,000	8,500,000
1901	26,262,000	33,100,000	12,980,000	7,825,000
1902	30,993.000	31,600,000	14,200,000	7,800,000

Customs duties are levied on tobacco, tea, colonial and foreign spirits, wine, currants and dried fruits, coffee, cocoa, chicory, and, since 1901, on sugar. In 1902 a duty was put on imported corn, meal, &c., estimated to yield £2,650,000 annually. The diminution of customs receipts in 1899 was mainly caused by a reduction in the tobacco duties in 1898. These duties in 1881 yielded £8,658,947, and in 1887, £9,367,186. In the latter year, however, the duty was reduced, and the receipts therefrom fell next year to £8,714,000, but then gradually rose till in 1898 they reached the sum of £11,433,909. The reduction of duty made in that year brought down the proceeds in 1899 to £10,994,000. In 1900 the duty was increased, and the proceeds in 1900–01 rose to £12,838,578, but in the following year fell to £10,567,706.

The customs duty (countervailing the excise duty) on spirits yielded £4,581,520 (besides £208,987 due to local taxation accounts) in 1901–02. The revenue from the duty on tea amounted in 1900 to £4,628,946 ; in the following year the duty was increased, and the revenue therefrom rose to £6,264,515 in 1901, falling again, to £5,792,966, in 1902. The customs duties on sugar, molasses, &c., in 1901–02 yielded £6,399,224. The only export duty levied in the United Kingdom is that on coal, which, from 19th April 1901 to 31st March 1902, yielded the net amount of £1,311,706.

Excise. In recent years important changes have been made in the taxes which fall under the head of excise. In 1880–81 the duties on malt and on sugar used in brewing were abolished, but at the same time an equivalent beer duty was imposed. In 1890, under the Customs and Inland Revenue Act, additional duties of 3d. per barrel on beer and 6d. per gallon on spirits were imposed, the proceeds of these taxes being assigned to local authorities. This step was in accordance with the system begun under the Local Government Act, 1888, by which English licences were transferred to county councils in England, a system which was extended to Scotland in the following year. (See *Local Finance* below.) In 1894 the duties on beer and spirits were increased; in 1896 the duty on spirits was reduced. In 1900 both beer and spirit duties were increased. The revenue from the excise duty on spirits in 1881 amounted to £14,393,572; for some years it declined, but in 1891 it reached £14,770,730; in 1901, £19,206,690; and in 1902, £17,647,421. The beer excise duty in 1882 yielded £8,530,819; in 1891, £9,390,141; in 1901, £13,490,620; and in 1902, £13,276,073. The local taxation revenue from excise duty on spirits in 1902 amounted to £843,358, and on beer to £442,364. In 1901–02 the customs and excise receipts for Imperial and local revenue from spirits, beer, and wine amounted to the net sum of £38,475,160.

Death duties.

After various changes had been made in the "death duties," these taxes were in 1894 rearranged, and a new estate duty was imposed in substitution of probate and account duty and of the estate duty formerly levied. The new duty is levied on the principal value of all settled property passing on death, at rates which vary from 1 per cent. on property from £100 to £500 in value, to 8 per cent. on estates valued at over £1,000,000. Including the share due to local taxation accounts, the net produce of this tax in 1901–02 amounted to £13,908,490. The legacy duty yielded £3,133,588, and other duties, less productive (including the succession duty amounting to £1,308,136), brought up the total proceeds of the death duties to £18,513,714.

Income tax.

The incidence and rate of the property and income tax have been changed several times in recent years. Up to 1894 the tax was chargeable on incomes of and over £150, with abatement of £120 on incomes under £400. From 1895 it was chargeable only on incomes above £160, while abatements were allowed of £160 on incomes not exceeding £400, of £150 on incomes above £400 but not above £500, of £120 on incomes above £500 and not over £600, and of £70 on incomes above £600 and not exceeding £700. The rate of the tax (which was 3d. per pound in 1878) and the amount of revenue which it has yielded in recent years are given as follows:—

Year ending 31st March.	Rate per £1.	Amount.
1881	6d.	£10,650,000
1886	6d.	15,160,000
1891	6d.	13,250,000
1896	8d.	16,100,000
1899	8d.	18,000,000
1900	8d.	18,750,000
1901	12d.	26,920,000
1902	14d.	34,800,000

Intra-national proportion of taxation yield.

The revenue from taxation in 1901–02, as adjusted to show, not the amount collected in, but that contributed by the three divisions of the United Kingdom, was as follows:—

Revenue from	England.	Scotland.	Ireland.	Total.
Customs:				
Coal exported	..	..	..	£1,312,000[1]
Spirits	£3,834,000	£414,000	£334,000	4,582,000
Sugar	5,021,000	690,000	688,000	6,399,000
Tea	4,408,000	574,000	811,000	5,793,000
Tobacco	8,355,000	1,115,000	1,098,000	10,568,000
Wine	1,238,000	95,000	116,000	1,449,000
Various	761,000	93,000	90,000	944,000
Total	£23,617,000	£2,981,000	£3,137,000	£31,047,000
Excise:				
Spirits	11,935,000	3,720,000	1,993,000	17,648,000
Beer	11,733,000	568,000	975,000	13,276,000
Various[2]	423,000	38,000	213,000	674,000
Total	£24,091,000	£4,326,000	£3,181,000	£31,598,000
Estate, &c., Duties	12,033,000	1,411,000	641,000	14,251,000[3]
Land Tax and House Duty[2]	2,354,000	148,000	..	2,502,000
Income Tax	30,063,000	3,645,000	1,176,000	35,379,000[4]
Stamps	6,818,000	604,000	316,000	7,772,000[5]
Grand total	£98,976,000	£13,115,000	£8,451,000	£122,549,000

These taxation revenues do not include the sums collected by Imperial officers for local authorities, amounting in 1901–02 to £8,314,000 for England, £1,082,000 for Scotland, and £261,000 for Ireland; total (including £73,000 contributed from other sources), £9,730,000.

Expenditure.

The national expenditure is incurred mainly on account of the national debt, the army and navy, and the civil services. The expenditure for these purposes in every fifth year from 1881 and in 1899–1902 was as follows:

Year ending March 31st.	National Debt Services.	Army and Navy.	Civil Service (excl. of Post-Office and Collect. of Rev.).
1881	£29,575,264	£25,784,600	£17,356,499
1886	23,449,678	39,538,593	19,214,151
1891	25,207,000	33,488,952	17,732,664
1896	25,000,000	38,344,000	21,211,357
1899	25,000,000	44,283,000	23,401,853
1900	23,000,000	69,815,000	23,899,810
1901	19,835,489	121,445,000	24,854,407
1902	21,685,532	123,787,000	31,928,790

The expenditure on the debt services in 1886 was abnormally low, and on the other services abnormally high. For that year the extinction of debt by means of terminable annuities (to the capital amount of £4,672,978) was suspended, and in the military expenditure there was included the sum of £9,451,000 on account of operations in Egypt. In 1900 and 1901 the sinking fund was suspended and the army expenditure was increased owing to the war in South Africa.

National Debt.

After 1880 the capital of the national debt rapidly diminished up to the time of the war in South Africa. The total reduction from 1881 to 1899 amounted to £138,681,876. This great reduction was brought about by the cancellation of £26,558,959 stock under the National Debt and Local Loans Act of 1887, and by redemption and other means. From 1888 to 1899 the net decrease amounted to £78,012,488, the annual average of decrease having been over £7,000,000. The capital of the funded and of the unfunded debt, and the total, including the capital value of terminable annuities, is shown below:—

Year (1st April).	Funded Debt.	Unfunded Debt.	Total (including terminable annuities).
1881	£709,078,526	£22,077,500	£766,144,461
1886	638,849,694	17,602,800	742,282,411
1891	579,472,082	36,140,079	684,070,959
1896	589,146,878	9,975,800	648,474,143
1899	583,186,305	8,133,000	627,562,585
1900	552,606,898	16,133,000	628,978,783
1901	551,182,153	78,132,000	690,992,622
1902	609,587,248	75,133,000	747,876,000

The increase of the funded debt and decrease of the unfunded debt shown for 1896 was due to the cancellation of £13,000,000 of unfunded and a corresponding addition to the funded debt in 1893. In 1901–02 the funded debt was increased by £60,000,000, and between 1899 and 1902 the unfunded debt was increased by £67,000,000, owing to the war in South Africa. By the operations under the National Debt Conversion Act, 1888, the interest on the funded debt was up to 1903 at 2¾ per cent., except £31,394,670, which was at 2½ per cent. Details of the capital of the debt on 1st April 1902 (see also under NATIONAL DEBT) are given in the subjoined statement:—

LIABILITIES—	
Funded debt	£609,587,248
Terminable annuities	63,190,859
Unfunded debt	75,133,000
	£747,911,107
Russian-Dutch Loan Act, 1891	203,838
Barracks Act, 1890	2,425,349
Telegraph Acts, 1892 to 1899	2,386,202
Naval Works Acts, 1895 to 1901	5,456,450
Uganda Railway Acts, 1896 to 1900	4,703,592
Public Offices Acts, 1895 and 1897	949,927
Royal Niger Company Act, 1899	828,190
Military Works Acts, 1897 to 1901	2,626,835
Land Registry Act, 1900	158,452
Pacific Cable Act, 1901	793,444
Total liabilities	£768,443,386
ESTIMATED ASSETS—	
Suez Canal shares	£27,935,000
Other assets	726,855
Exchequer balances at banks	8,566,948

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[1] Of this amount £1,085,000 was collected in England and £227,000 in Scotland.

[2] As collected.

[3] Including £166,000 from other sources.

[4] Including £495,000 from other sources.

[5] Including £34,000 from other sources.

Local finance.

The revenues annually provided for expenditure by local authorities for local purposes within the United Kingdom have rapidly increased in recent years. In the years 1880–81, 1890–91, and 1898–99 the receipts from all sources, including loans, were as follows :—

	1880–81.	1890–91.	1898–99.
England and Wales	£53,867,043	£58,543,947	£91,492,027
Scotland . .	6,058,600	8,097,456	13,804,788
Ireland . . .	3,872,249	4,499,500	5,242,042
United Kingdom .	£63,797,892	£71,140,903	£110,538,857

For England and Wales in 1898–99 the local government receipts and expenditure were as follows :—

Receipts from		Expenditure.	
	£		£
Rates . .	38,602,534	Poor relief . .	11,286,973
Water and lighting	9,487,255	School Boards .	10,506,110
Repayments . .	1,366,830	Town police, &c. .	51,883,586
Tolls, licences, &c.	5,799,823	County police, &c.	6,256,232
Rents and sales .	3,541,733	Harbours, &c. .	5,206,830
Government contributions . .	11,836,682	Highways, &c. .	1,859,635
Loans . . .	18,220,039	Various . .	5,602,455
Miscellaneous .	2,637,131		
Total . .	91,492,027	Total . .	92,601,821

Contributions from Imperial funds towards local purposes are made in various forms, but since the passing of the Local Government Act, 1888, the most important grants are the proceeds of duties collected by Imperial officers and handed over to local authorities. In 1888 one-third of the probate duty was assigned to local authorities ; in 1889 the share was increased to one-half, and in 1894 this was exchanged for an equivalent share in the estate duty then imposed. The transference of the English and Scottish licence duties to local authorities took place under the Acts of 1888 and 1889, and the additional beer and spirit duties were assigned in 1890. The Agricultural Rates Act, 1896, for England, and Acts of similar purpose for Scotland and Ireland, provided relief for agricultural ratepayers by means of payments from local taxation accounts, but the enactment as regards Ireland was repealed by the Local Government (Ireland) Act, 1898, which supplied other means of relief. For the year 1901–02 the payments to local authorities from the assigned duties were as shown below :—

Duties.	England and Wales.	Scotland.	Ireland.	United Kingdom.
	£	£	£	£
Additional beer and spirit duties .	1,184,856	156,505	133,958	1,475,319
Licences . .	3,555,736	373,533	...	3,929,269
Probate and estate duties . .	3,556,156	497,816	255,529	4,309,501
Total . .	8,296,748	1,027,854	389,487	9,714,089

The system of making advances from state funds for local purposes which had grown up under various Acts of Parliament was set on a new basis by the National Debt and Local Loans Act, 1887. In the early part of the 19th century loans had been made for local purposes out of Exchequer balances, and of these the outstanding amount on 31st March 1887 was about £13,000,000. To meet the increasing demand for advances, recourse was had in 1876 to the creation of unfunded debt, and of the amount so created there remained in 1887, £14,150,000. An Act of 1879 made the savings banks deposits available for such advances, and of these moneys the amount outstanding in 1887 was £9,468,713. The outstanding advances at that date thus amounted to £36,618,713. Of this amount, £36,526,057 was regarded as recoverable ; and under the Act of that year stock to an equivalent amount was created for the purpose of local loans. The advances from 1792 to 1901 for public works amounted to £153,929,114, of which in 1900 there remained outstanding £54,361,299.

The total debt of the local authorities in England and Wales in 1897–98 amounted to £276,229,048. This debt had been incurred for the purpose of carrying out permanent improvements, the most important having been waterworks, the outstanding amount for which was £49,795,662 ; harbours, piers, docks, &c., £35,171,963 ; highways and streets, £34,445,784 ; schools, £29,064,152 ; sewerage, £28,546,920 ; gasworks, £19,247,026. The local debt of Scotland at the end of the same year amounted to £44,355,588, and the debts of certain classes of local authorities in Ireland, in respect of loans, amounted to £11,122,824.

Savings and wealth.

In the Post Office Savings Bank the number of depositors' accounts and the amount deposited have increased threefold, and within the same period there has been a substantial addition to the amount of the deposits in the trustee savings banks, though in the number of their depositors there has not been a corresponding increase.

The following statement shows the number of deposit accounts open at the end of 1881, 1891, and 1900 in the Post Office Savings Bank and in the trustee savings banks in the whole of the United Kingdom, and in England and Wales :—

Year.	Post Office Bank.		Trustee Banks.	
	United Kingdom.	England and Wales.	United Kingdom.	England and Wales.
1881	2,607,612	2,410,946	1,532,486	1,184,627
1891	5,118,395	4,723,929	1,510,282	1,079,066
1900	8,439,983	7,685,317	1,625,023	1,078,705

The total amount received from and paid to depositors in the Post Office Savings Bank in each of those years, and the amount due to depositors at the end of each year (exclusive of Government stock held for depositors), were :—

Year.		United Kingdom.	England and Wales.
1881	Received . .	£12,694,146	£11,685,367
	Paid. . .	10,244,287	9,482,725
	Due . . .	36,194,496	33,771,412
1891	Received . .	22,993,050	21,170,281
	Paid. . .	19,019,855	17,574,047
	Due . . .	71,608,002	66,018,228
1900	Received . .	43,662,412	39,596,852
	Paid. . .	38,231,372	34,851,383
	Due . . .	135,549,645	122,365,193

In the trustee savings banks the amounts similarly received, paid, and due were as follows :—

Year.		United Kingdom.	England and Wales.
1881	Received . .	£9,227,816	£6,611,249
	Paid. . .	10,210,640	7,636,178
	Due . . .	44,140,116	35,204,605
1891	Received . .	9,253,470	6,039,149
	Paid. . .	11,089,693	7,839,277
	Due . . .	42,875,565	31,066,149
1900	Received . .	12,247,672	7,177,591
	Paid. . .	13,448,957	7,988,990
	Due . . .	51,455,917	32,680,718

In 1880 began the system of purchasing Government stock to a limited amount for depositors in savings banks. The amount of stock so purchased and standing to the credit of depositors at the end of 1881, 1891, and 1900 was as follows :—

Year.	Post Office Bank.	Trustee Banks.	
	United Kingdom.	United Kingdom.	England and Wales.
1881	£738,967	£124,668	£109,291
1891	5,087,765	1,282,238	1,126,916
1900	10,468,290	1,365,517	1,203,553

The total savings (deposits, interest, and stock) held by the savings banks of the United Kingdom at the end of 1900 thus amounted to £198,839,369, exclusive of a considerable sum represented by contracts for immediate or deferred annuities.

The annual return relating to trustee savings banks for the year ending 20th November 1900 shows that there were in England on that day 146 such banks, with altogether 1,033,702 accounts open, and in Wales 11 with 18,558 accounts. Their number is decreasing, and every year a large amount of cash is transferred from them to the Post Office Bank. Seven English and four Welsh counties have now no trustee banks, and eight English and six Welsh counties have only one each. The counties where they are most favoured are Lancashire, where, in November 1900, 332,613 depositors had £11,304,985 standing to their credit; Middlesex, 141,490 depositors, with £3,031,459 to their credit;

the West Riding of Yorkshire, 93,019 depositors, with £2,970,265 to their credit; the East Riding, 72,892 depositors, with £1,816,419; Devonshire, 64,080 depositors, with £1,886,316; Northumberland, 38,959 depositors, with £1,545,874; Cheshire, 23,773 depositors, with £1,027,647.

Income tax.

While the amount of the savings of the working classes gives a fair idea of the general prosperity of the country, the revenue derived from income tax, and the annual value of property and profits as assessed for the purpose of that tax, afford a surer indication as to the condition of the national wealth. The rate of the tax has varied considerably, and changes have been made in its incidence for the purpose of affording relief, but the net produce for each penny of the tax, though fluctuating, has on the whole largely increased. The net produce per penny of tax in the United Kingdom for the years specified was as follows:—

Year.	For each Penny.	Year.	For each Penny.
1881	£1,866,636	1896	£2,033,162
1886	1,980,395	1899	2,284,000
1891	2,215,856	1900	2,364,000

A comparison of the assessed values given for various years is complicated by the numerous assessment changes which have been made, notably by the substitution of one-third of the annual value in respect of the occupation of lands and tenements for the full value. In consequence of this reduction, the assessed value under Schedule B, which for the United Kingdom in 1895–96 stood at £55,471,734, fell in 1896-97 to £18,496,701, the fall with respect to England and Wales having been from £39,428,803 to £13,160,528. The total annual value of property and profits assessed in various years was as follows:—

Year.	United Kingdom.	England and Wales.
1881	£585,223,890	£493,583,819
1886	629,855,622	533,038,774
1891	698,407,549	597,265,843
1896	709,651,556	605,849,574
1899	758,571,709	653,686,806
1900	788,023,603	678,742,789

The annual values of lands, tenements, &c., assessed under Schedule A were for the United Kingdom, in 1881, £187,598,346; in 1891, £199,299,608; in 1900, £228,383,906. For England and Wales the corresponding values were in 1881, £154,711,410; in 1891, £165,956,061; in 1900, £191,112,811. The property under this schedule consists almost entirely of land and houses, and the increase in its assessed value is the more remarkable when the large decrease in the value of agricultural land is considered. The annual assessed values of lands and of houses respectively in 1881, 1891, and 1900 were for the United Kingdom and for England and Wales as follows:—

Year.	United Kingdom.		England and Wales.	
	Lands.	Houses.	Lands.	Houses.
	£	£	£	£
1881	69,291,973	117,465,877	51,599,428	102,417,104
1891	57,694,820	140,584,063	41,378,589	123,721,189
1900	52,814,291	174,430,501	37,110,545	153,193,414

The fall in the annual value of land as assessed under Schedule A was for the period 1881-1900 equivalent to 23 per cent., while the rise in that of house property was at the rate of 48 per cent. Even more important are the indications of prosperity supplied by the assessments under Schedule D, which comprises professional earnings and gains from trade and from the working of railways, mines, &c. The assessed values of such profits in the United Kingdom and in England and Wales for various years were as follows:—

Years.	United Kingdom.	England and Wales.
1881	£255,355,909	£219,996,536
1886	289,423,738	249,457,490
1891	351,590,691	306,854,829
1896	351,672,687	306,199,331
1899	412,410,291	357,834,541
1900	432,541,278	374,947,879

The increase during the period 1881–99 thus exceeded 69 per cent. of the value in 1881.

In a paper published in 1878 Sir Robert Giffen discussed the growth of capital in the United Kingdom down to 1875, and, following the same method in a paper published in 1889, he estimated the capital value of the property and profits assessed to income tax, and of those not assessed to income tax, in 1885 at £10,037,036,000. The manner in which this result was obtained is shown in the subjoined table:—

	Income.	Years' purchase.	Capital.
	£1000		£1000
Assessed to income tax:			
Under Schedule A—			
Lands	65,039	26	1,691,313
Houses	128,459	15	1,926,885
Other profits	877	30	26,310
Under Schedule B	65,223	8	521,864
Under Schedule C—			
Public funds (less home funds)	21,096	25	527,400
Under Schedule D—			
Mines, quarries, ironworks	10,801	4	43,204
Gasworks	5,026	25	125,650
Waterworks	3,260	20	65,200
Canals, &c.	3,546	20	70,920
Fishings, markets	1,208	20	24,160
Other public companies	34,789	20	695,780
Foreign and colonial securities	9,859	20	197,180
Railways in U.K.	33,270	28	931,560
,, out of U.K.	3,808	20	76,160
Interest paid out of rates	5,041	25	126,025
Other profits	1,435	20	28,700
Trades and professions	36,096	15	541,440
Total	428,833	...	7,619,751
Not assessed to income tax:			
Trades and professions omitted	8,179[1]	15	108,285
Income of non-income tax payers derived from capital	67,000	5	335,000
Foreign investments not in Schedules C and D	50,000	10	500,000
Movable property not yielding income (furniture, &c.)	...	...	960,000
Government and local property	...	...	500,000
Grand total	554,012	...	10,023,036

Army.

Since 1880 the normal effective strength of the army has been largely increased. The following figures show the average strength of the regular army at home and abroad in the years named:—

Year.	Strength.	Year.	Strength.
1881	188,798	1897	219,283
1886	203,805	1898	225,027
1891	209,699	1899	238,739
1896	220,742	1900	383,037

Recruits are enlisted (with few exceptions) for short service, usually seven years with the colours and five in the reserve, but the periods differ for different branches of service.

The recruits approved for the regular army in the last four years were enlisted as follows:—

In	1898.	1899.	1900.	1901.
England	28,584	30,149	36,553	33,906
Wales	1,207	985	1,063	1,251
Scotland	3,921	4,387	5,323	5,164
Ireland	4,094	3,987	4,040	3,778
Total	37,806	39,508	46,979	44,099

The numbers in the different arms of the militia and volunteers, 1902–03, were stated as follows:—

	Militia.	Volunteers.
Artillery	19,054	52,918
Engineers	2,352	19,587
Infantry	109,412	270,786
Channel Isles, &c.	6,002	...
Medical	919	3,478
Total	137,739	346,769

The enrolled yeomanry in 1902 numbered 17,407.

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[1] Comprising £960,000 not included in the capitalization.

The increase in the cost of the army is shown by the following figures:—

Year.	Expenditure.	Year.	Expenditure.
1881 . .	£14,680,762	1899 . .	£19,999,700
1886 . .	17,027,084	1900 . .	43,552,900
1891 . .	17,550,023	1901 . .	91,505,900
1896 . .	18,459,800	1902 . .	92,262,000

For 1902–03 the estimated expenditure amounted to the net sum of £69,310,000. The expenditure on staff, regimental, and reserve pay was put at £18,940,400; on militia pay at £1,381,000; on yeomanry and volunteer pay at £1,872,000; on transport and remounts at £11,242,000; on provisions and forage at £16,066,000; on clothing at £3,970,000; on warlike stores at £8,332,000; on works, buildings, &c., at £2,190,000. On the non-effective services the expenditure (half pay, pensions, &c.) was put at £3,728,000. The vast increase in the army estimates was caused by the military operations in South Africa. (See ARMIES).

Navy. The actual fighting strength of the navy and the number of vessels completing and building on 1st January 1901 was as follows:—

	Complete for Sea.	Launched and completing.	Building or projected.
Battleships, 1st class . .	14	7	8
,, 2nd class .	12	...	...
,, 3rd class .	11	...	...
Armoured cruisers . .	6	8	6
Protected cruisers . .	125	...	2
Torpedo gunboats, &c. .	33	...	...
,, destroyers . .	96	1	12
,, boats, 1st class .	11	...	4
,, ,, 2nd class .	71	...	...
,, ships . . .	2	...	...

Besides the completed vessels named above, there were 23 obsolete or coast defence battleships, 95 third class torpedo-boats, and many miscellaneous vessels of little account for fighting purposes.

The number of officers, seamen, and marines provided for in the estimates for 1902–03 was:—

Sea service—	
Officers and men for the fleet	88,691
Coast guard	4,200
Marines	19,589
Other services (training, &c.)—	
Officers and men	1,730
Pensioners	1,288
Boys	6,786
Marines	216
Total . . .	122,500

In February 1902 the ships in commission were distributed as follows:—

Mediterranean and Red Sea	54
Channel squadron	13
North America and West Indies . . .	14
South-east coast of America	3
Pacific	8
Cape Colony and West Coast of Africa . .	17
East Indies	10
China	41
Australasia	12
Reserve squadron	49
Cruiser squadron	6
Surveying	7
Total . . .	234

In consideration of subsidies amounting annually to £63,200, the Admiralty had up to 1902 a right to the services of 18 vessels, called "reserve merchant cruisers," belonging to the Cunard Company, the Peninsular and Oriental Company, the White Star Line, the Orient Company, the Royal Mail Steam Packet Company, the Pacific Company, and the Canadian Pacific Railway Company; and these companies held 31 other vessels at the disposal of the Admiralty without further subsidy. In October 1902, owing to the formation of the Atlantic Shipping Trust, new arrangements were made, involving a special subsidy to the Cunard Line, for which see under STEAM-SHIP LINES.

The Royal Naval Reserve consists of officers and men (fishermen and others) to the number of 27,780, who when qualified receive annual retainers and are drilled periodically in 9 drill ships, stationed at as many ports on the coasts of England and Scotland. There are two gunboats also provided for the training of reserve officers. The following statement illustrates the increase in the cost of this service:—

Year ending 31st March.	Expenditure.	Year ending 31st March.	Expenditure.
1881 . .	£10,511,840	1899 . .	£24,068,000
1886 . .	12,660,509	1900 . .	26,000,000
1891 . .	14,125,358	1901 . .	29,520,000
1896 . .	19,724,000	1902 . .	31,030,000
1897 . .	22,170,000		

(See also NAVIES and ADMIRALTY ADMINISTRATION.)

Minerals and mining. The mineral production of the United Kingdom in 1900 reached a total value of £135,957,676, of which £121,652,596, or over 89 per cent., represented the value of the coal output, and about 3 per cent. that of the output of iron ore. The weight of the more important minerals produced in 1900 and 1901 was as follows:—

Description of Minerals.	1900. Tons.	1901. Tons.
Coal	225,181,300	219,046,945
Iron ore	14,025,208	12,275,198
Slate	585,859	488,772
Sandstone	5,019,874	5,115,675
Clays	14,049,694	14,161,877
Chalk	4,373,331	4,328,344
Other limestones . .	11,905,477	11,180,579
Salt	1,861,347	1,783,056
Igneous rocks . . .	4,634,301	5,049,312
Oil shale	2,282,221	2,354,356
Tin ore (dressed) . .	6,800	7,288
Lead ore	32,010	27,976
Gravel and sand . .	1,837,202	1,958,929
Zinc ore	24,675	23,752
Gypsum	208,038	200,766
Arsenic	4,081	3,361
Copper ore and precipitate	9,488	6,792
Barytes	29,456	27,613
Wolfram	9	21
Strontium sulphate . .	9,121	16,651

Gold ore, manganese ore, and uranium ore are produced in small quantities, and the list of minerals worked in the United Kingdom includes alum, clay and shale, phosphate of lime, chert, and flint.

From the ores comprised in the table given above metals were obtained in 1900 in quantity and value as follows:—

Description of Metal.		Quantity.	Value at Average Market Price.
Iron . . .	tons	4,666,942	£19,596,910
Tin	,,	4,268	587,869
Lead	,,	24,364	418,960
Zinc	,,	9,066	188,573
Aluminium . .	,,	560	72,800
Copper . . .	,,	765	59,995
Silver . . .	oz.	190,850	22,465
Sodium . . .	tons	250	31,000
Gold	oz.	14,004	52,147
Total			£21,030,719

The inspection of mines is provided for under the Coal Mines Regulation Acts, 1887–96, the Metalliferous Mines Regulation Act, 1872, and the Quarries Act, 1894. The United Kingdom is divided into 13 districts, two of which are in Scotland, while Ireland is united with one of the English districts. For the purposes of the Coal Mines Acts, and of those of the Metalliferous Mines and Quarries Acts, the districts are in general the same, but in some cases the areas differ, and one district is constituted only for the purposes of the last-named Acts. Under the Coal Mines Acts are not only coal mines, but mines of stratified ironstone, shale, and fireclay. All mines not under these Acts are under the Metalliferous Mines Act. A quarry, as defined by the Act of 1894, is a place (not a mine) in which persons work in getting mineral, and of which any part is more than 20 feet deep.

The total number of persons employed in and about all the mines of the United Kingdom in 1901 was 839,178, of whom 806,735 worked at 3397 mines under the Coal Mines Act, and 32,443 at 731 mines under the Metalliferous Mines Act. Of the 806,735 persons working at the mines under the Coal Mines Act, 647,822, or about 80 per cent., were employed below ground. Of the 158,193 surface workers, 5195 or 3·2 per cent., were females. At the mines under the Metalliferous Mines Act, 18,804 persons, or nearly 58 per cent., worked below ground, and of the 13,639 surface workers, 393, or nearly 2·9 per cent., were females. At the quarries under the Quarries Act there were 94,188 persons employed, of whom 59,968 worked inside the actual pits or excavations, and 34,220 outside.

The number of mines under the Coal Mines Act in the United Kingdom, the number of persons employed under ground and above ground, and the number of deaths from accidents in every fifth year from 1881 were as follows :—

Year.	Mines.	Persons employed.			Deaths from Accident.
		Under ground.	Above ground.	Total.	
1881	3847	399,387	96,090	495,477	954
1886	3391	423,862	96,108	519,970	953
1891	3439	536.091	131,892	667,983	1005
1896	3385	557,026	135,658	692,684	1025
1901	3397	647,822	158,913	806,735	1101

In 1901 at the coal and other mines there were 21 explosions of fire-damp or coal dust, causing 125 deaths; 460 falls of ground, causing 482 deaths; 65 accidents in shafts, causing 75 deaths; the underground accidents from explosives, haulage, machinery, &c., numbered 255 and caused the death of 272 persons, while on the surface 151 persons were killed in 150 accidents.

Coal.—The production of coal in Great Britain, though marked by fluctuation, has on the whole largely increased since 1881, and in 1901 the output was 42 per cent. greater than that of 1881. The quantity extracted in every fifth year from 1881, with the value, was as follows:—

Year.	Quantity. Tons.	Value.
1881	154,184,300	£65,528,327
1886	157,518,482	38,145,930
1891	185,479,126	74,099,816
1896	195,361,260	57,190,147
1901	219,046,945	...

Of the coal output of the United Kingdom in 1900, 159,325,402 tons, valued at £83,884,411, were raised in England, and 32,618,935 tons, valued at £19,649,968, were raised in Wales, so that the coal production of England and Wales together constituted, in quantity and value, 85 per cent. of the whole.

In the various coal-producing counties of England and Wales the quantity raised in 1900 and its value at the pit's mouth were as follows :—

	Quantity. Tons.	Value.
Chester	699,411	£367,212
Cumberland	2,022,327	932,377
Derby	15,243,031	8,002,591
Durham	34,800,719	17,939,771
Gloucester	1,578,386	1,025,951
Lancashire	24,842,208	13,367,925
Leicester	2,106,343	1,140,936
Monmouth	9,818,829	5,891,297
Northumberland	11,514,521	5,928,539
Nottingham	8,626,177	4,708,455
Shropshire	780,420	409,720
Somerset	1,046,792	693,500
Stafford	14,222,743	7,179,573
Warwick	2,957,490	1,577,328
Westmoreland	940	564
Worcester	806,739	369,755
York	28,247,249	14,345,730
Total England	159,314,365	£83,881,224
Brecon	440,682	237,586
Carmarthen	1,333,880	709,317
Denbigh	2,447,092	1,407,078
Flint	662,523	380,951
Glamorgan	27,686,758	16,886,152
Pembroke	48,140	28,884
Total Wales	32,618,995	£19,649,968
Total England and Wales	191,933,360	£103,531,182

Thus it appears that of the coal raised in England in 1900 the county of Durham contributed 22 per cent., Yorkshire 17 per cent., Lancashire 16 per cent., Stafford and Derbyshire each about 9 per cent., and Northumberland 7 per cent., while of the coal raised in Wales 85 per cent. was contributed by the county of Glamorgan.

While the annual output of coal has largely increased, the quantity annually exported has more than doubled since 1875. Including coke and patent fuel expressed in the equivalents in coal, and also the coal supply shipped by steamers engaged in the foreign trade, the quantity exported was for various years as follows :—

Year.	Tons.	Year.	Tons.
1876	20,053,209	1896	44,586,811
1881	25,049,928	1898	48,266,699
1886	30,362,575	1899	55,810,024
1891	40,120,861	1900	58,405,087

Of the exports in 1900, 8,635,030 tons went to France, 5,985,161 to Germany, 5,336,157 to Italy, 4,485,416 to Sweden and Norway, 3,229,294 to Russia, 2,125,493 to Denmark, and 1,971,121 to Egypt.

Iron.—The annual output of iron ore in the United Kingdom has decreased both in quantity and value since 1881. The figures are as follows :—

Year.	Quantity. Tons.	Value.
1881	17,446,065	£6,201,068
1886	14,110,013	3,513,515
1891	12,777,689	3,355,860
1896	13,700,764	3,150,424
1897	13,787,878	3,217,795
1898	14,176,938	3,406,628
1899	14,461,330	3,895,485
1900	14,028,208	4,224,400

The iron ore raised in the various counties in 1900 was as shown in the subjoined table :—

	Tons.	Value.
Cumberland	1,103,430	£962,274
Derby	2,835	992
Devon	354	1,859
Durham	19,124	7,157
Gloucester	9,885	4,113
Lancashire	630,361	446,077
Leicester	750,708	80,242
Lincoln	1,924,898	229,456
Monmouth	13,335	4,000
Northampton	1,622,539	171,570
Nottingham	23	6
Oxford and Rutland	237,340	23,719
Shropshire	26,133	19,600
Somerset	6,139	1,459
Stafford	1,084,797	414,589
Warwick	25,911	2,037
Wiltshire	56,821	36,933
Worcestershire	6,808	2,244
Yorkshire	5,550,677	1,385,998
Total England	13,072,118	£3,794,325
Carnarvon and Denbigh	489	334
Flint	677	232
Glamorgan	6,252	3,126
Total Wales	7,418	£3,692
Scotland	849,031	408,713
Ireland	99,641	17,670
Total United Kingdom	14,028,208	£4,224,400

The number of furnaces in blast, and the quantities of pig-iron obtained, ore smelted (including imported ore), and coal used were for various years as follows :—

Year.	Furnaces in blast.	Pig-iron obtained.	Ore smelted.	Coal used.
		Tons.	Tons.	Tons.
1881	565	8,144,449	20,249,263	17,484,990
1886	399	7,009,754	17,297,483	14,249,715
1891	376	7,406,064	18,518,192	15,373,711
1896	373	8,659,681	21,204,284	17,114,374
1897	380	8,796,465	21,372,013	17,552,430
1898	378	8,609,719	20,958,167	17,196,436
1899	411	9,421,435	22,820,302	19,061,318
1900	403	8,959,691	22,100,774	18,742,022

The iron-works in operation, the furnaces in blast, and the pig-iron made in the various counties of England and Wales in 1900 are shown in the first table over leaf (fractions showing the proportion of the year furnaces were in blast). The total number of existing furnaces in 1900 was: in England 456, in Wales 42, in Scotland 106; total, 604; so that 33 per cent. of the number stood unused.

In 1888 the imports of iron ore amounted to 3,562,071 tons, in 1898 to 5,468,396 tons, in 1899 to 7,054,578 tons, in 1900 to 6,297,953 tons, in 1901 to 5,548,888 tons. In 1901, 4,749,933 tons were imported from Spain.

	Works in operation.	Furnaces in blast.	Pig-iron made.
			Tons.
Cumberland . . .	12	$25\frac{8}{12}$	856,851
Derby and Notts . .	13	$43\frac{5}{12}$	561,626
Durham	8	30	973,010
Lancashire . . .	7	$24\frac{4}{12}$	729,074
Leicester and Lincoln .	6	19	388,745
Monmouth . . .	7	$13\frac{7}{12}$	324,261
Northampton . . .	7	$13\frac{3}{12}$	247,908
Shropshire . . .	3	4	39,177
Stafford	24	$38\frac{2}{12}$	596,807
Wilts and Worcester .	4	4	74,309
Yorkshire . . .	27	$83\frac{1}{12}$	2,427,185
Total England . .	118	$298\frac{6}{12}$	7,218,953
Wales	12	$19\frac{4}{12}$	583,853
Scotland	19	$85\frac{5}{12}$	1,156,885
Total United Kingdom .	149	$403\frac{3}{12}$	8,959,691

Lead.—The quantity of lead ore produced within the United Kingdom is now less than one-half of the output of 1877, and the total value only one-fourth of what it then was. In 1877 the output amounted to 80,850 tons, valued at £1,123,952. The quantity and value of the output for various years was as follows :—

Year.	Quantity. Tons.	Value.
1881 . . .	64,702	£656,725
1886 . . .	53,420	471,295
1891 . . .	43,859	356,783
1896 . .	41,069	303,398
1900 . . .	32,010	349,094

The most productive counties are Flint, Durham, Derby, and Denbigh; the ore obtained in the Isle of Man is increased in value by the quantity of silver it contains. The output of ore, the quantity of lead and of silver obtainable from it, and the value of the ore in 1900 were as follows :—

	Lead Ore.	Lead obtainable.	Silver obtainable.	Value of Ore.
	Tons.	Tons.	Ounces.	
England . . .	13,817	10,306	43,788	£130,532
Wales . . .	12,503	9,800	67,948	147,981
Scotland . . .	1,839	1,432	10,003	24,067
Ireland . . .	8	6	36	76
Isle of Man . .	3,843	2,820	66,077	46,438
Total . . .	32,010	24,364	187,852	£349,094

Tin.—The annual output of tin ore, which in 1878 amounted to 15,045 tons, valued at £530,737, fell to 12,898 tons in 1881, though the value in that year rose to £697,444. During the years 1882–92 the average output was over 14,000 tons and its average value about £770,000, but in 1893 a decline began, as shown by the following figures :—

Year.	Tin Ore. Tons.	Value.
1893 . . .	13,689	£637,053
1895 . . .	10,612	370,530
1896 . . .	7,663	259,928
1897 . . .	7,120	254,218
1898 . . .	7,380	288,325
1899 . . .	6,392	440,509
1900 . . .	6,800	523,604

Tin ore is obtained from thirty-five mines and six quarries in Cornwall, and from refuse sand and mud on the shores and streams. The two mines which are worked in Devonshire are unimportant.

Copper.—Like others of the less important mining industries, copper mining in the United Kingdom has declined. In 1881 the output amounted to 52,556 tons, in 1891 to 9158 tons, in 1893 to 5576 tons. During the last few years (owing to a rise in the price of the metal) the output has slightly increased. The ore is obtained mostly from six mines in Cornwall and Devonshire. Copper precipitate is taken from water pumped up from old copper mines on Parys Mountain, in Anglesey.

Zinc.—Zinc ore is obtained chiefly from mines in Cumberland, Wales, and the Isle of Man. In 1881 the output reached 35,527 tons, valued at £110,043; in 1891 the output was only 22,216 tons, but its value was £113,445. In 1897 the quantity was 19,278 tons, and the value £69,134, but in 1898 the price had risen so that the output of 23,552 tons was worth £117,784. In 1900 the output of 24,675 tons was worth £97,606.

Gold.—Gold mines have been worked continuously in Merionethshire since 1888. In that year the output of auriferous quartz amounted to 3844 tons, valued at £27,300, and yielding 8745 ounces of gold worth £29,982. The annual output and value of ore and gold have been as follows :—

Year.	Ore.	Value.	Gold.	Value.
	Tons.		Ounces.	
1895	13,266	£16,584	6,600	£18,520
1897	4,517	6,282	2,032	7,185
1898	703	1,158	395	1,299
1899	3,047	10,170	3,327	12,086
1900	20,802	42,925	14,004	52,147

In 1900 there were five productive mines belonging to as many companies. It should be noted also that from imported cupreous iron pyrites, copper, gold, and silver are extracted at thirteen metal extraction works in Great Britain. From 386,858 tons of burnt ore in 1900 there were obtained 13,925 tons of copper, 1777 ounces of gold, and 309,486 ounces of silver.

Various Minerals.—The production of phosphate of lime (coprolites) in the counties of Bedford and Cambridge amounted in 1884 to 51,866 tons, valued at £103,976, but had fallen in 1900 to 620 tons, valued at £1085. Sodium is produced at Runcorn, Cheshire. Alumina, produced from clay in Antrim, is despatched to Foyers, near Inverness, where aluminium is extracted by means of electricity generated by water-power.

Textile industries.

The most important of the textile industries of Great Britain is cotton manufacture. The quantities of raw cotton imported, exported, and retained for consumption for various years since 1880 were as follows :—

Year.	Imported.	Exported.	Retained.
	℔	℔	℔
1881	1,679,068,384	207,710,608	1,471,357,776
1886	1,715,044,800	197,858,080	1,517,186,720
1891	1,994,885,312	182,008,064	1,812,877,248
1896	1,754,890,256	183,823,808	1,571,066,448
1899	1,626,246,944	283,932,768	1,342,314,176
1901	1,829,710,064	204,465,856	1,625,244,208

In 1890 there were in the United Kingdom 2538 cotton factories, of which 935 were for spinning only, 990 for weaving only, 438 for both spinning and weaving, and 175 for other operations. The number of spindles was: for spinning, 40,511,934, and for doubling, 3,992,885. The power-looms numbered 615,714. In 1890 there were 528,795 persons employed in cotton factories, 208,187 male and 320,608 female. In 1899 the total number employed was 526,107, of whom 328,406 were females. Of the 197,701 males employed, 51,059 were under eighteen years of age. Of the total number of workpeople, 496,296 were employed in England and Wales, 29,002 in Scotland, and 809 in Ireland. In the cotton manufacturing districts in England the numbers were: Lancashire, 408,090; Cheshire, 34,289; West Riding of Yorkshire, 35,209.

The extent of the woollen and worsted manufactures of the United Kingdom is indicated by the following table showing the imports and exports of wool and the quantity retained for use in various years :—

Year.	Imports.	Exports of imported Wool.	Retained.
	℔	℔	℔
1881	450,141,735	265,583,927	184,557,808
1886	596,470,995	312,000,380	284,464,615
1891	720,014,070	384,224,656	335,789,414
1896	718,537,253	334,691,803	383,845,450
1899	668,817,315	292,937,192	375,880,123
1901	692,374,231	294,213,768	398,160,463

The number of factories, spindles, and looms employed in the woollen, worsted, and shoddy industries in 1890 was as follows :—

	Factories.	Spindles.		Power-looms.
		Spinning.	Doubling.	
Woollen . .	1793	3,107,209	299,793	61,831
Worsted . .	753	2,402,922	669,328	67,391
Shoddy . .	125	94,404	691	2,284

In these industries 301,556 workpeople were employed in 1890; the number in 1899 was 256,425, of whom 106,207 were males and 150,218 females. Of the males, 24,217 were under 18 years of age; of the females, 39,268. Of the total number, 224,879 were employed in England and Wales, 28,223 in Scotland, and

3323 in Ireland. The district where woollen manufactures are principally carried on is the West Riding of Yorkshire, where the workpeople in 1899 numbered 187,079. In Lancashire their number was 10,746.

The number of flax, hemp, and jute factories, and the number of their spindles and power-looms in 1890, are given as follows :—

	Factories.	Spindles.		Power-looms.
		Spinning.	Doubling.	
Flax .	357	1,134,813	61,521	48,714
Hemp .	105	41,724	11,949	516
Jute .	116	268,165	11,874	14,107

In these industries there were employed in 1890, 162,965 workpeople; in 1899, 156,705. Of the latter number, 49,063 were males and 107,642 females. Of the males, 15,369 were under eighteen years of age; of the females, 24,533. Of the total number, 15,907 were employed in England and Wales, 72,841 in Scotland, and 67,957 in Ireland. Of those in Scotland, 48,662 were in Forfarshire and 13,369 in Fife. Of those in Ireland, 38,331 worked in the county of Antrim, and 12,654 in Down.

In 1890 there were in the United Kingdom 628 silk factories, with 846,575 spinning and 182,778 doubling spindles, and 11,464 power-looms. The number of workers in the silk factories in that year was 41,277; the number in 1899 was 35,461, of whom 10,324 were males and 25,137 females. Of the males, 2255 were under eighteen years of age. Of the whole number, 33,196 were employed in England and Wales, 2194 in Scotland, and 71 in Ireland. Of the English workers, 9882 were in the West Riding of Yorkshire, 7114 in Cheshire, and 2991 in Lancashire.

In the manufacture of hosiery in 1890 there were 257 factories, employing 24,838 workpeople. In 1899 the number of workers in this industry was 35,464, of whom 18,677 were in Leicestershire. In 1890 there were 403 lace factories, employing 16,930 workers. In 1899 there were 17,005 lace workers, of whom 8133 were in Nottinghamshire and 4724 in Derbyshire. Other textile industries are the plaiting or weaving of horse-hair, elastic, and cocoanut fibre, employing in all 9403 workers in 1899. Elastic is woven chiefly in Leicestershire, and cocoanut fibre in Suffolk.

Factory Acts.—The Factory and Workshop Acts passed in the years 1878–97 have extended the inspection of factories and workshops, and have made the regulations for their management more stringent. Provision has been made against insanitary conditions, overcrowding, danger from machinery, from fire, and from unhealthy conditions in processes of manufacture. The number of hours a day during which women or young people may be employed has been prescribed, and the registration of accidents is required. Regulations are laid down for the notification of accidents to the Government inspectors and, in the case of the more serious accidents, to the certifying surgeons as well. In 1896 the number of factories of all descriptions under the Acts was 160,948; in 1897, 178,756. In 1896 the persons employed numbered 4,483,800; in 1897, 4,398,983. The following figures show the number of accidents notified to certifying surgeons and the number (including these) notified to inspectors :—

Notified.	1896.	1897.	1898.
To surgeons .	14,433	15,987	19,227
To inspectors .	33,557	40,474	57,562

The increase in the number of notifications seems due, not to increase in the number of accidents, but to the extension of factory inspection.

Fisheries.—See article FISHERIES.

Commerce. The following table shows the value of the total imports, the exports of British produce and manufactures, and the total imports and exports (including exports of foreign and colonial produce) for recent years :—

Year.	Imports.	Exports of British Produce, &c.	Total Imports and Exports.
1881	£397,022,489	£234,022,678	£694,105,264
1886	349,863,472	212,725,200	618,822,935
1891	435,441,264	247,235,150	744,554,982
1896	441,808,904	240,145,551	738,188,118
1899	485,035,583	264,492,211	814,570,241
1900	523,075,163	291,191,996	877,448,917
1901	521,990,198	280,022,376	869,854,466

The proportion of imports and exports per head of population of the United Kingdom was :—

Year.	Imports.	Exports of British Produce.	Total Imports and Exports.
1881	£11 7 4	£6 14 0	£19 17 5
1886	9 12 8	5 17 2	17 0 10
1891	11 10 5	6 10 10	19 4 0
1896	11 3 11	6 1 8	18 14 1
1898	11 14 1	5 16 2	19 0 6
1899	11 19 2	6 10 5	20 1 8
1900	12 15 9	7 2 4	21 9 0

The merchandise most largely imported consisted of foodstuffs (corn, flour, bacon, hams, butter, sugar, tea), raw materials for manufactures (chiefly cotton and wool), wood and timber, and manufactured silk; while the chief exports are cotton, woollen, and linen manufactures, iron and steel manufactures and machinery, and coal.

In the calendar years 1899 and 1900 the values of the chief imports were :—

Imports.	1899.	1900.
Corn and flour . .	£58,037,692	£58,942,390
Bacon and hams . .	14,494,102	15,995,778
Butter	17,213,516	17,450,435
Sugar	19,163,502	20,350,147
Tea	10,620,007	10,686,910
Raw cotton . . .	27,672,399	40,982,594
Wool (with yarn). .	26,957,616	25,015,160
Wood and timber . .	25,676,988	29,071,227
Silk manufactures .	16,108,596	14,281,250

The chief exports of the produce and manufactures of the United Kingdom were :—

Exports.	1899.	1900.
Cotton manufactures—		
Piece goods, unbleached . .	£16,327,646	£16,188,594
,, ,, bleached . .	12,502,838	13,232,873
,, ,, dyed or printed .	22,028,581	22,961,179
Other cotton goods . . .	8,629,977	9,626,504
Cotton yarn . . .	8,058,866	7,741,129
Total	£67,547,908	£69,750,279
Woollen manufactures—		
Woollen tissues . . .	£5,275,691	£5,806,279
Worsted tissues . .	6,250,541	6,467,750
Tapestry, blankets, carpets, &c.	3,262,938	3,308,125
Woollen yarn	6,721,792	6,123,349
Total	£21,510,962	£21,805,503
Linen manufactures—		
Piece goods	£3,795,056	£3,851,615
Other linen goods . . .	1,277,736	1,372,979
Linen yarn	909,066	934,201
Total	£5,981,858	£6,158,795
Iron and steel—		
Pig and puddled . .	£4,785,244	£5,994,306
Bar, bolt, &c. . . .	1,229,088	1,543,143
Railway	3,127,474	3,192,067
Wire (not telegraph) . .	886,347	904,142
Tin plates	3,168,614	3,976,796
Hoops, sheets, plates . .	4,355,709	4,978,351
Cast and wrought . . .	5,779,381	6,328,154
Old iron	388,322	369,322
Steel and manufactures . .	4,380,860	4,706,394
Total iron and steel .	£28,101,049	£31,992,675
Machinery	£18,372,184	£18,167,784
Coal, cinders, and fuel . .	£23,093,250	£38,619,856

The annual value of the imports into the United Kingdom has largely increased, but there has been no corresponding increase in that of the exports of British produce and manufactures. Many industries which formerly were mainly in British hands have been developed on the continent of Europe, in America, and in the East, and the resulting commercial competition will doubtless become keener. The value of the manufactured cotton goods (exclusive of yarn) exported from the United Kingdom in 1881 amounted to £65,924,478, an amount which has not again been reached. The corresponding value in 1897 was only £54,043,633, but rose in 1900 to £62,009,150. The value of the woollen and worsted manufactures exported in 1881 amounted to £18,128,756, in 1889 to £21,324,892, but in 1900 to only £15,682,154. In 1881 iron and steel goods were exported amounting to £27,590,908, in 1890 to £31,565,337, in 1894 to £18,688,763, and in 1900 to £31,992,675. The exportation of coal has steadily increased. In

1881 the value of the shipments to foreign countries amounted to £8,785,950, in 1891 to £18,895,078, and in 1900 to £38,619,856.

The following tables show the value of the imports from the principal British possessions and foreign countries into the United Kingdom, and of the exports of the produce and manufactures of the United Kingdom to the principal British possessions and foreign countries in 1901:—

	Imports.	Exports.
British possessions—		
India	£27,391,734	£34,978,126
Australasia	34,852,936	27,013,778
British North America	20,387,330	8,143,695
West Indies and Guiana	2,280,530	2,471,529
Cape Colony and Natal	10,093,250	17,154,380
Ceylon	4,476,552	1,534,914
Straits Settlements	6,112,304	3,203,511
Hong Kong	602,841	2,612,725
Other possessions	4,253,171	7,675,743
Total	£110,450,748[1]	£104,788,401
Foreign countries—		
United States	£141,015,465	£18,393,883
France	51,213,424	16,472,068
Germany	32,207,214	23,573,785
Netherlands	32,871,843	9,089,149
Belgium	24,666,081	8,156,203
Russia	21,903,574	8,673,334
Sweden and Norway	15,352,063	7,699,985
Spain	14,040,184	4,827,110
Denmark	14,234,102	3,615,223
Argentine Republic	12,414,863	6,751,632
Egypt	11,905,646	6,314,867
Turkey	5,838,556	6,881,976
Chile	4,313,095	3,230,837
Italy	3,383,858	7,612,562
Portugal	3,305,150	1,710,829
Brazil	4,957,794	4,152,091
China (excluding Hong Kong)	2,116,119	6,773,599
Rumania	3,993,970	1,023,103
Greece	1,465,985	1,679,138
Austria	1,191,294	2,141,185
Japan	1,830,290	8,132,223
Peru	1,813,505	991,350
Philippine Islands	2,701,810	862,711
Java	212,222	2,028,473
Cuba	38,070	1,217,945
Uruguay	474,501	1,322,968
Other countries	6,325,814	11,905,746
Total	£416,416,492	£175,233,975
Grand total	£526,867,240[1]	£280,022,376

The customs revenue collected in the three divisions of the United Kingdom in 1900 and 1901 was as follows:—

	1900.	1901.
England and Wales	£20,752,353	£26,228,335
Scotland	2,305,259	2,990,814
Ireland	2,249,113	2,342,038
United Kingdom	£25,306,725	£31,561,187

Of the customs revenue in 1901, about 42 per cent. was collected at the port of London, 58 per cent. at London and Liverpool, and 73 per cent. at five ports. As customs duties are levied on few articles, the amount received at different ports is not proportional to the volume of their trade. The following list comprises the names of all the ports or places in the United Kingdom where the customs receipts amounted to £150,000 in 1900 or 1901:—

Port.	1900.	1901.
London	£11,388,560	£13,249,155
Liverpool	4,174,793	5,011,837
Bristol	1,886,808	2,321,596
Glasgow	1,408,760	1,435,087
Belfast	1,264,828	1,158,358
Leith	474,714	715,223
Dublin	633,042	707,295
Newcastle and Tyne ports	380,460	695,878
Cardiff	36,999	490,097
Hull	135,901	380,435
Nottingham	385,794	378,538
Manchester	188,455	291,790
Newhaven	222,713	260,218
Dundee	147,003	189,593
Harwich	139,122	171,268
Greenock	35,909	169,467
Sunderland	101,996	162,336

During recent years there has been a great development of the shipping movement of the United Kingdom. Since 1881 the tonnage entered and cleared at British ports from and to foreign countries and British possessions has increased by about 68 per cent. The tonnage of British vessels employed in the carrying trade between the United Kingdom and foreign countries has increased by about 51 per cent., and that of foreign vessels by about 110 per cent., but the absolute increase in the British tonnage so employed exceeds that of the foreign. The British and foreign vessels (both sailing and steam) that entered and cleared from and to foreign ports and British possessions in 1881 and in every subsequent fifth year were in aggregate tonnage as follows:—

Year.	Entered.		
	British.	Foreign.	Total.
	Tons.	Tons.	Tons.
1881	20,437,035	8,081,980	28,519,015
1886	22,741,061	8,294,557	31,035,618
1891	26,637,187	10,221,828	36,859,015
1896	30,881,919	11,595,540	42,477,459
1901	31,336,644	17,264,372	48,601,016
	Cleared.		
1881	21,106,224	8,324,306	29,430,530
1886	23,337,238	8,468,221	31,805,459
1891	27,320,248	10,633,357	37,953,605
1896	31,182,416	11,802,547	42,984,963
1901	31,453,197	17,296,800	48,749,997

In 1881 steam vessels engaged in the foreign and colonial trade entered British ports to an aggregate tonnage of 19,268,327, of which a tonnage of 16,038,726 consisted of British steamers; in 1901 the steam vessels that entered had a total tonnage of 44,936,305, of which 30,272,229 tons represented British steamers.

In the coasting trade in 1901 the total tonnage that entered at ports of the United Kingdom amounted to 55,809,105, of which 50,176,941 tons represented steam vessels; the total cleared, 54,454,183 tons, of which 48,926,672 tons belonged to steamers.

The tonnage of the vessels engaged in the foreign and colonial and coasting trade that entered and cleared at the principal ports of the United Kingdom in 1901 was as follows:—

Port.	Entered.	Cleared.	Total.
	Tons.	Tons.	Tons.
London	15,952,453	15,204,882	31,157,335
Liverpool	9,704,160	9,671,604	19,375,764
Cardiff	9,290,785	9,498,557	18,789,342
Tyne ports	8,491,535	8,299,793	16,791,328
Glasgow	3,757,271	4,022,149	7,779,420
Hull	3,102,869	2,935,975	6,038,844
Southampton	2,892,346	2,793,171	5,685,517
Sunderland	2,468,933	2,583,929	5,052,862
Dublin	2,422,125	2,419,171	4,841,296
Cowes	2,104,396	2,104,150	4,208,546
Newport	2,102,028	2,097,878	4,199,906
Greenock	1,963,030	2,121,478	4,084,508

The number and gross tonnage of the registered sailing and steam vessels belonging to the United Kingdom were as follows at the end of each of the years named:—

Year.	Sailing Vessels.		Steam Vessels.	
	Number.	Gross Tonnage.	Number.	Gross Tonnage.
1886	16,179	3,512,783	6653	6,321,504
1891	13,823	3,108,379	7720	8,545,252
1896	12,274	2,909,296	8522	10,237,703
1901	10,572	2,135,265	9484	12,472,584

These figures show, not only that steamers have been rapidly taking the place of sailing vessels, but also that large steamers are preferred to small, their average tonnage having increased from 950 tons in 1886 to 1315 in 1901.

Shipbuilding is carried on principally on the Tyne, at Sunderland and Hartlepool, on the Clyde, and at Belfast. In the year 1901 there were finished (exclusive of vessels for the navy and vessels for foreigners) 567 sailing vessels of an aggregate tonnage of 54,967, and 637 steamers of, in all, 720,714 tons net, the total net tonnage of the new vessels being thus 775,681, the largest turn-out of any former year having been that of 1883, when the corresponding amount was returned as 768,576 tons. Of the steamers finished in 1901, 31, of 73,277 tons net, were built at

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[1] This total includes the value of the diamonds exported from Cape Colony to Great Britain.

East and West Hartlepool; 58, of in all 132,284 tons net, at Sunderland; 99, with an aggregate net tonnage of 141,982, at the Tyne ports (Newcastle and North and South Shields); 151, of altogether 217,008 tons net, on the Clyde, and 9, of 38,568 tons, at Belfast. For foreigners there were built 10 steamers, of, altogether, 11,000 tons net, for war purposes, and 71 sailing vessels, of 6696 tons, and 113 steamers, of 189,756 tons net, for mercantile purposes. The total net tonnage (exclusive of vessels for the British navy) completed during the year thus amounted to 983,133 tons. In the Board of Trade returns the value of the vessels built for foreigners in 1901 is put at £9,149,444.

Post Office.—See Post Office.

Telephones.

The telephone came into use in 1879, and soon afterwards two companies were formed to establish telephone exchanges or offices whence lines should extend to the offices of subscribers. The proceedings of these companies were declared to be an infringement of the Post Office monopoly in the transmission of telegrams, but an arrangement was made whereby licences were granted to the companies to carry on the work of telephone exchanges in London and in various provincial towns, while the Post Office established exchanges in other places. This arrangement proved unsatisfactory, and in 1892 an Act was passed providing for the purchase by the Post Office of the trunk lines belonging to the companies, and for the restriction of the companies' operations to local areas. After about four years' negotiation the agreement for the transfer was signed 25th March 1896, and on 6th February 1897 the transfer was completed. The price paid to the National Telephone Company was £459,114. The length of trunk line transferred was 2651 miles, and the length of wire was 29,000 miles. The Post Office had erected 19,620 miles of trunk wire, and had in course of construction 4180 miles of trunk wire, so that in 1897 it had in all 52,800 miles of trunk telephone wire, and for trunk telephone business 243 post offices were open. On 31st March 1902 the number of post office trunk wire centres was 328; the trunk circuits in use numbered 1165, and contained 98,000 miles of wire, the total amount of capital expenditure on the purchase and development of the system having been £1,896,650. During the year 1901–02 the number of trunk wire conversations was 10,080,716, involving at least 20,161,432 spoken messages, and the revenue therefrom amounted to £238,720. At the end of March 1902 the number of contracts in existence for Post Office telephone exchange wires and for private telegraph wires was 6151; the mileage of such wires was 41,207; the instruments numbered 15,432, and the rentals for the year amounted to £182,143. Under the Telegraph Act, 1899, works necessary for the establishment of a Post Office exchange system in the London area were undertaken, and on 24th February 1902 the central exchange was opened. The capital outlay up to 31st March 1902 was £795,846.

The licence held by the National Telephone Company (granted for 31 years) will expire in 1911. The company pays to the Post Office department a royalty of 10 per cent. of its gross receipts, the amount of the royalty in 1901–02 having been £149,910. At the end of the year 1901 the company in its various local areas had 219,849 telephone stations (or instruments), which worked through 1019 exchanges, the number of public call offices open being 2610. Of the exchanges, 762 were working as metallic circuit exchanges, and the rest were in process of conversion. During the year 1901 the number of messages was 723,000,000, or an average of about 2,410,000 for each working day. In the London metropolitan area the company had 46,364 telephone stations (or instruments), 51 exchanges, and 909 public call offices. The number of messages in London in 1901 was 125,000,000. In November 1901 a fresh agreement was made between the Post Office and the National Telephone Company providing for intercommunication between subscribers to the systems of the company and the Post Office in the London area.

(For Banking, Savings Banks, &c., see separate articles.)

Authorities.—The following publications relating to the United Kingdom are issued annually in London:—*Finance Accounts; Financial Estimates; Return showing Revenue and Expenditure* (*England, Scotland, and Ireland*); *National Debt during 60 Years; Local Taxation Returns; Army Estimates; Army Returns; Army List* (quarterly); *Navy Estimates; Navy List* (quarterly); *Mineral Statistics; Reports of Inspectors of Mines; Reports on Factories and Workshops; Reports of Inspectors of Fisheries; Return of Fish conveyed inland by rail; Statement of the Trade of the United Kingdom; Statement of the Shipping and Navigation of the United Kingdom; Report of the Postmaster-General; Statistical Abstract for the United Kingdom.* Among books may be mentioned the following:—Anson. *The Law and Custom of the Constitution.* 2 vols., 2nd ed. Oxford, 1892–96.—Boutmy. *Le Developpement de la Constitution et de la Société politique en Angleterre.* 2nd ed. Paris, 1897. [Of this there is an English translation (from 1st ed.) by I. M. Eaden. London, 1891.] *Études de Droit Constitutionel, France, Angleterre, États-Unis.* Paris, 1885. [English translation by E. M. Dicey. London, 1891.]—Brassey. *The Naval Annual.* Portsmouth, 1886 onwards.—Clowes and other writers. *History of the Royal Navy.* London, 1896–1901.—Dicey. *Introduction to the Study of the Law of the Constitution.* 5th ed. London, 1897.—Eardley-Wilmot. *Our Fleet To-day and its Development during the Last Half Century.* London, 1900.—Fortescue. *History of the British Army.* London, 1899.—Gastrell. *Our Trade in the World in relation to Foreign Competition, 1885–1895.* London, 1897.—Giffen. *Essays in Finance.* London, 1880 and 1886.—Gneist. *Das Englische Parlament in tausendjährigen Wandelungen.* Berlin, 1885. [Translated into English by A. H. Keane. *History of the English Parliament.* London, 1889.] *Englische Verfassungsgeschichte.* Berlin, 1882. [Translated into English by P. A. Ashworth. London, 1891.]—Hull. *Our Coal Resources at the Close of the Nineteenth Century.* London, 1897.—Rogers. *Industrial and Commercial History of England.* London, 1892.—Seeley. *The Growth of British Policy.* 2 vols. London, 1895.—Taylor. *The Origin and Growth of the English Constitution.* 2 vols. London, 1889–99.—Todd. *Parliamentary Government in England.* New edition revised by S. Walpole. 2 vols. London, 1892. (I. P. A. R.)

United Provinces. See North-Western Provinces and Oudh.

UNITED STATES.

I. Physical Features.

THE natural resources and climate of the United States are treated at length in *Ency. Brit.* vol. xxiii. (ninth edition) (see also America, vol. xxv.). We have here to deal chiefly with the physical features in the light of recent physiographic researches.

The Superior oldland.

An outlying upland of the Laurentian highlands of Canada projects into the United States west and south of Lake Superior. Although composed of greatly deformed rocks, chiefly of crystalline texture, the upland as a whole is gently rolling, and the inter-stream surfaces are sometimes plateau-like in their evenness, with altitudes of from 1400 to 1600 feet in the higher portions. The uplands are occasionally surmounted by low hills of particularly resistant rocks. Here, therefore, we find one of those ancient mountain regions reduced by long-continued erosion to a surface of moderate relief. The erosion of the region must have been well advanced in very ancient times, for the denuded surface is bordered by the overlapping marine fossiliferous strata of early geological date (Cambrian), which imply a depression of the region beneath an ancient sea subsequent to a long existence as dry land. After renewed elevation of moderate measures, erosion in later periods gently bevelled the ancient land in producing the even skyline of to-day. The valleys by which the uplands are here and there trenched indicate another uplift of still more modern date. Glaciation has strongly scoured away the deeply-weathered soils that presumably existed in pre-Glacial time, revealing firm and rugged ledges in the higher parts and spreading an irregular drift cover over the lower parts, whereby the drainage is much disordered, here being detained in lakes and swamps (muskegs), there rushing down rocky rapids. The region is therefore uninviting to the farmer, but it is attractive to the lumberman and to the miner. Native copper is found on Keweenaw Point, on the southern side of Lake Superior; and abundant iron ores, exploited in recent years, have greatly affected the iron industry of the United States. The Adirondack mountains of northern New York are of similar history, but they do not seem ever to have been so well worn down as the ancient mountains of the Superior region, and to-day they present rather strong relief, although without sharp peaks (Mount Marcy, 5344 feet). Their rugged rocky surface, heavy forests, and abundant lakes make them natural preserves of wild game and a noted summer resort. Much timber has been cut from them, but systematic effort is now directed towards the better conservation of the forested areas.

Region of the Great Lakes.

The Palæozoic strata which lap upon the southern slope of the Superior oldland are but part of a great area of similar strata, hundreds of feet in thickness, which decline very gently southwards from their overlap upon the Laurentian oldland of Canada. They represent the deposits of an ancient sea whose floor was provided by the submergence of a still more ancient land. Since the elevation of the region, and the addition of the sea-bottom sediments to the continental area, they have been much eroded, and hence do not now retain their original extent. As is always the case in the broad denudation of gently-inclined stratified structures, the weaker layers are worn down in subparallel belts of lower land between the more resistant strata which rise in uplands. The firm Niagara limestone makes one of these uplands; it may be traced on a curving course from western New York, where it separates the lowlands that contain the basins of Lakes Ontario and Erie, through the province of Ontario to the belt of islands that separates Georgian Bay from Lake Huron, thence westwards and southwards to along the narrow strip of upland that divides Green Bay from Lake Michigan in eastern Wisconsin, and finally across southern Wisconsin and into north-eastern Iowa. The arrangement of the Great Lakes is thus seen to be closely sympathetic with two belts of weaker strata: Ontario, Georgian Bay, and Green Bay occupying depressions in the lowland, on the oldland side of Niagara upland; Erie, Huron, and Michigan lying in depressions in the lowland on the other side of the same upland. Lake Superior is an exception to this statement; it lies in the oldland, as if occupying a basin of local deformation. This is a most fortunate though unsystematic extension of the Great Lakes, for thereby the wheat of the north-western prairies, the lumber from the forests, and the copper and iron ores of the Superior oldlands are given cheap transportation to the more eastern states; the freight that passes through the Sault Ste Marie ship canal between Lakes Superior and Michigan exceeds in tonnage, if not in value, that which goes through the Suez Canal.

Middle Appalachians.

The middle Appalachians, in Pennsylvania, Maryland, and northern Virginia, may be divided into two belts; one chiefly of crystalline rocks on the south-east, the other of heavy Palæozoic strata on the north-west. Both belts have been greatly deformed, and both were doubtless strongly mountainous for a long period after the time of deformation; but that was so long ago that they have been reduced to a peneplain or lowland of mild relief by subsequent (Mesozoic) erosion. A general elevation occurred in Tertiary time, of greater measure to the north-west (inland) than to the south-east (near the coast), in consequence of which the weaker strata have been etched out of the uplifted lowland to form lower lands of a second order, while the resistant rocks still exhibit uplands and long even-crested ridges, 1000 to 2500 feet in height, whose altitude indicates more or less closely the uplift given to the peneplain of the previous cycle of denudation. The belt of stratified rocks exhibits a peculiar large-scale zig-zag pattern in its ridges and valleys, somewhat similar to the lines seen on a weather-beaten board of irregular grain. This is the present geographical consequence of the huge wave-like folds into which the strata were long ago crushed. The ridges are cloaked with coarse stony waste and are given over to tree growth; the lowlands between them are generally occupied by farms whose soil is especially fertile when the underlying rocks are limestones. Some of the valleys between the ridges contain the important deposits of anthracite coal for which Pennsylvania is famous. The chief streams and rivers of the region have eroded deep notches or "gaps" through hard strata of the ridges, during the etching of lowlands on the adjoining weaker strata; hence the drainage lines have a rectangular pattern, changing from longitudinal paths in the valleys to transverse paths through the ridges.

The dissected uplands of the crystalline belt are of moderate height, because the uplift of this belt since its peneplanation has been of moderate measure. Along its north-west side the hills are high enough to make occupation difficult; the stony slopes are left forested, while the more even uplands are cultivated in isolated farms. On the south-eastern side of the crystalline belt, where its uplift was small, the rolling hills are usually cleared and occupied by farms and villages. Near the line of the Delaware river between Trenton, N.J., and Philadelphia, Pa., the uplands decrease in height till they dip underground, and thenceforward to the south-east they are covered by the later strata of the coastal plain.

Appalachians of the north-east and south-west.

The belt of stratified rocks in the Appalachians becomes less mountainous north-east of Pennsylvania and south-west of Virginia, because its resistant members there weaken or thin out more or less completely. It is therefore generally worn down to a lowland, known as the Champlain–St Lawrence valley, inland from New England; and as the valley of east Tennessee, inland from North Carolina. These two lowlands are indeed connected by some of the etched lowlands between the ridges of the middle Appalachian section described above; and the continuous depression stretching from Lake Champlain to Alabama is commonly called the Great Appalachian valley. Conversely, the belt of crystalline rocks broadens from its middle to the north-east and south-west; and in New England and North Carolina it forms extensive uplands—parts of the uplifted peneplain of the previous cycle of erosion—which gradually ascend inland from their lower border near the sea. The uplands are much dissected by valleys, in which many of the villages and towns are situated. Over the uplands in the interior rise the White Mountains of New England and the Black Mountains of North Carolina, unconsumed remnants of a once much loftier and more extensive mountain system. They include many dome-like summits between 5000 and 7000 feet in height (Mount Washington, N.H., 6293 feet; Mount Mitchell, N.C., 6711 feet). Their slopes are seldom precipitous, and are usually covered by dense forests; but the White Mountains rise somewhat above the tree line. In New England, where the sloping uplands descend gradually to the sea, the coast is of irregular outline, on account of a slight submergence after the erosion of the upland valleys; many low rocky headlands and islands are separated by inreaching arms of the sea. On the other hand, the eastward slope of the broad crystalline uplands that are piedmont to the mountains of southern Virginia and North Carolina leads forward to the coastal plain of the southern Atlantic states. The loss of breadth in the crystalline belt about Philadelphia—that is, midway between the broader and mountainous crystalline areas of New England and North Carolina—is probably only apparent. It is due to a greater depression in the middle than to the north-east or south-west after the region had been worn down to a peneplain, as above described. By reason of this depression, the sea overlapped the former land area more here than elsewhere; and when elevation afterwards revealed the deposits of the overlapping sea in the coastal plain from New York southwards, the crystalline belt remained very narrow about Philadelphia. It is a highly significant fact that the important Atlantic cities—New York, Philadelphia, and Baltimore—all lie on the border of the narrowest part of the crystalline belt, where its reduced width and height offer the least obstruction to traffic between the coast and the interior; while the mountains of the crystalline belt in the north-east and south-west are effective barriers to movement; it is in spite of the hilly uplands, and largely on account of early settlement and shorter distance to European ports, that Boston has maintained its high position among the Atlantic cities.

The coastal plain.

After the general wearing down of the ancient Appalachian mountains, a portion of the lowland thus produced was depressed beneath the sea on the south-east, and there received as marine sediments the waste from the neighbouring mainland. North-east of New York City, a later movement of depression has allowed still further encroachment of the sea on the land, producing the New England harbours; but south-west of the same point the later movements were uplifts, and the sediments of the sea floor have been revealed in a broadening coastal plain that gives character to the border of the southern Atlantic and Gulf states. By these uplifts the mountains of North Carolina have gained an additional measure of height, while the northern depression has correspondingly lowered the mountains of New England. If this balancing movement had been reversed, it might have added a thousand feet to the height of the White Mountains, which would then bear small glaciers, while now they are completely bare of snow in summer, except for a few lingering drifts in certain high ravines. The different parts of the southern coastal plain exhibit a good variety of the features that usually characterize such structures. In South Carolina, for example, where the plain is about 100 miles wide, the extension of the rivers from the crystalline oldland across the plain in the general direction of its slope, and the growth of numerous river branches on the plain itself, have produced many valleys whereby the plain has been more or less completely converted into a hilly region, especially along its inner half; only the coastal border, where the uplift is more recent and of lesser height, still retaining a smooth surface. The plain is thus irregularly divided into many transverse hilly strips or "interfluves," that extend with decreasing height from the oldland towards the shore. A similar arrangement is found in the much wider Texan portion of the coastal plain. In Alabama, where the plain is over 150 miles wide, another style of dissection has resulted from the occurrence of a series of particularly weak calcareous strata at the base of the coastal plain series, followed by more resistant sandy strata in the middle. The former are eroded to a lowland of fertile soils along the inner side of the plain, while the latter retain in the "Chunnenugga ridge" much more of their original height of uplift, falling off to the inner lowland by a relatively strong infacing slope, and descending very slowly to the coastal lowland. The inner lowland is the cotton belt of the state. Here the long rivers from the oldland on the north and the short streams from the infacing slope of the "ridge" unite to discharge their waters by a river that traverses the upland belt on its way to Mobile Bay. The narrowing plain in New Jersey exhibits a similar arrangement of relief, but of less strength; the inner lowland is underlaid by plastic clays, supporting many potteries: it has long been a line of travel between New York and Philadelphia. The enclosing upland consists of sandy layers with some marl beds which are used as fertilizers all along the upland. The outer slope descends slowly to the sea, and is largely occupied by "pine barrens" on an infertile sandy soil; here, as in other borders of the coastal plain, artesian wells afford excellent water. This longitudinal arrangement of relief is like that by which the Niagara upland and the lowlands of the Great Lakes are determined, as above described; it is well known in many parts of the world, as in central England and north-eastern France, yet it has received no general name by which its features may be easily brought to mind, unless it may be called a belted coastal plain, or a coastal plain of longitudinal relief. Florida is an extension of the coastal plain—low and level, or gently undulating. Its calcareous strata contain many shallow lakes without outlet. Calcareous phosphates, promising to be of increasing value as the soils of northern prairies require fertilizers, occur abundantly here and in other low borders of the coastal plain. In its southern extremity Florida has been lengthened by the addition of fringing coral reefs and mangrove swamps. The mild climate of the peninsula induces the cultivation of semi-tropical fruits, but this is occasionally interfered with disastrously by the arrival of a "cold wave" in winter, with temperature just below freezing-point.

Certain parts of the coastal plain have been slightly depressed since their dissection, thus decreasing their breadth, drowning the lower valleys into bays of irregular outline, much valued as fishing grounds and oyster beds, and greatly shortening the rivers, while the dissected interfluves form peninsulas fringed with low headlands. Delaware and Chesapeake Bays, the lower part of what is called "Potomac river," with several other estuaries in "tide-water Virginia," and the large sounds, Albemarle and Pamlico, in North Carolina, are thus explained. Elsewhere the plain is usually bordered by off-shore sand reefs, enclosing shallow salt-water lagoons or tidal marshes. Where the tides are weak, as in the Gulf of Mexico, the sand reefs extend without interruption for scores of miles, as along the Texas coast. Where the tides have a medium value, the reefs are broken, at distances of 10 or 20 miles, by inlets, kept open by flood or ebb currents, as along the New Jersey coast. Where the tides are somewhat strengthened in a re-entrant of the coast, the inlets are numerous, becoming so close together that the reefs are inconspicuous, as on the coast of South Carolina; here the transverse action of tidal currents seems almost to gain the ascendancy over the 'long-shore movements by which the smooth outline of the reefs is elsewhere controlled. All the tidal inlets are shallow and their channels are embarrassed by shifting bars; hence they do not afford convenient entrance to harbours. A few exceptional forms of shore line are found in the cusp-like capes of the North Carolina coast, where the concave sand reefs of the intervening bights unite in sharp points projecting into the sea. The cusps are evidently formed and continuously maintained by the action of sea waves and currents, for otherwise their weak sandy points would soon be worn back by the attack of the sea. The controlling cause of their form is believed to be a series of slowly eddying currents between the Gulf Stream and the mainland, the prevalent 'long-shore movement being to the south-west in each bight, and the cusps occupying what would otherwise be dead-water triangles between adjacent eddies. Cape Canaveral, on the eastern coast of Florida, seems to be of similar origin.

The Alleghany plateau.

The same series of Palæozoic rocks that is folded in the Appalachians remains almost horizontal north-west of the mountains, sharing, however, the uplifts of Tertiary time. Originally a broadly continuous plateau gradually decreasing in height westwards, the surface is now elaborately dissected by the valleys of irregularly-branching streams, leaving a multitude of hills, with altitudes of from 2000 to 4000 feet near the Appalachians, and local relief of quarter or half that height, but declining in strength westwards. This rugged country is known as the Catskill Mountains in New York, the Alleghany plateau in Pennsylvania and West Virginia, and the Cumberland plateau in Kentucky, Tennessee, and northern Alabama; the second name is here used for the whole area. The valleys branch intricately between the hills and spurs, giving the impression of an orderless maze. Here, if anywhere, one may be convinced of the origin of valleys by the erosive action of their streams; for, as John Playfair wrote a hundred years ago, every stream runs in a valley proportionate to its size, and all the streams unite to form a system of valleys communicating with one another and having so nice an adjustment of their declivities that no branch joins a main valley at either too high or too low a level—"a circumstance which would be infinitely improbable, if each of these valleys were not the work of the stream that flows in it." The general absence of either broad uplands or open lowlands and the prevalence of steep-sloping hill-sides has made the occupation of the dissected plateau difficult. There are few stretches of level ground adapted to agriculture; every detached farm on an upland requires its own road from the valley, difficult to construct and expensive to maintain; the valley floors are narrow and exposed to floods that rise rapidly, so that bridges are often swept away, the building of stronger ones being beyond the means of the scattered population. The higher parts of the dissected plateau remain relatively a wilderness between the greater population of the coastal lands and the interior prairies, and the people are generally poor and slow of progress; in the more remote districts, as yet not invaded by transverse railways, the people have been well called "our contemporary ancestors," so largely do they retain old-fashioned habits of action and speech. They call themselves "mountaineers," in distinction from the dwellers in the open lower country. The great area of forest brings lumbermen to the hills and saw-mills to the valleys; in western Pennsylvania the coking coals are of immense value in iron-works; rock oil and natural gas have been actively exploited; and here a large industrial population has gathered, Pittsburg being a city of altogether exceptional size in the plateau country. In West Virginia, Kentucky, and Tennessee, the abundant coal beds are only beginning to be worked extensively, and the fuller development of that part of the plateau country is left to the future.

The northern glaciated area.

Although the Glacial period is usually supposed to concern the geologist, still the effects of glacial action are manifest in many geographical features over the country north of the Ohio and east of the Missouri rivers. The dissected uplands around Lake Superior and in New England have been made more rugged, as we have seen, by the scouring off of the soil with which they were probably covered in pre-Glacial times, and the drainage has been much obstructed by the irregular distribution of Glacial drift; hence the streams are held back in numerous lakes or turned into new courses, where they rush or fall over rocky ledges. Lower lands have on the other hand been made less rugged, partly by wearing away their more salient pre-Glacial forms, partly by blanketing them with drift of sub-Glacial origin (*till*), as in the district bordering the Great Lakes (except Superior) on the south; here the drift surface is continuous and nearly level for many miles together, while the underground rock floor has low hills and shallow valleys, as has been proved by numerous borings for gas and oil. In some districts the sub-Glacial drift or till was accumulated in arched hills of lenticular form one or two hundred feet high, known as "drumlins," giving the landscape a well-specialized appearance, as in parts of south-east Wisconsin, western New York, and southern New England. Boston harbour is characterized by drumlin islands, cliffed by the waves. A complexity in the Glacial period is proved by the greater or smaller erosion suffered by the till sheets of different districts; thus in the prairies of northern Missouri and southern Iowa what was once a plain of till is now well dissected, even by small streams and rivulets; this till is referred to an early Glacial invasion; elsewhere the till retains its initial surface little changed, except where trenched by the narrow valleys of the larger streams, as in the prairies of northern Illinois and Iowa, and over much of Minnesota; this till sheet is taken to be the deposit of the latest Glacial epoch. The inter-Glacial epoch, between the two invasions represented by these till sheets, was much longer than the current post-Glacial epoch.

The front of the latest ice sheet (best known because its records are least changed) was lobate, in consequence of the faster advance of the ice along the lowlands that led from its Canadian source, and of its retarded movement over the intervening higher lands. The occurrence of large lakes in close relation to the several ice lobes of the Glacial front has given ground for ascribing the lake basins in greater or lesser degree to Glacial erosion. Successive terminal moraines were formed around and under the lobate margin of the ice at its farthest advance and during halts in its final retreat. The moraines are belts of low hills enclosing undrained hollows; they are often several miles in breadth, and sometimes over a hundred feet in local relief, with increasing strength on the interlobate cusps; they are frequently the only interruptions of the monotonous expanse of the prairies. Small lakes are numerous in the moraines of northern Indiana and throughout Minnesota. During the presence of the ice sheet the streams that ran away from the ice margin were charged with gravel and sand, with which they filled or aggraded their valley floors; after the ice retreat the streams trenched the valley gravels, producing terraces, such as are common from Ohio eastwards to New England. On the other hand, the rivers that flowed towards the ice sheet from the unglaciated country on the south were more or less disordered. It frequently happened that such rivers were constrained to flow along the ice margin; temporary marginal lakes were thus formed in the obstructed valleys, and new channels were cut by the deflected rivers through the hills of the pre-Glacial interfluves, ultimately draining the marginal lakes. It is believed that the present courses of the middle Ohio and of the lower Missouri rivers were thus in great part determined. Many of the ice margin lakes were small and short-lived; their silty deposits are unimportant; but in the later stages of retreat, when the ice sheets had evacuated the Great Lakes lowlands, but still obstructed their north-eastern discharge, vast bodies of standing water gathered in front of the ice margin, overflowing by the lowest passes through the uplands on the south, and carving large channels on their way to the Mississippi. Many short channels of this kind are known among the hills of the Alleghany plateau in western Pennsylvania; an important channel of the same class is now followed by the Chicago drainage canal and Illinois river, and one of the longest and largest channels is that adopted by the existing Minnesota river. The silt deposited in the vast ice marginal lakes forms rich and smooth prairies to-day, as in the great plain of the Red River of the North, stretching from Minnesota and North Dakota into Manitoba, and again around the southern borders of Lakes Erie and Michigan. It was only as a farther retreat of the ice front opened an eastward discharge of the marginal lakes that Niagara river came into existence; hence the length of the gorge that it has cut from the north-facing bluff of the Niagara upland back (southwards) to the present cataract has been taken as measuring post-Glacial time (see NIAGARA FALLS). In these, and in very many other ways, the Glacial period was directly or indirectly responsible for numerous existing geographical features.

The Mississippi valley.

A slight warping of the continental mass, by which an axial trough was established between the broad slopes from the higher lands on the east and west, resulted in the formation of a vast river system of which the Mississippi is the trunk, with the Ohio and Tennessee as chief branches on the east, and the Missouri, Arkansas, and Red on the west. The area of the basin is 1,240,000 square miles, and the actual river length from mouth to farthest head (in Montana, at the source of the Missouri) is over 4000 miles. The medial portion of this vast basin is often spoken of, rather vaguely, as the "Mississippi valley." On the east it begins with the glaciated uplands of Wisconsin; then follow the prairies of Illinois in the glaciated area; the hilly uplands of western Kentucky and Tennessee, gradually descending from the Alleghany plateau; and the greater embayment of the southern coastal plain in westernmost Tennessee, Mississippi, and Louisiana. On the west the "valley" begins with the oldlands of Minnesota (Lake Itasca, a small lake among morainic hills, here gains a fictitious importance because the name "Mississippi" is carried all the way up to it, while many other head-waters of equal intrinsic importance and at greater distance from the Mississippi mouth are left unmentioned); the prairies on the smooth and rolling younger and older drift sheets of Minnesota, Iowa, and Missouri; the Ozark plateau in southern Missouri and northern Arkansas, very similar in history and form to the less rugged parts of the Alleghany plateau; the Ouachita (Washita) Mountains of central Arkansas and Indian Territory repeating many features in the history and topography of the stratified belt of the Appalachians; and, finally, the southern coastal plain.

In the earlier accounts of the United States much emphasis was given to the economic value of the navigable members of the Mississippi system, on account of their great length and their penetration to great distances inland; but with the enormous development of railways, especially on the prairies and plains of the interior, river transportation has taken a subordinate place. It is still of importance along the trunk river from St Louis to New Orleans, and of service for local traffic on the branch rivers; but the Mississippi and its larger tributaries are to-day rather hindrances than aids in commercial movement, on account of the great expense involved in bridging their broad waters. The upper Mississippi and its branches follow valleys from one to five miles wide that have been eroded in drift and the underlying rocks; they are therefore of modern date, and many of them gained their present form while the local river volume was increased during the ice retreat by the overflow of the great ice-margin lakes, as already described. Throughout the northern part of the system the flood-plains are relatively narrow; but the lower Mississippi, below Cairo, Ill., traversing the great re-entrant of the southern coastal plain, has eroded a broad valley in the weak strata that it there encounters, forming a flood-plain that is from 20 to 60 miles in width; the plain being enclosed by the uplands of the coastal plain, on which cities are built wherever the great river swings against the marginal cliffs—Memphis, Vicksburg, Natchez, and Baton Rouge thus standing on the cliffs of the eastern uplands, and Helena on the western. The mighty river meanders freely on the flood-plain, constantly wearing away its outer bank, shifting its course laterally, and thus frequently cutting through the narrowing neck of land that separates two bends. A well-defined channel, often over 80 feet deep, is maintained near the outer side of the curves, but the stretches or tangents between the curves are obstructed with shifting shoals, making navigation difficult. As in all flat-floored valleys, the deposit of silt at time of flood, chiefly in the neighbourhood of the main channel, causes the flood-plain to slope gently away from the main river at a rate of 5 or 10 feet to the mile. Hence the flood-plain settlements are close along the river front; but New Orleans is the only large city thus situated. The sides of the plain are frequently swampy, and not yet brought into cultivation, nor can they safely be utilized until a greater mastery of the river is accomplished by the completion of the system of levees (dykes) near its banks. Much of the plain is forested; the soil is very fine and rich, and where the surface is high enough, or well enough protected by levees, it is cultivated and yields abundant crops of cotton and sugar-cane. Occasional high floods are still extremely destructive; that of 1897 covered 13,000 square miles of the plain, destroying property worth at least $15,000,000. The flood waters spread over and flow down the back swamps, returning to the main channel perhaps hundreds of miles below the points of chief overflow.

The delta of the Mississippi is strongly digitate in outline and determined by the outflow of several distributaries or outgoing branches, whose mouths or "passes" lead to the gulf. One of the passes has been extended by the construction of artificial jetties, thus strengthening the current and increasing the depth of the water to serve the needs of navigation. The volume of river discharge is 75,000 cubic yards a second; it annually bears to the gulf 406,250,000 tons of suspended sediment, and 112,832,000 tons of materials (chiefly limestone and salt) in solution.

The Great Plains, standing at altitudes of from 3000 to 6000 feet at the base of the Rocky Mountains, slope very gradually eastwards for two-thirds of the distance to the

Mississippi river, where they merge into the several districts already described as composing the western side of the "Mississippi valley." The plains extend far northwards into Canada, but narrow rapidly southwards in Mexico. This belt of the continent remained beneath sea-level until a late geological period, maintaining marine connexion between the Gulf of Mexico and the Arctic Ocean. The sediments there gathered were received largely from the waste of the mountains on the west, for the strata become thicker and coarser in that direction. The broad uplift of these marine strata produced the plains, with alternating conditions of erosion and deposition: the rivers from the mountains sometimes acted as destructive agents, denuding the uplifted surface; sometimes as constructive agents, spreading the mountain waste far and wide in fluviatile deposits; broad and shallow lakes are thought to have been formed in areas of slight depression, and here fine sediment was gathered, of special interest from the numerous vertebrate fossils which it has preserved. The surface features of the Great Plains include a large variety of forms, although on the whole presenting the broad vistas to which their name is due. In North and South Dakota they are diversified by stony moraines of the Laurentian glacier. In Montana the neighbourhood of the Rocky Mountains is varied by forms of volcanic origin, including dissected volcanoes (Bearpaw Mountains), networks of dykes upholding horizontal strata elsewhere worn away (Crazy and Highwood Mountains), or isolated dykes and lava-capped mesas. Lava mesas and dyke ridges occur also in New Mexico and Colorado. There are a few local dome-like uplifts, more or less deeply eroded, of which the Black Hills of South Dakota are the largest; here the deep underlying crystalline rocks have been revealed, and a centre of mining and lumbering has been determined in the midst of the semi-nomadic life of the plains. The Little Rocky Mountains of northern Montana are of similar origin, but of much smaller area. Here and there in the eroded districts the more resistant strata rise in low uplands, and their outcropping edges stand forth in ragged escarpments. The western extension of the Ouachita Mountains narrows the plains in Oklahoma, but they broaden again in the Llano estacado of northern Texas, where an extensive upland descends eastwards in a strong escarpment of erosion. Most of the rivers occupy valleys incised a few hundred feet beneath the general level, the valley sides being sharply dissected by wet-weather streams; but so far is the volume of the rivers reduced by the small rainfall of the region, and so great is the load of waste borne by the rivers from the weak strata of the plains themselves, as well as from the mountains on the west, that they are unable to cut down their valleys to a very gentle grade; hence the local relief of the region is less than might be expected from its considerable altitude. Indeed, Arkansas river in western Kansas flows for many miles at the level of the bordering plains, which appear to have been formed by river-borne waste; the muddy stream here maintains a channel, but is unable to erode a valley.

The Great Plains.

Deficient rainfall is the leading climatic feature of the plains; the annual precipitation is generally under 18 inches, and in the south-west it is still less. Indeed, the gradual change to more populous districts on the east is due solely to the gradual increase of rainfall towards the Mississippi valley; hence the vagueness of the boundary between these two physiographic areas. The surface is treeless, except for cottonwoods near the streams and scattered pines on some of the higher escarpments. In certain parts of the sub-arid plains, where the strata are of fine texture and vegetation is almost wanting, the little rain that falls produces eroding rills even up to the finest head-water branches of a drainage system, thus carving the surface into innumerable little valleys separated by ridges and spurs of minute and intricate pattern. The early explorers or "voyageurs" called these districts "mauvaises terres pour traverser," because of their minute ruggedness; and this name is now rendered into "bad lands." The elaborate dissection and barrenness of the "bad lands" in Nebraska and Wyoming have laid bare great numbers of remarkable fossils, of much interest from the light they throw on the theory of evolution; the many-toed ancestors of the modern horse being among the most important. Elsewhere, the sandy strata of the plains are heaped into innumerable dunes by the winds, giving the surface an undulating form beyond the limits of vision; these are known as "sand-hill" districts, and are common in Nebraska and Kansas. Scanty pasture is found in the hollows among the dunes, as well as in the valleys of the bad lands. Here as well as elsewhere over the plains herds of bison ("buffaloes") used to wander; they have now been exterminated, except for a few that remain in protected parks, and are replaced by cattle, which range freely over great areas, reaching water once or twice a day, and there turned back by the "cow-boy" or by the fences of barbed wire that have now been stretched for thousands of miles over the once open plains. The passing traveller, accustomed to the grassy fields of moister lands, may wonder where the cattle find subsistence, and he may marvel how they survive the cold winds of winter. Truly, there is a struggle for existence; yet the cattle are shipped by rail in large numbers from the plains to eastern markets, sometimes stopping on the prairies to improve their condition. Cultivation of the ground is not possible over the more arid plains, but wheat is grown in increasing quantities along their eastern border, towards the true prairies, and irrigation is practised in many valleys and on certain uplands along the base of the western mountains.

The Rocky Mountains.

The eastern members of the Western highlands (or Cordilleras) of North America are known under the general name of the Rocky Mountains. This system of elevations, comprising many separate ranges, is usually sharply separated from the plains on the east; on the north-west it extends far into Canada; on the south it appears to be terminated in 36° N., where the region of the Basin Ranges reaches eastwards to the Great Plains in New Mexico; on the west it is bounded by the lava plateaux of the Columbia and Snake rivers and by the plateaux of Utah and Arizona. The breadth of the system is usually from 150 to 300 miles. Altitudes of 10,000 to 14,000 feet frequently occur, but no summits reach 14,500 feet. There are many serrate ranges with well-defined peaks and passes, but they seldom have the sharp form that characterizes the European Alps or the boldest ranges of Canada. In the south the climate is so dry that even the highest summits (Blanca Peak, Colorado, 14,390 feet; Mount Harvard, Colorado, 14,375 feet) retain only small snow patches in summer; but in northern Montano snow-fields and glaciers of moderate size are found. Traces of ancient glaciers occur in all the higher ranges, and nearly all the few lakes that occur appear to be in association with past glacial action. The structure of different ranges varies greatly; two examples only can be here described. South of the Missouri, the ranges fronting on the plains are of comparatively simple anticlinal structure, exhibiting a broad granitic core, flanked with upturned Palæozoic and Mesozoic strata; but north of the Missouri a synclinal structure prevails, in which the youngest strata occupy the axial summits and the oldest strata are turned up in the flanks, the separation between mountains and plains probably being here determined by a great overthrust, as is known to be the case farther north in Canada. Dissected mountains of volcanic origin are occasionally found. The Spanish peaks, on the borders of the front range in southern Colorado, are of this kind. Land-slides of great dimensions are found in some of the narrower valleys of the San Juan range of south-western Colorado.

The continental divide between drainage discharging to the Atlantic and the Pacific is very irregularly set upon the various ranges of the Rocky Mountains. The branches of the Missouri system and of the Rio Grande source rise within the mountain belt; one of the branches of the Columbia rises in northern Montana on the eastern flanks of the front range, traversing all the other ranges on its way to the Pacific. One of the best-marked characteristics of the region is the inclusion of numerous basins among the ranges, chiefly the result of warping or deformation of recent geological date, after much denudation had already been accomplished. All the basins are heavily floored with waste brought by the streams from the surrounding mountains, and each basin is drained through a cañon or gorge cut by the trunk river in the enclosing range. In many cases the cañon outlet is so narrow and steep-walled as to be impassable, unless by expensive railway construction; hence ordinary roads run from one basin to another by climbing over passes in the ranges. According to the depth to which outflowing rivers have cut down their cañons, the floors of the basins are more or less dissected, their altitudes commonly varying from 4000 to 7000 feet. Thus San Luis "valley," between the San Juan and Sangre de Cristo ranges of southern Colorado and northern New Mexico, is a plain about 140 miles long and 50 wide, from which the Rio Grande escapes southwards through a deep cañon; but the cañon is not yet cut deep enough for the river to trench the plain, except near the outlet. The upper Arkansas gathers its waters in a smaller basin behind the front range in Colorado, through which the river has cut the Royal Gorge, a deep and narrow cleft in granitic rocks, and the basin floor for some distance up-stream from the gorge is slightly trenched. Big Horn river (a branch of the Missouri system) rises in a large basin and cuts its way through an enclosing range of the same name; the floor of the basin is well dissected, the valleys being several hundred feet below the uplands. Green river (a large head branch of the Colorado of the west) drains a large arid basin of the same name in Wyoming through a deep cañon in the Uinta range on the south; and the basin is deeply dissected, presenting "bad lands" of strong relief. All these basins seem at first sight to have contained lakes, but it is highly probable that, as a rule, the basin floors were aggraded, and the outlet cañons were degraded about as fast as the warping of the region progressed, and that if lakes occurred at all they were shallow and short-lived; continuous drainage by rivers probably prevailed during the time of deformation as well as since. This explanation applies to the examples above named and to many others, such as those of the upper Missouri and its branches among the ranges of Montana, the trunk river finally passing through the "Gate of the Mountains," as the gorge in the front range was named by the early explorers, Lewis and Clark. The higher basins in Colorado are known as "parks," from the scattered growth of their trees among grassy glades. The Yellowstone Park is exceptional among the intermontane basins, in having its floor built up by heavy lava flows, above which rise the ruins of some once lofty volcanoes, while on the east the mountains are deeply-dissected masses of volcanic materials. The Park is remarkable for its geysers and hot springs, on account of which it has been made a public reservation. The cañon by which the Yellowstone river is discharged to the northward is a new course, deep cut in decomposed and many-coloured lavas, of the outlet of Yellowstone Lake, which formerly drained westwards *viâ* Snake and Columbia rivers to the Pacific.

The basins among the Rocky Mountains are all of drier climate than those of the ranges, but their generally open surface promotes their use for grazing lands and for agricultural settlements, while the mountains are the seat of mining towns and lumber camps. Modern methods of mining usually exhaust rich mineral deposits in ten or twenty years, and the earlier mining camps in the Rockies are now abandoned and nearly forgotten. Even Leadville, growing rapidly between 1870 and 1880, under the feverish excitement of working rich silver mines, was on the decline for some years thereafter. Cripple Creek, Colorado, a more recent gold-mining district, is still largely productive. Butte, Montana, has an unusually long-lasting productiveness of silver and copper ores; mining and smelting works of great magnitude have been established there. The timber industry has been much injured, especially in the north-west, by forest fires, commonly the result of carelessness and indifference on the part of hunters and settlers; but the enormous destruction of past years is now checked. The settlements in the basins are of a more permanent nature than those about the mines, and nearly all show signs of steady growth. Irrigation is practised as far as streams are available, but the amount of ground thus brought under cultivation is at the best only a small fraction of the region. None of these settlements has yet reached as great a population as Denver, the chief city of the plains, or as Salt Lake City, the chief one of the interior basin on the west.

The plateaux of Utah and Arizona.

The plateaux of Utah and Arizona embrace a lofty region of too arid a climate for settlement except upon small irrigated areas, but of marvellous geological history and extraordinary geographical form. Here, as well as in the Rocky Mountains, there was continuous deposition of stratified rocks from Palæozoic and Mesozoic times, uninterrupted by the break at the close of the Carboniferous formation that was formerly thought to be universal. Here are broad upheavals with hardly perceptible tilting over scores of miles, and great fractures or faults by which adjacent plateau blocks are separated. Here, as hardly anywhere else in the world, one finds manifest evidence of enormous erosion in the production of receding cliffs that form steps by which the altitude of successive plateaux rises from 6000 feet in the south to 10,000 or 11,000 feet in the north, and in the origin of deep-cañons by which the platforms between the cliffs are trenched. The cliffs of the plateau region may be divided into two classes, according to their origin and arrangement. Those of the first class have been formed by the normal processes of erosion, allowing the edges of the resistant strata to gain strong relief, while the weaker strata are stripped off above and undermined below; cliffs of this nature have a relatively constant height, depending chiefly on the thickness of the resistant strata, but a very irregular front, receding where attacked by streams and advancing in inter-stream promontories. Most of the cliffs of the region belong to this class. They may be named by the formation that determines them, as Permian, Triassic, and Jurassic cliffs; or according to their colour, clearly seen on their barren faces, as the brown, red, and white cliffs; or by various local names. Cliffs of the second class are associated with the displacements or faults by which the region is divided into huge blocks, a hundred or more miles in length, north and south, but much less in breadth, with differential upheavals of hundreds or even of thousands of feet. The cliffs follow the margins of the blocks, but the displacements are too ancient for the cliffs to show the actual faces of fractures; erosion has already caused a greater or lesser amount of recession and dissection from the original fracture lines—great where the strata are weak, small where they are resistant; it is the fault-cliffs that are still maintained by the resistant strata that are here considered. Cliffs of this nature are characterized by a relatively straight course for scores of miles, for the fractures have few sinuosities; but the cliffs have significant variations of height, depending on the changing measure of displacement. The Grand Wash Cliffs, limiting the plateau region on the south-west, and the Hurricane ledge, a little farther east, are among the best-defined examples of this class. Associated with the dissected fault-cliffs are the slopes of the monoclinal displacements by which some of the plateau blocks are separated. These were due initially to an unequal uplift of the adjacent blocks, the two being separated not by a fracture but by a flexure of the layers, so that the corresponding horizontal formations in adjacent plateaux differed in altitude by a thousand feet or more. The monocline, by which the Kaibab plateau descends to the platform of the Marble cañon on the east, is an excellent example of its kind, the slope not now exhibiting its initial surface, but the surface of a resistant formation from which the weaker overlying strata have been worn away.

The deep and widespread erosion by which the overlying strata have been removed and the cliffs formed has been greatest where the uplift was greatest, mainly in the south-west. There a great expanse of strong Carboniferous strata (here of marine origin, and non-coal-bearing, as is always the case in the western United States) now forms a plateau at an altitude of 5000 or 6000 feet. Erosion has been much less to the north where uplift was less, and there are found the plateaux capped with youngest strata and of the greatest altitude, up to 9000 or 11,000 feet; they have a moister climate than the lower plateaux, and are well forested. The cañons by which the plateaux are deeply dissected are the work of the rivers, aided by the weathering and washing of the walls. They are for the most part independent of the fracture lines, although between the higher plateaux on the north many valleys have been eroded along the fractures. The chief cañons seem to have been eroded in consequence of a broad elevation of the region that took place, for the most part, after the widespread erosion above mentioned. The most remarkable cañon is that of the Colorado, which traverses the entire plateau region from north-east to south-west. In the Kaibab plateau the cañon is 5000 to 6000 feet deep and 12 or more miles wide; its sides are elaborately dissected by gigantic ravines. A branch railway nearly reaches the southern rim of the cañon at one of the finest points of view. The few tributaries received by the Colorado enter it by side cañons. Although the erosion required for the production of these cañons is stupendous, it is very much smaller than that by which the general surface of the plateaux was stripped in the production of the cliffs.

Volcanic phenomena are exhibited on the plateaux in good variety. Some of the higher plateaux in the north are capped with heavy lava sheets, which must have been poured out in early Tertiary time before the great erosion of the region farther south. Dissected volcanic cones, several thousand feet high, with forested slopes, are found on the broad Carboniferous platform south of the Colorado cañon; these must have been built after the great erosion, yet long enough ago to be deeply ravined. Ash cones and fresh black lava flows of recent date are found at various points; some of the flows poured into the Colorado cañon in great volume, but have since been mostly worn away. In the north-east part of the region the Henry Mountains are laccoliths, or masses of intruded lava, blister-like, between the stratified formations which they domed up; the covering strata have now been greatly denuded and the intrusive igneous rocks revealed. The settlements in the plateau region are few and small. Streams are so few and generally so inaccessible at the bottom of cañons that irrigation is rarely possible. Springs are rare and of great value, and the rough roads or trails by which the plateaux are traversed are traced so as to pass by them. The higher plateaux have abundant timber and summer pasture, but their winter climate is severe and they do not attract permanent settlement. The population of the region must remain very small. Although the plateaux are traversed already by two railways, their surface is too rough and too inhospitable to detain the pleasure-seeker on a transcontinental journey; but the region must become a place of pilgrimage for lovers of the grand and marvellous in desert nature.

The lava plateaux of the Columbia basin.

An area of over 200,000 square miles between the Rocky Mountains and the Pacific ranges, chiefly in Idaho, Washington, and Oregon, is occupied with vast sheets of lava, which have converted a broad intermontane basin into a plateau, whose present elevation, due to filling, uplift, and warping, varies from 600 to 3000 or more feet. The sources of these great outpourings is not certainly known, but they are believed to have been erupted from fissures; their date is Tertiary. The margin of the lava sheet is unusually well defined against the surrounding mountains; here entering and filling a valley as if to form a bay, there retreating around an advancing ridge as if rounding a promontory. Isolated mountain tops sometimes rise like islands above the plain, as in Steptoe Butte, a noted point of view, rising 1000 feet over the lavas. Local disturbances have here and there uplifted and tilted blocks of the plateau in its western part, so as to form long ridges with a steep face of fracture on one side and a long descending slope on the other; huge land-slides have sometimes fallen in disorder from the fractured face. The younger lava sheets still have a fresh and barren surface unworn by streams; the older ones are well dissected by numerous valleys, between which the lavas of the uplands are deeply weathered into fine and fertile soil. In western Washington the lavas are often covered with the finely stratified sediment of a Tertiary lake.

The Columbia river has eroded an important valley near the northern and western margin of the lavas, exposing their successive sheets. In southern Idaho Snake river has worn a fine cañon in which its famous cataract occurs; farther north-west this river traverses the Blue Mountains of Washington, a broad arch of the plateau reaching a height of 5000 feet; here occurs a cañon 4000 feet deep, rivalling that of the Colorado in strength and variety of form, but more sombre in colour. Uncounted lava flows are shown in the cañon walls, with interstratified ash-beds containing petrified trees. At one point a mountain that was once completely buried by the lavas is now transected: its summit is 1500 feet below the plateau and 2500 feet above the river. No less remarkable is a cañon once eroded by the Columbia river on the path that it temporarily followed while its main valley was invaded by the ice streams that descended from the mountains on the north and west during the Glacial period: the cañon is now nearly or quite dry; high walls enclose the greater part of its course, and near a small settlement known as Coulee City its floor is broken by the cliffs of what was once a great cataract, a feature that ranks high among the marvels of the Western country.

The climate of the lava plateau is dry. It is treeless, except for scattered pines near its margin and on its higher uplifts. The more elevated parts have an abundant pasturage, but the lower surface is covered with sage brush, an apparent waste, yet containing enough pasture to support numerous cattle, whose dusty trails leading to water are among the characteristic features of the lava plains. Irrigation is seldom practicable, owing to the depth at which the streams have eroded their valleys. But the deeper-weathered soils, whose surface is sometimes rolling as if wind-blown, retain enough moisture to produce in eastern Washington excellent crops of wheat, of which there has been a large yield since the recent settlement of the region.

The region of the basin ranges.

We come now to the extensive area, limited on the north by the Columbia lava plateaux (near the Nevada boundary), and bounded there on the east and west by the Wahsatch and Sierra Nevada Mountains, narrowing in the middle between the Arizona plateaux and the southern Sierra, but widening farther south so as to reach the Pacific coast on the west in southern California, and to pass around the boundary of the Arizona plateaux and the Rocky Mountains, and meet the Great Plains on the east in New Mexico. The region continues into Mexico. It is traversed by numerous mountain ranges running roughly north and south, commonly measuring from 30 to 100 miles in length and from 5 to 10 in width; rising to an altitude of from 6000 to 11,000 feet, or to a local relief of from 2000 to 6000 feet. The open space between the ranges is occupied by sloping piedmont plains, which unite to form broad flat-floored intermontane troughs; these are floored for the most part by the waste that has been washed from the valleys in the ranges. In the north-west, where this region enters southern Oregon, and north-eastern California, the ranges seem to be of relatively recent origin, for here they still retain the form of upheaved and tilted blocks, little sculptured; while in the south-west the ranges are of much older date, for here they are but remnants of their former dimensions, much of their area being now reduced to gently-sloping floors of rock, grading into the medial plains of waste. But in general the mountains are of strong form and well carved; sometimes rugged and sharply serrate, but more commonly exhibiting smoothed slopes and rounded summits. The higher ranges enjoy a climate moist enough to permit the growth of trees, chiefly pines; running streams issue from the larger valleys, but the mountain flanks are dry and barren. The rocks of the ranges are of great variety, both igneous and sedimentary; they sometimes contain valuable ore deposits, as at Virginia City and Eureka, Nevada (gold and silver), and in the Phœnix district of Arizona (copper). Mining towns rise, flourish, and dwindle away in the neighbourhood of these deposits, as the mineral product grows and fails with the modern methods of rapid exploitation.

The sloping piedmont plains are arid, clothed with abundant sage-brush and other desert plants, but possessing very little pasture. Cattle nevertheless range over the less arid districts near the settlements. The smaller streams from the mountains soon wither away, yet even from dry valleys a heavy rain such as occasionally falls on the mountains produces rushing torrents that carry forward abundant coarse and fine detritus, spreading it in the stony alluvial fans of long radius and gentle declivity which give character to the region. Some of the fans in south-eastern California are of large size—500 to 600 feet higher at the apex than at the margin, with a radius of 10 or more miles; ground water is here stored in considerable quantities, and tunnels are driven in from near the base to convey water for irrigation on the lower slopes. The perennial mountain streams may flow far enough forward to unite in a trunk stream in the flat intermontane trough between the sloping plains; and the trunk stream in turn withers away on a desert plain, or (especially in the north-west, where the streams are fed by the more abundant rains of the Sierra Nevada) forms a lake in a shallow basin, or (especially in the south-east) escapes to the sea by joining one or the other of the two outflowing rivers, the Colorado or the Rio Grande. Some of the rivers have the curious habit of traversing a mountain range in a deep-cut cañon, instead of running around the end of the range not far distant, thus suggesting that the stream was antecedent to the mountains. The permanent streams are now used for irrigation on the piedmont slopes, thus supporting many settlements that would be called "oases" in Africa. Their population is largely Mormon in Utah, but less so elsewhere. The irrigated fields produce excellent crops, but their total area is a very small fraction of the entire region; thus a low limit is set upon the number of locally-supported inhabitants.

Most of the lakes in the intermontane basins are strongly saline; others are brackish or alkaline. The most famous of the former is Great Salt Lake (salinity, 24 per cent.). The smaller lakes are as evanescent as the wet-weather streams; mere films of water fed by occasional rains, turbid with fine silt that is raised from the bottom by the waves. When the waters dry away, a very smooth surface of mud is left absolutely barren; impassable when wet, hard baked when dry. Such mud-plains are known by the Spanish name of *playas*. All the lakes were larger in a recent geological period of moister climate, presumably coincident with the Glacial period elsewhere, as proved by the extensive series of shore lines on the enclosing mountains. The two largest of these extinct lakes, named Bonneville and La Hontan after early explorers of the region, have been elaborately described by Gilbert and Russell in Monographs I. and XI. U.S. Geological Survey.

The Pacific ranges.

The Sierra Nevada of California and the Cascade range of Oregon and Washington, with the subordinate mountains nearer the coast, may be grouped under the general title, Pacific ranges. They are, as a rule, clearly separated from the regions of the Columbia lava and of the basin ranges on the east by a strong ascent, that which leads from the interior basins to the southern Sierra being especially steep and high. The Sierra Nevada does not appear to be in its first cycle of erosion. It was deeply denuded after its original elevation, and then uplifted *en bloc;* its eastern slope is the dissected face of a great fracture, while the slanting uplands of the western slope are now deeply cañoned by many rivers. Lake Tahoe, a clear body of water of great beauty near the crest of the range, occupies a basin formed by a subordinate fracture. In the southern part of the range, chiefly of granitic rocks, erosion before uplift does not seem to have progressed so far as farther north; here the mountain scenery is bold, including the highest summit in the United States (Mount Whitney, 14,898 feet), yet so dry in summer that the snow-fields are small and the glaciers are rare and minute. The Yosemite Valley, enclosed by precipitous granite walls, is a famous resort, now a public reservation. In the middle of the range the uplands are frequently covered by extensive lava flows, of origin anterior to the erosion of the existing cañons. Gold is found in the quartz veins of this district and in the river gravels that were formerly deposited at the western base of the range, now more or less uplifted and dissected, as well as in the gravels here and there preserved under the lava flows. Farther north, volcanoes and lava sheets become increasingly important. Mount Shasta is the finest cone (14,380 feet), now extinct and well ravined by radial streams. Meadows about the base of this and other cones represent aggraded lakes, once formed by lava barriers in ancient valleys, now excellent agricultural land.

The deep transverse valleys of Pitt and Klamath rivers, by which a small part of the basin on the east gains discharge through the mountains, one north, the other south of Mount Shasta, to the Pacific, divide the Sierra Nevada from the Cascade range. The latter is, like the Sierra, an uplifted block in a second cycle of erosion. The mountain block as a whole appears to have been bent or faulted up from the lava-floored basin on the east. The highest summits are volcanic cones, most of which are deeply dissected. They bear snow-fields and glaciers, of which the finest now known are on Mount Rainier (14,526 feet). Lake Chelan occupies a deep, fiord-like, ice-scoured valley on the eastern slopes. Crater Lake in southern Oregon occupies a deep circular basin or caldera, five miles in diameter, enclosed by strong cliffs that form the rim of a half-destroyed volcanic cone. The lake is marvellously beautiful, similar to the circular lakes of central Italy, but of grander proportions. Before the destruction of the lost summit of the cone, probably by under-melting and engulfment, radial ravines had been worn down its slopes; the truncated ravines now notch the rim of the caldera. Glacial moraines lie in some of the ravines, as if deposited by glaciers that once descended from the summit of the cone; hence the engulfment is probably of post-Glacial date. Columbia river traverses the Cascade range at its middle; and like the transverse rivers farther south, appears to be of origin antecedent to the uplift of the range. The lacustrine strata that lie on the north-west part of the lavas in the inner Columbia basin (see above) are probably to be correlated with the transverse valley of the river in the mountains, the lake standing behind the rising range, while the river was cutting down its cañon. The forests on the western slopes of the range are noted for their density and for the great size of many of the trees; they are now extensively cut for lumber.

The Coast ranges bordering the Pacific are, as a rule, of subdued form; they have been repeatedly uplifted and deformed, and long eroded. The Santa Barbara Islands, off the coast of southern California, are to be associated with the Coast ranges as isolated mountain blocks. The sea-border of the mountains has few indentations, and some of the ranges—the Santa Lucia Mountains, for example—descend precipitously to an almost inaccessible shore. Transverse valleys are rare; the most remarkable are slightly submerged in the Bay of San Francisco and in the estuary of Columbia river, the former determining the site of the chief city of the Pacific coast.

A more or less continuous depression lies between the inner and outer members of the Pacific ranges. The southern part of the depression is the "valley" of California, a great waste-floored basin formed by the flat, laterally confluent, alluvial fans of the rivers from the east and west; along its axis, a level, unbroken plain. Tulare Lake lies on the southern part of the plain, a shallow and variable water-sheet, held back by the faster growth of some fans next on the north. This great plain has dry summers, especially in the south; the winters are rainy, especially in the north; irrigation is practised extensively, the form of the surface being excellently adapted to it. The extensive cattle ranges of the Mexican occupants before 1850 have been replaced by wheat farms, and these by the irrigated fruit orchards of the present.

Another basin of smaller size and more uneven surface opens between the inner and outer ranges north and south of Columbia river. The summer dryness is less marked here than farther south, and agriculture flourishes without irrigation. Farther north the many branches of Puget Sound indent the intermontane trough, providing many excellent harbours, two of which have become of importance as the termini of transcontinental railways. Here the forest growth is so heavy that the cost of clearing the land for farming is forbidding; even if the trees are sawn for timber, the removal of the huge stumps is heavy work; but when the land is once ready for cultivation, it returns rich harvests of grain and fruit. (W. M. D.)

II. Statistics.

Population.—The population of the United States, including that of Alaska, Indian territory, and Indian reservations, in 1890 was 62,979,766; in 1900 it was 76,149,386, to which must be added the population of Hawaii, giving a total of 76,303,387. The official census of Porto Rico, taken 10th November 1899, gave to it a population of 953,243. No official enumerations of the populations of the other new possessions of the United States have been made, but the latest estimates, accepted in the census bulletins, are as follows: Philippines, 6,961,339; Guam, 9000; and American Samoa, 6100. The grand total for the United States and its possessions thus stood at 84,233,069 in 1900. Taking only the populations of the states and territories, the increase in 1890 over 1880 was 24·9 per cent., and in 1900 over 1890, 20·7 per cent., being a smaller percentage than was shown by any previous census. The population by geographical divisions in the census returns of 1890 and 1900 was as follows:—

States and Territories.	1890.	1900.[1]	Increase per cent.
North Atlantic . .	17,406,969	21,046,695	20·9
South Atlantic . .	8,857,922	10,443,480	17·9
North Central . .	22,410,417	26,333,004	17·5
South Central . .	11,170,137	14,080,047	26·1
Western . . .	3,102,269	4,091,349	31·9
Alaska . . .	32,052	63,592	98·4
Hawaii . . .	89,990	154,001	71·1

The unusual rate for Alaska is explained by the influx of population due to the discoveries of gold deposits, and that of Hawaii by the rapid development of sugar plantations and the foreign labour introduced for the cultivation. Particular states showed remarkable differences in growth. Nebraska gave the smallest percentage of increase, 0·3, and the territory of Oklahoma, thrown open to settlement in May 1890, gave the largest, 407·6. While the relative importance of the great geographical divisions (census) remained unchanged since 1890, certain states altered their position or rank in the scale of importance. The states and territories showing an increased importance were New Jersey, Oregon, and Oklahoma; those of diminished rank were Delaware, District of Columbia, New Hampshire, Vermont, Nevada, Utah, and Wyoming. Nevada was the only state that showed an actual decrease in population since 1890.

The growth of the central and western divisions of the country was due to the large immigration of foreigners, as well as to a steady movement of native population from the eastern states. The force of this latter agency is measured by the returns of the native-born and the states of their origin. In the north central division, of a total of native-born of about 22,000,000 persons, nearly 1,700,000 were born in the Atlantic states; in the south central, of 13,700,000, nearly 730,000 were natives of the Atlantic states. These returns do not give the full movement, however, as a part of the migrants passed on to the western division, where 1,370,000 out of a total of 3,250,000 native-born came from states in the Union wholly beyond the limits of that division. The immigration movement of foreigners during the period 1887–1901 was as follows:—

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[1] The figures in this column do not include 91,219 persons in the military and naval service of the United States stationed abroad, not credited to any state or territory.

Year.	Number of Immigrants.	Year.	Number of Immigrants.	Year.	Number of Immigrants.
1887	490,109	1892	623,084	1897	230,832
1888	546,889	1893	502,917	1898	229,299
1889	444,427	1894	314,467	1899	311,715
1890	455,302	1895	279,948	1900	448,572
1891	560,319	1896	343,267	1901	487,918

There has been a marked change in the origin and character of this movement. In earlier years western Europe furnished the larger part, and the United Kingdom, Germany, and the Scandinavian countries were the principal factors. In 1888 all Europe sent 538,131 emigrants to the United States, and 373,846 of these came from the countries named. In 1901 the total movement from Europe was 469,237, but only 106,431 came from the same countries. Italy, Austria-Hungary, and Russia were the leading contributors, these three nations giving 334,643 in that year. This change in the nature of the immigration has occurred in the face of more rigid inspection of immigrants under laws intended to exclude the chronic pauper as well as the criminal and incompetent. While the lands of the west and south still attract permanent settlers, the mines and factories and such undertakings as railway construction and city improvement give an opportunity for the temporary residence which is the characteristic of the Italian immigration. Although the laws excluding the Chinese are enforced as far as possible, more than two thousand Chinamen enter each year, and the immigration of Japanese has much increased and shows every evidence of becoming an important factor.

Foreign-born.

The relation of foreign- to native-born population has not varied greatly since 1860. The census of 1900 gave 65,843,302 native-born, or 86·3 per cent. of the total population, and 10,460,085 foreign-born, or 13·7 per cent. Nearly one-half of this foreign-born population (49·5 per cent.) was found in cities having upwards of 25,000 inhabitants; and the proportion of foreign-born in the principal cities was nearly three times that of the country outside of these cities. The distribution of the foreign-born population has great significance, and in 1890 and 1900 was:—

Geographical Division.	1890.	1900.	Increase per cent.
North Atlantic . .	3,888,177	4,762,796	22·5
South Atlantic . .	208,525	216,030	3·6
North Central . .	4,060,114	4,158,474	2·4
South Central . .	321,834	357,635	11·1
Western . . .	770,910	846,321	9·8

The increase in the foreign-born has been concentrated in a few states, and was not so large as that shown by the returns of 1890 and 1880. This is to be explained both by a decreased movement of immigration in the two periods and by the increase in a temporary migration, a characteristic of the people of southern Europe. Nor has the rate of growth of the foreign-born in the ten years ending 1900 equalled that of the native-born, being only 12·4 per cent., compared with 22·5 per cent. in the previous decade. Natives of Germany constitute the largest element of the foreign-born (25·8 per cent.), and those of Ireland are second in importance (15·6 per cent.). The number of those who were born in south-eastern Europe more than doubled in the ten years 1890–1900, while that of the foreigners born in northern Europe, though absolutely greater, remained almost unchanged.

The number of persons born of foreign parentage (one or both parents being of foreign birth) was 26,198,939 in 1900, or 34·3 per cent. of the total population. The corresponding figures for 1890 were 20,676,046, and 33 per cent. The manufacturing states of the east and of the north-central division contain the largest proportion of those of foreign parentage. More than one-half (51·1 per cent.) of the total population of the North Atlantic division comes under this description, the highest percentages being those of Rhode Island (64·2 per cent.), Massachusetts (62·3 per cent.), and New York (59·4). Even these relations are exceeded in some of the more western states, as in North Dakota, with 77·5 per cent. of its total population of foreign parentage, Minnesota, with 74·9 per cent., and Wisconsin, with 71·2 per cent. In the states of the south the number of those born of foreign parentage is so small as to be an inappreciable element in the total population, as North Carolina (0·7 per cent.), South Carolina (1·3 per cent.), Mississippi (1·8 per cent.), and Georgia (1·7 per cent.). But in Louisiana the proportion is larger, 11·8 per cent., as well as in Texas, 15·5 per cent., exceptions explained by economic causes. Of the total native white population of the United States in 1900 (56,740,739), more than one-fourth (27·6 per cent.) was of foreign parentage.

Negroes.

In the states and territories the persons of negro descent increased from 7,488,788 in 1890 to 8,840,789 in 1900, or 18·1 per cent., the rate being somewhat less than that of the white population (21·4 per cent.). The census report says: "If an examination is made of the relative increases of these two elements in the south Atlantic and south-central divisions, in which nearly nine-tenths of all the persons of negro descent are found, the same conditions are apparent. In the south Atlantic division there has been an increase in the white population since 1890 of 19·9 per cent. as compared with an increase in the negro population of 14·3 per cent., while in the south-central division the whites have increased during the same period 29·1 per cent. and the negro element 19·9 per cent. If the comparison in these two divisions is extended to the several elements of the white population, it is seen that among the foreign white there has not been so rapid an increase as among persons of negro descent, but that among the native whites, both of native and foreign parentage, the relative increase during the decade has been much greater." In two states South Carolina and Mississippi the negroes outnumber the whites, and in Louisiana they have been in the minority only since 1890. Such a situation has led to constitutional provisions for restricting the use of the franchise by the negro. On the whole, the relative numbers of negroes to whites for the entire country are steadily decreasing. The migratory movement of the negro population towards the far south has steadily progressed since 1850. (See NEGRO.)

Interior migration.

The interior movement of the population from state to state is indicated by the returns of the state or territory of birth. Excluding certain elements which were not covered by the enumeration, the native-born living in the state or territory of birth constituted 79 per cent. of the total native-born, or 51,979,651 in a total of 65,767,451. Since 1860 this proportion has slowly risen from 75·1 per cent. to its present figure. The two great divisions of the north and south Atlantic, though showing the largest percentage of native-born living in the state of birth, give a slight decrease compared with the returns of 1890, and only a single member in these divisions —West Virginia—offers an increased percentage. In the other geographical divisions the proportion of resident native-born is less, and the movement differs. The comparison by divisions is:—

Geographical Division.	Percentage of Native-born residing in State or Territory of Birth.	
	1890.	1900.
North Atlantic . .	87·5 per cent.	86·3 per cent.
South Atlantic . .	90·1 ,,	89·1 ,,
North Central . .	69·9 ,,	73·6 ,,
South Central . .	79 ,,	78·5 ,,
Western . . .	46 ,,	50·4 ,,

The number of native-born persons living in states other than those of birth (13,787,800) is greater than the foreign-born (10,444,717). The native immigrants thus form a more important element in the settlement of the states than the foreign immigrants. The constitution of the population of each state must be studied by itself, and it is not possible to generalize.

Urban population.

The extraordinary growth of cities has been continuous. Taking the incorporated places—and these will include nearly all cities, towns, and villages of any size—there were 7578 such places in 1890 and 10,602 in 1900. In the former year 41·4 per cent. of the total population was to be found in the incorporated places, and in 1900, 47·1 per cent. The increase has been almost wholly in places of 25,000 inhabitants and over. It is the larger cities that have gained the most. The relative position of places having populations of less than 25,000 hardly changed within the decade ending 1900. In New York, New Jersey, Massachusetts, Illinois, Rhode Island, Pennsylvania, Colorado, and Connecticut more than three-fifths of the total population live in incorporated places. In the southern states, and in certain of the more recently constituted divisions of the west, like Oklahoma, less than one-fifth of the population is found in such places. The nineteen cities of the first class, which include those having a population in 1900 of 200,000 and over, increased in population by 40·7 per cent. between 1880 and 1890, and by 32·6 per cent. between 1890 and 1900. Only New York, Boston, New Orleans, and Newark gave a greater rate of increase in the second period. So far as comparison may be made, the population of incorporated places in 1890 was 26,079,828, and 35,849,516 in 1900.

In determining the question of urban and rural population, other figures must be used, the reason being the practice of New England localities to include within town limits a population that elsewhere is treated as rural. The census gives the urban population, on a basis of places of 4000 inhabitants or more, at 20,768,881 in 1890, or 32·9 per cent. of the total population; and 28,411,698 in 1900, or 37·3 per cent. of the total. The great increase has occurred in New York, New Jersey, Pennsylvania, and the states of the north-central division. In every division the urban population has increased since 1890 more rapidly than the total population, and the difference is so large as to mark the intensity of the movement from the farm into the town or city:—

Geographical Division.	Increase in Total Population.		Increase in Urban Population.	
	Number.	Per cent.	Number.	Per cent.
North Atlantic .	3,639,726	20·9	3,541,779	35·2
South Atlantic .	1,585,558	17·9	495,330	31·9
North Central .	3,922,587	17·5	2,598,277	38·5
South Central .	2,909,910	26·1	557,423	41·6
Western . .	989,080	31·9	433,609	41·9

Yet in but few states outside of the north Atlantic division has there been an actual loss in the rural population, and both in the south and west many states show a substantial gain. While in the north-eastern states the gain in population has almost wholly been in the urban, in the new states of the west and in some of those of the south the gain has been in the rural population. The movement of population is thus a fair indication of economic status or development.

Statistics of National Elections.

The general political complexion of each state is best shown by the division of its electoral vote in the Presidential elections.

STATE.	1884.		1888.		1892.			1896.		1900.	
	Cleveland. Dem.	Blaine. Rep.	Cleveland. Dem.	Harrison. Rep.	Cleveland. Dem.	Harrison. Rep.	Weaver. Pop.	Bryan. Dem.	McKinley. Rep.	Bryan. Dem.	McKinley. Rep.
Alabama . .	10	...	10	...	11	...	...	11	...	11	...
Arkansas . .	7	...	7	...	8	...	...	8	...	8	...
California . .	...	8	...	8	8	1	...	1	8	...	9
Colorado . .	...	3	...	3	...	...	4	4	...	4	...
Connecticut . .	6	...	6	...	6	...	...	...	6	...	6
Delaware . .	3	...	3	...	3	...	...	...	3	...	3
Florida . .	4	...	4	...	4	...	...	4	...	4	...
Georgia . .	12	...	12	...	13	...	...	13	...	13	...
Idaho . . .	...	...	...	...	...	...	3	3	...	3	...
Illinois . .	...	22	...	22	24	...	...	...	24	...	24
Indiana . .	15	...	...	15	15	...	...	...	15	...	15
Iowa . . .	...	13	...	13	...	13	...	...	13	...	13
Kansas . .	...	9	...	9	...	...	10	10	...	...	10
Kentucky . .	13	...	13	...	13	...	...	1	12	13	...
Louisiana . .	8	...	8	...	8	...	...	8	...	8	...
Maine . . .	...	6	...	6	...	6	...	...	6	...	6
Maryland . .	8	...	8	...	8	...	...	...	8	...	8
Massachusetts .	...	14	...	14	...	15	...	...	15	...	15
Michigan . .	...	13	...	13	5	9	...	...	14	...	14
Minnesota . .	...	7	...	7	...	9	...	...	9	...	9
Mississippi . .	9	...	9	...	9	...	...	9	...	9	...
Missouri . .	16	...	16	...	17	...	...	17	...	17	...
Montana . .	...	...	...	...	...	3	...	3	...	3	...
Nebraska . .	...	5	...	5	...	8	...	8	...	...	8
Nevada . .	...	3	...	3	...	...	3	3	...	3	...
New Hampshire .	...	4	...	4	...	4	...	...	4	...	4
New Jersey . .	9	...	9	...	10	...	...	...	10	...	10
New York . .	36	...	...	36	36	...	...	...	36	...	36
North Carolina .	11	...	11	...	11	...	...	11	...	11	...
North Dakota .	...	...	...	...	1	1	1	...	3	...	3
Ohio . . .	...	23	...	23	1	22	...	...	23	...	23
Oregon . .	...	3	...	3	...	3	1	...	4	...	4
Pennsylvania .	...	30	...	30	...	32	...	...	32	...	32
Rhode Island .	...	4	...	4	...	4	...	...	4	...	4
South Carolina .	9	...	9	...	9	...	...	9	...	9	...
South Dakota .	...	...	...	...	...	4	...	4	...	...	4
Tennessee . .	12	...	12	...	12	...	...	12	...	12	...
Texas . . .	13	...	13	...	15	...	...	15	...	15	...
Utah . . .	...	...	...	...	...	...	...	3	...	...	3
Vermont . .	...	4	...	4	...	4	...	...	4	...	4
Virginia . .	12	...	12	...	12	...	...	12	...	12	...
Washington .	...	...	...	...	...	4	...	4	...	...	4
West Virginia .	6	...	6	...	6	...	...	...	6	...	6
Wisconsin . .	...	11	...	11	12	...	...	...	12	...	12
Wyoming . .	...	...	...	...	...	3	...	3	...	...	3
Total . .	219	182	168	233	277	145	22	176	271	155	292

Voting population. The number of potential voters, that is, the number of males twenty-one years of age and over, in the United States (excluding in 1900 the 226,837 of special enumeration) was :—

	1890.	1900.	Increase.		Total Population Per cent.
			Number.	Per cent.	
Native-born . .	12,591,852	16,082,261	3,490,409	27·7	22·4
Foreign-born .	4,348,459	5,020,721	672,262	15·5	11·9
Total . .	16,940,311	21,102,982	4,162,671	24·6	20·7
Also divided into Native white—					
Native parents .	8,807,223	10,535,748	1,728,525	19·6	18·5
Foreign parents	2,150,273	3,458,556	1,308,283	60·8	36·1
Foreign white .	4,242,360	4,914,173	671,813	15·8	12·1
Coloured . .	1,740,455	2,194,505	454,050	26·1	18·8
Persons of negro descent . .	(not given)	2,056,552	..	..	..

In every case the increase in the number of possible voters was greater than the increase in the same description of the general population. The geographical distribution of those of voting age in 1890 and 1900, by percentages, will indicate the changes that have occurred in the ten years.

Geographical Division.	Native White.		Foreign White.	Coloured.
	Native Parents.	Foreign Parents.		
	Per cent.	Per cent.	Per cent.	Per cent.
North Atlantic 1890 .	48·9	16·3	33·0	1·8
,, ,, 1900 .	44·0	20·1	33·7	2·2
South Atlantic 1890 .	57·7	3·8	4·9	33·6
,, ,, 1900 .	58·8	4·2	4·1	32·9
North Central 1890 .	51·1	16·0	30·9	2·0
,, ,, 1900 .	48·5	21·7	27·5	2·3
South Central 1890 .	59·9	4·2	6·5	29·4
,, ,, 1900 .	60·9	5·2	5·3	28·6
Western 1890 .	43·5	13·1	34·0	9·4
,, 1900 .	43·6	18·2	30·3	7·9
United States 1890 .	52·0	12·7	25·0	10·3
,, ,, 1900 .	49·9	16·2	23·1	10·8

For the United States there are 3·6 persons to each potential voter. The results of the two enumerations of population on the number of representatives in the House of Representatives were to increase the apportionment in 1890 to 356, and in 1900 to 386 members.

Manufactures.—So far as the returns of manufacturing and mechanical industries in 1890 and 1900 are comparable, the following table comprises the more important items :—

	1890.	1900.
Number of establishments .	355,415	512,726
Capital	$6,525,156,486	$9,874,664,087
Wage-earners, average number	4,251,613	5,321,087
Men, 16 years and over .	3,327,042	4,120,716
Women ,, .	803,686	1,031,747
Children under 16 years	120,885	168,624
Total wages . . .	$1,891,228,321	$2,330,273,021
Cost of material . . .	$5,162,044,076	$7,360,954,597
Value of products . . .	$9,372,437,283	$13,040,013,638

The figures for 1900 are preliminary, subject to some correction ; and the manner of preparing the returns differed in some particulars in the two censuses. The five leading states in manufactures, in the order of importance, were New York, Pennsylvania, Illinois, Massachusetts, and Ohio. The tendency to form combinations of a number of establishments, working under one financial management, also received attention in the census returns; but only such combinations were included as consisted of a number of formerly independent mills brought together into one company under a charter obtained for that purpose. A mere limited union of interests, or corporations organized with the object of holding the stock of other corporations, but not directly owning the plant or carrying on the business of manufacturing, were not considered. While these returns include the larger number of what are popularly known as "trusts," yet every large aggregation of capital or control of a number of plants should not be so regarded. The detailed list, issued by the Census Office, covers 2029 active plants, operated by 183 corporations.

The division into groups was as follows :—

Industry.	No. of Combinations.	No. of Plants.	Capital.	Wages paid.	Value of Products.
Iron and steel	40	447	$341,779,954	$81,098,583	$508,626,482
Food and allied products . . .	21	273	246,623,633	12,326,601	282,408,081
Chemicals	14	248	175,002,887	12,746,006	182,391,744
Metals, other than iron and steel .	11	89	118,519,401	12,356,772	180,154,703
Liquors and beverages . . .	28	219	118,489,158	4,869,457	93,432,274
Vehicles for land transportation .	6	65	85,965,683	17,571,613	85,985,533
Tobacco	4	41	16,191,818	5,278,151	74,063,029
Textiles	8	72	92,468,606	13,297,357	71,888,202
Leather	5	100	62,734,011	4,070,641	45,684,829
Paper and printing	7	116	59,271,491	7,478,962	44,418,417
Clay, glass, and stone products .	15	180	46,878,928	10,994,488	23,258,182
Lumber	8	61	24,470,281	4,389,944	20,378,815
Miscellaneous	16	118	45,408,869	8,056,140	48,605,073
Total	183	2029	$1,433,804,720	$194,534,715	$1,661,295,364

The total value of the products reported by these industrial combinations is estimated to be one-fifth (20·4 per cent.) of the total gross products of the manufacturing industries of the country as they existed in 1900. Of the 183 corporations, 63 were formed prior to the year 1897, 7 in 1898, 20 in 1899, and 13 prior to June 1900. Thus of the total number, one-half (92) were chartered from 1st January 1899 to 30th June 1900, or on the eve of taking the census. After the census was taken, the largest combination of all, the United States Steel Corporation, was formed, with an authorized capital of $1,404,000,000.

Mineral Production.—The total value of the mineral products of the United States in 1890 was $619,512,173 ; in 1900, $1,092,224,380. The leading articles and their value in 1900 were reported by the U.S. Geological Survey as follows :—

	Quantity.	Value.
Metallic products—		
Pig iron, long tons . . .	15,878,354	$242,174,000
Silver (coining value), troy oz. .	59,653,788	77,126,382
Gold ,, ,, .	3,880,578	80,218,800
Copper (value at New York), ℔ .	597,443,212	86,629,266
Lead ,, short tons	270,700	23,280,200
Zinc ,, ,,	140,822	11,265,760
Non-metallic products—		
Bituminous coal, short tons .	225,607,649	236,201,899
Anthracite coal, long tons .	60,242,560	112,504,020
Natural gas	...	27,067,500
Petroleum, barrels . . .	69,389,194	66,417,335
Brick clay	...	13,800,000
Cement, barrels . . .	20,068,737	15,786,789
Stone	...	55,615,926
Phosphate rock, long tons . .	1,483,723	5,316,403
Salt, barrels	20,566,661	6,617,449
Zinc, white, short tons . .	38,889	3,111,120

The coining value of silver was taken at $1·2929 per troy ounce : that of gold at $20·6718 per troy ounce. The quantity of iron ore mined in 1901 was 28,887,479 long tons, with a value at the mines of $49,256,245.

Railways.—The number of miles of railway in the United States, exclusive of Alaska, Porto Rico, Hawaii, and the Philippine Islands, was 163,597 in 1890, and 193,346 in 1900. Since 1880 two years have been marked by large additions to the number of miles in operation: 1882, when the mileage increased by 11,569, and 1887, when 12,876 miles were added. Since 1890 the annual increase has been much less, never exceeding 4500 miles in any one year, and falling as low as 1650 miles in 1895. The number of miles per 100 square miles of territory was 5·51 in 1890 and 6·51 in 1900; but measured by population it was 25·99 miles per 10,000 inhabitants in 1890, and 25·44 in 1900. The tendency of the railways towards consolidation, the shorter lines being absorbed by the longer, is shown by the fact that in 1890 lines of more than 1000 miles constituted 77,873 miles, or 47·5 per cent. of the total railway mileage of the United States, and in 1900, 117,880 miles, or 61 per cent. of the total. The economy in management since 1894, due to the increase in the size and power of locomotives and in size and capacity of cars, both freight and passenger, is also notable:—

Equipment—Number.

	1894.	1900.
Locomotives—		
Passenger	9,893	9,863
Freight	20,000	21,596
Others	5,599	6,204
Total	35,492	37,663
Cars—		
Passenger	33,018	34,713
Freight	1,205,169	365,531
Others	39,891	50,594
Total	1,278,078	1,450,838

A comparison of passenger and freight service in the two years 1890 and 1900 will demonstrate the work performed by the roads:—

Service—	1890.	1900.
Passengers, number carried .	492,430,865	576,865,230
,, carried 1 mile .	11,847,785,617	16,039,007,217
Tons of freight carried .	636,541,617	1,101,680,238
,, carried 1 mile .	76,207,047,298	141,599,157,270

The amount of securities representing railway property in the two years was as follows:—

	1890.	1900.
Stock—		
Common . .	$3,803,284,943	$4,522,291,838
Preferred . .	606,373,542	1,323,287,755
Total . .	$4,409,658,485	$5,845,579,593
Funded debt—		
Bonds . .	$4,123,921,557	$4,900,626,823
Other obligations	450,654,574	744,828,544
Total . .	$4,574,576,131	$5,645,455,367
Total capital .	$8,984,234,616	$11,491,034,960

The income account was:—

	1890.	1900.
Gross earnings from operation .	$1,051,877,632	$1,487,044,814
Operating expenses	692,093,971	961,428,511
Income from operation .	$359,783,661	$525,616,303
Income from other sources .	126,767,064	162,885,071
Total income	$486,550,725	$688,501,374
Total deductions from income .	384,792,138	461,240,927
Net income	$101,758,587	$227,260,447
Total dividends	89,688,204	139,602,514

As statistics of the *internal commerce* of the United States are not prepared in any form, the nearest approach to such figures is afforded by the freight traffic movement on the railways. The total tonnage carried in 1900 was 957,863,605 tons, of which 516,432,217 tons originated on the reporting road. The principal descriptions of freight were:—

	Tonnage originating on Line.	Tonnage received from Connecting Lines, &c.
Products of agriculture—		
Grain . . .	28,804,245	36,194,645
Flour . . .	6,088,070	9,217,623
Hay	4,112,092	3,721,714
Cotton . . .	2,482,930	3,497,417
Fruit and vegetables	5,213,210	7,892,816
Products of animals—		
Live stock . .	8,491,998	7,130,059
Dressed meats . .	1,589,703	3,122,722
Other packing-house	2,038,215	3,695,677
Hides and leather .	737,150	1,163,595
Products of mines—		
Anthracite coal .	53,245,195	43,692,936
Bituminous coal .	130,443,500	83,638,690
Coke . . .	18,917,811	24,188,490
Ores . . .	37,005,530	38,048,994
Stone, sand, and the like . . .	28,445,488	14,343,029
Products of forests—		
Lumber . . .	40,977,098	35,107,899
Manufactures—		
Petroleum . .	3,819,670	4,537,211
Sugar . . .	2,050,558	2,216,190
Iron, pig and bloom .	12,281,361	13,028,848
Iron and steel rails .	3,565,501	3,219,360
Other castings and machinery . .	7,186,880	7,831,321
Bar and sheet metal .	8,144,271	9,247,417
Cement, brick, and lime . . .	13,429,478	8,333,907
Merchandise . .	21,974,201	20,546,892

Foreign Commerce.—The salient features of the foreign commerce of the United States may be gathered from the following tables.

Domestic Exports (Value in Millions of Dollars).

Description.	1890.	1895.	1901.
Products of agriculture . .	$629·8	$553·2	$943·8
,, mining .	22·3	18·5	38·0
,, forests . .	29·5	28·6	54·3
,, fisheries . .	7·5	5·3	7·7
Manufactures . . .	151·1	183·6	412·2
Miscellaneous . . .	5·1	4·2	4·5
Total . .	$845·3	$793·4	$1460·5

The important growth has been in the exports of manufactures. In 1890 they contributed 17·9 per cent. of the total exports, and in 1901, 28·2 per cent.

The value of imports for consumption (net imports), by classes, was:—

Description.	1890.	1895.	1901.
Articles of food and animals .	$248·6	$226·4	$213·7
,, in crude condition .	178·4	187·5	271·0
,, manufactured, for use as materials . .	84·7	83·8	74·9
,, manufactured, ready for consumption .	154·5	140·8	135·8
,, voluntary use, luxuries, &c.	107·5	92·7	112·5
Total . .	$773·7	$731·2	$807·8

Of the imports of 1901 the merchandise subject to duty was $468,670,045, or 48 per cent. of the total imports; the amount of duty collected was $233,556,110, being 50 per cent. on the value of these imports.

The total movement of imports and exports of merchandise and silver between 1890 and 1901 was as shown in the following table:—

	Exports.	Imports.	Excess of Exports over Imports.	Excess of Imports over Exports.
1890	$892,702,613	$818,091,965	$74,610,648	...
1891	907,071,798	871,896,684	35,175,114	...
1892	1,063,088,707	857,014,309	206,074,398	...
1893	888,402,518	889,594,174	...	$1,191,656
1894	942,591,837	668,281,174	274,310,663	...
1895	854,833,451	752,181,144	102,652,307	...
1896	943,148,608	808,501,860	134,646,748	...
1897	1,112,940,194	795,263,639	317,676,555	...
1898	1,286,587,569	646,977,435	639,610,134	...
1899	1,283,342,357	727,823,545	555,518,812	...
1900	1,451,195,357	885,197,486	565,997,871	...
1901	1,552,050,171	859,558,686	692,491,485	...

The increased export of the products of agriculture, beginning in 1897 and continuing through 1901, presented an interesting feature in the commercial experience of the United States. The relative importance of exports of agricultural produce in the total export trade was not materially changed, but the values represented gave rise to a large balance due to the United States amounting to more than $2,600,000,000 in the five years on merchandise account alone. This balance has proved to be largely fictitious, although it undoubtedly played an important part in supporting the feeling of prosperity that characterized that period. Erroneous methods of reporting official values of exports are in part responsible for this result.

Against this apparent excess of exports over imports the movement of gold coin and bullion was :—

	Exports.	Imports.	Excess of Exports over Imports.	Excess of Imports over Exports.
1890	$17,274,491	$12,943,342	$4,331,149	...
1891	86,362,654	18,232,567	68,130,087	...
1892	50,195,327	49,699,454	495,873	...
1893	108,680,844	21,174,381	87,506,463	...
1894	76,978,061	72,449,119	4,528,942	...
1895	66,468,481	36,384,760	30,083,721	...
1896	112,409,947	33,525,065	78,884,882	...
1897	40,361,580	85,014,780	...	$44,653,200
1898	15,406,391	120,391,674	...	104,985,283
1899	37,522,086	88,954,603	...	51,432,517
1900	48,266,750	44,573,184	3,693,566	...
1901	53,185,177	66,051,187	...	12,866,010

Merchandise Exports and Imports, 1901.

Exports to each Country.	Per cent. of Total Exports.	Country.	Per cent. of Total Imports.	Imports from each Country.
$631,177,157	42·42	United Kingdom	17·42	$143,388,501
191,780,427	12·89	Germany	12·21	100,445,902
78,714,927	5·29	France	9·17	75,458,739
84,356,318	5·67	Netherlands	2·50	20,598,799
49,389,259	3·32	Belgium	1·77	14,601,711
34,473,189	2·32	Italy	2·99	24,618,384
15,480,288	1·04	Spain	·66	5,409,301
105,789,214	7·11	Dominion of Canada	5·16	42,482,163
25,964,801	1·74	Cuba	5·28	43,423,088
8,876,052	·60	British West Indies	1·56	12,851,325
36,475,350	2·45	Mexico	3·50	28,851,635
6,707,465	·45	Central America	1·32	10,838,663
11,663,574	·78	Brazil	8·59	70,643,347
11,537,668	·77	Argentina	·98	8,065,318
5,294,726	·35	Chile	1·05	8,683,279
6,251,804	·42	British East Indies	5·33	43,882,493
19,000,640	1·28	Japan	3·55	29,229,543
10,405,834	·70	Chinese Empire	2·23	18,303,706
8,009,848	·54	Hong Kong	·17	1,416,412
30,726,687	2·06	British Australasia	·58	4,767,661
21,654,458	1·45	British Africa	·10	813,440
$1,136,504,605	76·39	Europe	52·19	$429,620,452
196,534,460	13·21	North America	17·63	145,158,104
44,400,195	2·98	South America	13·41	110,367,342
49,390,712	3·34	Asia	14·30	117,677,611
35,392,401	2·36	Oceania	1·38	11,395,195
25,542,618	1·72	Africa	1·09	8,953,461
$1,487,764,991				$823,172,165

The tariff law of 1890 provided for reciprocity agreements with other countries, with the object of reducing somewhat the customs duties upon a small number of imported products, while extending the exportation of American commodities. With the single exception of Brazil, the results were not important, and in 1894 a return was made to general tariff provisions, in place of special reductions in duties in favour of a few countries. The removal of all duties upon sugar in 1890, and upon raw wool in 1894, did much more to extend commercial connexions than all the reciprocity agreements of 1900. Free wool, especially, opened an important trade with South American states — one of the avowed objects of the reciprocity policy. The Tariff Act of 1897, the highest protective measure ever passed in the United States, not only re-imposed the duties on wool, but raised almost the entire range of protective duties. Hides, exempt from duty since 1872, were made dutiable, and thus a double injury was inflicted upon South American export interests. A provision for framing reciprocity agreements was intended to relieve certain articles from excessive charges or to grant to certain countries advantages in the domestic markets. As the agreements formed under this provision were subject to the approval of both Houses of Congress, such an unusual condition has proved sufficient to prevent any action towards modifying duties through reciprocal arrangements with foreign countries.

Shipping.—The tonnage of the merchant marine of the United States in 1890 was—sailing vessels (including canal boats), 2,565,409 tons; in 1900, 2,507,042 tons: steam vessels (1890), 1,859,088 tons; (1900), 2,657,797 tons. The employment of this tonnage showed that the increase was almost entirely in shipping in the coasting trade. The steam tonnage engaged in foreign trade was 192,705 tons in 1890 and 337,356 tons in 1900. Since 1899 the number of steam vessels built in the United States has increased, but the total construction of vessels of all descriptions has not attained 500,000 tons in any one year. Foreign shipping engaged in American trade may be controlled by American capital, but the vessels are not registered as American. The returns of the value of merchandise, imported and exported, carried in American and in foreign vessels, are not entirely correct. These returns show that in 1890, of a total merchandise movement of $1,573,567,830, American vessels carried only 12·9 per cent., or $202,451,086; in 1900 they took only $195,084,192, which was 9·3 per cent. of the total of $2,089,528,616. The total tonnage of American and foreign vessels, sailing and steam, entered into the seaports of the United States in 1890 was 15,365,604 tons, of which 3,404,584 tons were American; in 1900 the total was 23,533,597 tons, of which 3,974,239 tons were American.

Finances.—The total interest-bearing public debt of the United States in 1890 was $725,313,110, and in 1901, $987,141,000. The annual interest charge was almost the same in the two years, being $29,417,603 in 1890 and $29,789,153 in 1901. In the latter year $445,940,750 of the principal carried 2 per cent. interest; $99,621,420, 3 per cent.; $419,724,770, 4 per cent.; and $21,854,100, 5 per cent. The ordinary revenue of the Government in 1901 was : from customs, $238,585,456 ; internal revenue, $307,180,664; postal service, $111,631,193 ; and miscellaneous, $41,919,217; total, $699,316,530. The more important objects of expenditure were: legislative, $11,211,515; treasury, $100,216,686; war, $147,493,921; navy, $60,985,304; interior, $168,959,479; post office, $118,180,981; total (including all other), $621,598,546. The expenditure for the interior covers that for pensions, which amounted to $138,531,484 in 1901. The number of pensioners carried on the lists was 997,735, of whom 748,649 were invalids.

(For details as to army, navy, education, religion, charities, crime, justice, industry and agriculture, banking, post office, telegraphs, communications, &c., see the articles on these subjects or the articles on the separate states or territories.) (W. C. F.)

III. CONSTITUTION AND GOVERNMENT.

i. *Introductory.*

§ 1. Whoever undertakes to describe the constitution and government of any country will naturally begin with an account of the various organs and authorities which exist in it and of the rules and doctrines which determine their action, and will then proceed to show what is the actual working of these organs, and in what manner they discharge those administrative functions for which every civilized community must provide. In unified or centralized countries, where there is one supreme government, whence all minor authorities derive their powers, this is a comparatively simple matter. But in federal countries, where there are two distinct sets of governmental organs—those of the general or federal government, and those of the component communities or States, members of the federation—the task is more complicated, because it becomes necessary to describe two distinct governments, together with the relations of these two to one another. Accordingly, a description of the Government of the United States falls naturally into three parts:—

First, an account of the States and their governments.

Second, an account of the Federal system, including the relation of the States as communities to the Federation as representing the whole nation.

Third, an account of the structure and organization of the Federal Government considered as the general Government of the nation.

It is possible to begin either with the Federation or with the States. But as the States are older than the Federal Government, and as the latter was, indeed, in many respects modelled upon the scheme of government which already existed in the thirteen original States, it may be convenient to begin with the States and then to proceed to the National Government, whose structure is more intricate and will require a fuller explanation.

Before entering, however, on a description of the State Governments, one feature must be noticed which is common both to the States and to the Federation, and which gives to the governmental system of both a peculiar character, different from that of the Government of Great Britain. This feature is the existence of a supreme instrument of government, a document which has been enacted by the people, which controls, and which cannot be altered by, any or all of the ordinary organs of government. In Great Britain, Parliament is the supreme power, and can change any of the laws of the country at any moment. In the American Union, and in each and every State of the Union, there exists a documentary or rigid Constitution, creating and defining the powers of every authority in the Government. It is the expression of the ultimate sovereignty of the people, and its existence gives to the working both of the Federal Government and of the several State Governments a certain fixity and uniformity which the European, and especially the British, reader must constantly bear in mind, because under such a Constitution a legislature enjoys far scantier powers than in the United Kingdom or, indeed, in most European countries.

ii. *The State Governments.*

Origin of the American State.

§ 2. The State is the oldest political institution in America, and is still the basis and the indestructible unit of the American system. It is the outgrowth from, or rather the continuation of the colony, as the latter existed before the Declaration of Independence in 1776. In every one of the North American Colonies there was in operation at that date a system of self-government under a charter granted by the British Crown. In each there was a governor, with minor executive officers, a legislature, and a judiciary; and although the Crown retained the power of altering the charter, and the British Parliament could legislate over the head of the colonial legislature so as to abrogate statutes passed by the latter, still in practice each colony was allowed to manage its own affairs and to enact the laws it desired. Thus the people were well accustomed to work their institutions, and when they gained their independence continued to maintain those institutions with comparatively little change. In two colonies, Rhode Island and Connecticut, the colonial charter was substantially maintained, as the constitution of the State, for many years, in the former case till 1842, in the latter till 1818.

Rights and powers of a State.

§ 3. Each State was under the Confederation of 1781 sovereign (except as regarded foreign relations), and practically independent. In adopting the Federal Constitution of 1787–89, each parted with some of the attributes of sovereignty, while retaining others. Those which were retained have been to some extent diminished by the 14th and 15th amendments to the Constitution, and if the right to secede from the Union ever existed (a point much controverted), it was finally negatived by the Civil War of 1861–65. Otherwise, however, these attributes survive. The powers of a State are inherent, not delegated, and each retains all such rights and functions of an independent government as it has not, by entering the Union, affirmatively divested itself of in favour of the Federal Government. Each has its own documentary constitution; its legislature of two elective houses; its executive, consisting of a governor and other officials; its judiciary, whose decisions are final, except in cases involving Federal law; its system of local government and local taxation; its revenue, system of taxation, and debts; its body of private, civil, and criminal law and procedure; its rules of citizenship, which may admit persons to be citizens of the State and of the Union, under conditions differing from those prevailing in other States.

The rights and functions of a State practically cover the field in which lie most of the relations of private citizens to one another and to the authorities with which they come into contact in daily life. An American may through a long life never be reminded of the Federal Government, except when he votes at Federal elections (once in every two years), lodges a complaint against the Post Office, or is required to pay duties of customs or excise. His direct taxes are paid to officials acting under State laws. The State (or a local authority created by the State) registers his birth, appoints his guardian, provides schools for him and pays for them, allots him a share in the property of a parent dying intestate, licences him when he enters a trade (if the trade needs a licence), marries him, divorces him, entertains civil actions against him, hangs him for murder. The police that guard his house, the local boards which care for the poor, control highways, provide water, all derive their powers from the State. Nevertheless, despite this wide range of powers, the State is (as will be explained later) a declining factor in the public life of the nation, because public interest tends more and more to centre in the Federal or National Government.

State constitutions.

§ 4. The constitution of each State is framed and enacted by the State itself, without any Federal interference, save that in the case of new States (*i.e.*, those which did not already exist when the Federal Union was formed, but were subsequently admitted to it) the Federal Legislature has the right of making the adoption, or omission, of any particular provision in a State constitution a condition of the admission of that particular State. Even in these cases, however, the constitution derives its force not from Congress, but from the people of the State. The invariable method of forming a constitution is for the citizens to elect by popular vote a body called a convention to draft the document, which, when drafted and circulated, is usually, though not quite invariably, submitted to popular vote. This is done either when a State is to be formed out of a Territory (as to which see *post*, § 10), or when an existing State desires to give itself a new constitution.[1]

A State constitution usually consists of the following parts:—

A description of the boundaries of the State;

A Bill of Rights, defining the so-called "primordial rights" of the citizens to security of life, liberty, and property;

A declaration and enactment of the frame of State government, *i.e.*, the names, functions, and powers of the houses of the legislature, the chief executive officials, and the courts of justice, with provisions regulating the electoral franchise;

Provisions creating a system of local government for cities and rural areas;

Miscellaneous provisions relating to law and administration, including the militia, revenue and taxation, State prisons and hospitals, agriculture, banking and other corporations, railways, labour questions;

Provisions for the amendment of the constitution;

A schedule prescribing the method of submitting the draft constitution to the vote of the people, with temporary provisions regulating the mode of transition from the old constitutional arrangements to the new ones.

The method of amending the constitution varies in detail from State to State, but that most usual is for the legislature to propose amendments, often by a prescribed majority, and for these amendments to be voted on by the people. Such amendments have latterly come to constitute a species of direct legislation by the people similar in principle to what is called in Switzerland the Referendum.

Two remarkable changes have passed over the State constitutions. In the earlier days of the Republic they were comparatively short and simple instruments, confined to the definition of civic rights and the establishment of a frame of government. They have now become very long and elaborate documents, seven, eight, or ten times as long as the Federal Constitution, and containing a vast number of provisions on all sorts of subjects, many of them partaking of the nature of ordinary statutes passed by a legislature rather than safeguards suitable to a fundamental instrument. And secondly, whereas in earlier days the constitutions were seldom changed, they are now frequently recast or amended. No State, except a few of the newest, now lives under its original constitution. Some have recast their constitutions six or seven times. Notwithstanding the facility and frequency of amendments, the variations between one constitution and another are less conspicuous than might have been expected. There is, however, a distinction of type and character between those of the Western and those of the Eastern States, the former being generally more prolix, more prone to go into details, more apt to contain new experiments in legislation.

Comparing the old constitutions with the new ones, it may be said that the note of those enacted in the first thirty or forty years of the Republic was their jealousy of executive power and their careful safeguarding of the rights of the citizen; that of the second period, from 1820 to the Civil War (1861–65), the democratization of the suffrage and of institutions generally; that of the third period (since the War to the present day) a disposition to limit the powers and check the action of the legislature.

State legislatures.

§ 5. In every State the legislature consists of two houses. This remarkable feature, originally due to the practice that had prevailed in some colonies, and to the example of Great Britain, soon became universal, and the belief in its necessity has passed into a fundamental dogma, the idea being that a single chamber would be either hasty, or tyrannical, or unscrupulous—perhaps all three—so that there must always be a second chamber to keep the first in order. The smaller house is called the senate, the larger one is (usually) called the house of representatives, sometimes, however, the assembly. Both are chosen by popular vote, almost universally by the same voters, and usually in single-membered districts, and at the same time. The senatorial districts are, of course, larger than the house districts. A senator is usually chosen for a longer term (often four years) than a representative, and, in most cases, whereas the house is elected all at once, the senate is renewed only partially at each election. In some States by law, and in all by custom also, a member must reside in the district which he represents.

Universal manhood suffrage, subject to certain disqualifications (such as crime and the receipt of poor relief) is the rule in the great majority of States. Certain terms of residence within the United States, in the State, and in the voting district are generally prescribed, the periods varying from State to State. Four States—Wyoming, Colorado, Utah, and Idaho—give the electoral suffrage for all State elections to women.[2] Women can vote at school elections in eleven States—viz., Kansas, Massachusetts, Michigan, Montana, New Hampshire, North Dakota, Ohio, Oregon, South Dakota, Washington, and Wisconsin, and in the Territory of Oklahoma. Two—Massachusetts and Connecticut—have excluded illiterates, while of later years a few Southern States, beginning with Mississippi (constitution of 1890) have been seeking to exclude from voting the negroes, or the great bulk of them, by means of educational tests, property qualifications, a combination of both, or by other means. The suffrage for legislature elections generally determines that for all other elections within the State. And by the Federal Constitution it is also the suffrage for Federal elections, viz., elections of members of Congress and of Presidential electors. (See *post*, § 20.)

The number of members of the legislative chambers varies from State to State. Delaware, with 9 senators and 21 representatives, has the smallest; Minnesota, with 63 senators, has the largest senate; and New Hampshire (a small State) has, with its 397 representatives, the largest house. The New York houses number 50 and 150 respectively; those of Pennsylvania, 50 and 244; of Illinois, 51 and 153; of Ohio, 36 and 109; of Massachusetts, 40 and 240. In all States members of the legislature receive a salary, which is the same for both houses, some States fixing an annual sum, but most preferring a per diem rate, while the maximum is generally determined by a limitation on the length of the session.

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[1] Details as to State constitutions will be found in the writer's *American Commonwealth*, chaps. xxxvii.–xxxix., which is referred to here and subsequently as containing a fuller treatment of all the topics dealt with in this article.

[2] Woman suffrage amendments to State constitutions have been recently rejected by the people in eleven States and in two Territories. State organizations of women to oppose the extension of the suffrage to women exist in Illinois, Massachusetts, New York, and Oregon.

It has become the wish of the people in most places to have sessions both short and few. Whereas formerly legislatures met annually, regular sessions are now biennial except in New York, New Jersey, Massachusetts, Rhode Island, Georgia, and South Carolina—all original States.

Powers and functions of the State legislatures.

The senates act as courts for the trial of State officers impeached by the house (in imitation of the British House of Lords and the Federal Senate), and have in many States the function of confirming or refusing appointments made by the governor. Otherwise the powers and procedure of the two houses are everywhere substantially identical, though it is worth noting that whereas every house chooses its own Speaker, the president of the senate is, in most States, the lieutenant-governor, whom the people have directly elected. Bills may originate in either house, save that in twenty-one States money Bills must originate in the house of representatives, a survival of British custom which has here, where both houses equally represent the people, no functional value. Both houses do most of their work by committees, much after the fashion (to be presently described) of the Federal Congress, and it is in these committees that the form of Bills is usually settled and their fate decided. Sometimes, when a committee is taking evidence on an important question, reporters are present, and the proceedings receive comment in the newspapers; but in general the proceedings of committees and even debates in the houses are imperfectly reported and excite no great public interest. In all the States except four, viz., Rhode Island, Delaware, North Carolina (all original States), and Ohio, Bills passed by the two houses must be submitted to the State governor for his approval. Should he return it to the legislature disapproved, it is lost unless repassed "over his veto" by a majority, usually of two-thirds, in each house. A good governor is apt to use his veto freely—indeed, a frequent exercise of the power is deemed in many States to be a sort of test of the governor's character.

Subjects of State legislation may be classified under three heads:—

1. Ordinary private law, including property, contracts, torts, family relations, offences, civil and criminal procedure.

2. Administrative law, including the regulation of urban and rural local government, State and local taxation and finance, education, public works, the liquor traffic, vaccination, adulteration, charities, asylums, prisons, the inspection of mines and factories, general laws relating to corporations, railways, labour questions.

3. Matters of a local or special nature, such as Bills for chartering and incorporating gas, water, canal, tramway or railway companies, or for conferring franchises in the nature of monopolies or special privileges upon such companies, or for altering their constitutions, as also for incorporating cities or minor communities and regulating their affairs. Although there usually exist general laws under which corporations or companies (including railway and tramway companies) can be formed, laws which in some States and for some purposes confer a greater freedom of incorporation than the general law allows in the United Kingdom, there is nevertheless a noticeable tendency to come to the legislature for special purposes of this kind.

As respects class 1, there is not much change in the law from year to year. The legal profession does not like to see the ordinary and established rules disturbed. Sometimes the laws belonging to this class are codified, or rather consolidated, and then usually by a special committee of competent lawyers whose work is passed *en bloc* by the legislature.

As respects class 2, a good many measures are passed, particularly in matters affecting labour, and for the protection of any sections of the population which may be deemed to need protection.

It is, however, in class 3 that the legislatures shew most activity, much of it pernicious, because prompted by persons seeking to serve private interests which are often opposed to the interests of the whole community. A peculiarly notable form of this special or private Bill legislation is that of dealing by special statutes with the governmental forms and details of management of municipalities; and the control exercised by the State legislatures over city governments is not only a most important branch of legislative business, but at the same time a means of power to scheming politicians and of enrichment to greedy ones. Speaking generally, it is chiefly in the sphere of special or private legislation that State legislatures have shown their weak side, and incurred, in many States, the distrust of the people.

The members of these bodies belong for the most part, though by no means entirely, and least so in the agricultural States, to the class of professional politicians. They are seldom persons of eminent ability or high social standing. Except as a stepping-stone to a seat in Congress or a high executive post, the place is not one which excites the ambition of aspiring men. The least respected legislatures are those of the richest and most populous States, such as New York and Pennsylvania.

The general decline in the quality of these bodies, and especially their proneness to pass ill-considered or pernicious Bills at the instance of private promoters, has led to the restriction in recent years of their powers by the insertion in the State constitutions of many provisions forbidding the enactment of certain classes of measures, and regulating the procedure to be adopted in the passing, either of statutes generally or of particular kinds of statutes. Even these provisions, however, are frequently evaded.

The State executive.

§ 6. At the head of every State government stands an official called the governor, who is the descendant and representative of the governor of colonial times. Under the earlier constitutions of most of the original thirteen States, he was chosen by the legislature, but he is now everywhere directly elected by the people, and by the same suffrage as the legislature. His term of office is four years in twenty States (including Pennsylvania and Illinois), three years in one (New Jersey), two years in twenty-two (including New York and Ohio), and one year in two (Massachusetts and Rhode Island). There are no prohibitions on re-election.

It is the duty of the governor to see that the laws of the State are faithfully administered by all officials, and the judgments of the courts carried out. He has, in most States, the right of reprieving or pardoning offenders, but some recent constitutions place restrictions on this power. He is also commander of the militia or other armed forces of the State, which he can direct to repel invasion or suppress insurrection or riot. He appoints some of the State officials, his nominations usually requiring the concurrence of the State senate; but his patronage is not in any State very large—in many it is indeed insignificant—because the offices of greatest importance are filled by direct popular election. He has also the almost mechanical function of representing the State for various formal purposes, such as demanding from other States the extradition of offenders, the issuing of writs for the election of members of the legislature and of members of the Federal House of Representatives, and the receiving of reports from various State officials or boards.

Not less important than his directly executive work is the influence which a governor exerts upon State legislation through his possession (in all but four States) of a veto power. His right of recommending measures to the legislature (which does not include that of framing and presenting Bills) is of no great practical value, since that body need not regard his counsels, though when a commercial crisis occurs much may depend on his initiative. But his veto is a thing to be reckoned with. It is seldom overridden by a two-thirds majority, especially if the Bill against which it is directed be one of a jobbing nature. And as the people look to him to kill bad measures, he is frequently able, if he be a man both strong and upright, to convey intimations to the legislature, or to those who are influential in it, that he will not approve of certain pending measures, or will approve of them only if passed in a form satisfactory to him. The use of this potential authority which the possession of the veto power gives has now become one of a governor's most important duties.

In New England, and in the greater States generally, the governorship is still a post of dignity, and affords an opportunity for a display of character and talents. During the War of Secession, when each governor was responsible for organizing troops from his State, much turned upon his energy, popularity, and loyalty. And in recent years the danger of riots during strikes has in some States made it important to have a man of decision and fearlessness in the office which issues orders to the State militia.

In thirty States there is a lieutenant-governor, elected by popular vote. He is usually president of the State senate, is sometimes a member of some administrative boards, and steps into the governor's place should it become vacant.

Executive councils advising the governor, but not chosen by him, existed under the first constitutions of all but one (Georgia) of the original thirteen States. They have now disappeared except in Massachusetts, Maine, and North Carolina.

Administrative offices in a State.

§ 7. The names and duties of the other officers vary from State to State. In every State there is a secretary of state, who is custodian of the documents and archives, and a treasurer. Nearly everywhere there is also a comptroller or auditor, who keeps the accounts and is the principal financial officer, an attorney-general or legal adviser, an adjutant-general, who has immediate charge of the militia, and a superintendent of public instruction, with some little authority over the public schools. Most of the States have also a board of charities, a board of health, a board of railway commissioners, and either boards or single commissioners for banking, insurance, agriculture, public lands, and prisons. Other administrative departments found in different States are those having control of public works—principally canals—insane hospitals, factory inspection, labour statistics, and immigration. New York State, with nearly fifty different administrative bureaus, has a larger number than any other State. In many States the most important of these officials are elected by the people at a general election, but some officials are either chosen by the legislature or appointed by the governor, the latter method applying mainly to offices of recent creation. The terms of office vary for the different offices, very few exceeding four years. The State officials, being thus largely independent of the governor, and responsible only to the people, are in no sense a cabinet or ministry. Each has his own department to administer, subject to the detailed regulation imposed by statutes, and as these statutes determine such matters as might come into controversy, a general agreement in policy among the administrative officials is not essential.

In many States officials may be removed, sometimes by vote of the legislature, sometimes by the governor on the address of both houses, or by the governor either alone or with the concurrence of the senate; but such removals must be made for specific misconduct.

The extent of direct State administration of public institutions and works is very limited, and most of the State bureaus have only a supervision over private enterprises, or over local administrative officers. On this account the subordinate civil service of the State is not large compared with that of either the Federal Government or of the large municipalities, and only in a few States does it possess any importance. However, these bureaus are seldom well manned, because salaries and tenure of office are seldom such as to induce able men to offer themselves, while the places are often given as rewards for political service. New York, Massachusetts, and a few other States have systems of civil service examinations, similar to those in the Federal administration, which serve to keep certain branches out of politics.

The State judiciary.

§ 8. The judiciary is in every State an independent department of the Government, directly created by the State constitution, and not controlled in the exercise of its functions either by the legislature or by the executive. In every State it includes three sets of courts: a Supreme Court or Court of Appeal; superior Courts of Record; and local courts, but the particular names and relations of these several tribunals vary greatly from State to State. Most of the original thirteen colonies once possessed also separate courts of chancery; and these were maintained for many years after the separation from Great Britain, and were imitated in several of the earlier among the new States; but special chancery courts now exist only in a few of the States, chiefly in the East and South. In other States the common law judges have also equity jurisdiction; and in four States—New York, North Carolina, California, and Idaho—there has been a complete fusion of law and equity.

In colonial days the superior judges were appointed by the governors, except in Rhode Island and Connecticut, where the legislatures elected them. These precedents were followed in all the revolutionary constitutions, except in Georgia, where election by the people was established. During the democratizing period from 1812 to 1860 the system of popular election was extended, especially in the new States, and at present this system prevails in thirty-two States, including practically all of the new States and four of the original States—New York, Pennsylvania, Maryland, and North Carolina. Five of the original thirteen have their judges elected by the legislatures, and in five others, together with Maine, Mississippi, and Louisiana among the newer States, they are appointed by the governor, subject to the approval of the executive council or the senate. Local judges are generally chosen by the voters of the district in which they hold court.

Originally the superior judges were in most States appointed for life and held office during good behaviour, but only four States now retain this system. Eight to ten years is the average term; in New York it is fourteen years, and in Pennsylvania twenty-one years, while a judge is always re-eligible. Salaries, too, are small in most States, often not more than one-tenth of what a prominent lawyer can make by private practice.

These three factors—popular election, limited terms, and small salaries—have all tended to lower the character of the judiciary; and in not a few States the State judges are men of moderate abilities and limited learning, inferior (and sometimes conspicuously inferior) to the best of the men who practise before them. Nevertheless, in nearly all States the bench is respectable in point of character, while in some it is occasionally adorned by men of the highest eminence. The changes introduced since 1870 have been on the whole towards improvement. Corruption seems to be very rare. Things would doubtless have become worse but for the watchfulness which the bar generally shows in endeavouring to secure the selection of honest and fairly competent men.

It must be remembered that the courts of each State form a judicial system, complete in itself, and independent of the Federal courts, and of course of other States. There is no appeal from the highest State court, except in those cases where a question of Federal law is involved, for then such cases may be removed, in manner to be explained hereafter, to the Federal courts. And, subject only to this limitation, the jurisdiction of the State courts covers the entire field of civil and criminal law. The existing legal systems of all the States, except Louisiana, whose law is based on the Roman, have been built upon the foundation of the principles contained in the common and statute law of England as that law stood in 1776, when the thirteen colonies declared their independence. In the development of the law since that time the courts of one State are not bound either by law or by usage to follow the decisions either of the Federal courts or of the courts of any other State, any more than they would follow English courts, although such decisions are used and discussed as evidence of the common law, and great deference is always shown to the opinions expressed by the Federal courts. In many States the legislatures have taken action in the development of law by adopting statutory codes of procedure, and in some instances have even enacted codes embodying the substance of the common law fused with the statutes. These latter codes have not, however, received the general approval of the legal profession.

It is of course to the State courts that the duty belongs of construing the constitution as well as the statutes of the State, and if they find any State law to be inconsistent with the State constitution, it is their duty to declare it invalid. It is also the duty of the State court to declare any State law invalid if it is contrary to the Federal Constitution or to a Federal statute or treaty. As in the case of the similar power of the Federal judges, this is founded on no special commission, but arises out of the ordinary judicial function of expounding the law and discriminating between the fundamental law and laws of inferior authority. Some observations on this point will be found in the account of the Federal courts to be given hereafter. (See *post*, § 25.)

Change in the political importance of the State.

§ 9. Wide as is the range of the rights and powers of a State, and elaborate as is the structure of its government, the State holds a practically less important position in the American system than it once did, and has not so strong a hold as it had in the first quarter of the 19th century upon the loyalty and affection of its citizens. The political interest and the patriotism of the people generally are now given rather to the nation as a whole than to a State, whereas in the two generations following the Revolutionary War the opposite would have been the case. This notable difference is due not to any constitutional changes, for there have been none except those contained in the 13th, 14th and 15th Amendments to the Constitution, but to the three following causes:—

The first is the growth of the party system with its complicated machinery, which has linked the citizens of different States more closely together, and has led to the eclipsing of political issues confined to a State by issues which are matters of controversy throughout the nation.

The second cause is the Civil War of 1861–65, which practically negatived the far-reaching claims of State sovereignty and the right of secession made by statesmen of the type of Calhoun, and showed that the nation was really much stronger than any group of States.

The third is the enormous development of swift and cheap communications by land and water, which has brought every part of the country into much closer relations with every other part, and has increased the sense of economic solidarity.

Thus the State, important as it is in the constitutional scheme, is both economically and sentimentally a declining factor in the public life of the nation.

The Territories.

§ 10. During the entire history of the United States there has been a considerable area within the jurisdiction of the Federal Government not included in that of any one or more of the States; and the systems of government for the various parts of this area, collectively called the Territories, require some description. The Territories now existing present many variations, and it will be necessary to consider separately: 1. The District of Columbia; 2. the three organized Territories of the older type—Arizona, New Mexico, and Oklahoma; 3. Alaska; 4. the Indian Territory; 5. the Hawaiian Islands; 6. Porto Rico; 7. the Philippine Islands; and 8. the temporary military rule in Cuba.

The *District of Columbia* is a piece of land of seventy square miles, set apart to contain the city of Washington, which is the seat of the Federal Government. It has no local legislature nor locally-elected officers of any kind. Congress itself is the legislative authority, while the local and municipal administration is in the hands of three commissioners appointed by the President, and the judicial system consists of special courts, the judges for which are also appointed by the President.

Arizona, New Mexico, and Oklahoma.—These are the last remaining examples of the type of districts enjoying almost complete autonomy, a type which began with the ordinance of 1787 providing for the government of the "territory of the United States north-west of the river Ohio." The government of these three Territories is established by Act of Congress, and there is nothing corresponding to a State constitution. The scheme of government, however, resembles in many respects that already described as existing in the States. There is a legislature of two houses—a council of twelve or thirteen, and a house of representatives of twenty-four or twenty-six — each elected by the voters of the Territory for two years. The sphere of legislation allowed to these bodies is almost as wide as that enjoyed by the legislature of a State, but Congress always retains the power to annul any act of a Territorial legislature and to legislate directly itself. There is a governor and other executive officers, chosen, however, not by the people, but by the President of the United States with the consent of the Senate. The judges are also appointed by the President, but the Territorial legislature is allowed to regulate the practice and procedure of the courts in which they sit. The Territories elect neither senators nor representatives to Congress, nor do they take any part in Presidential elections. Each, however, sends a delegate to the House of Representatives, who is permitted to sit and speak, but not to vote. The Territories organized on this system may be called inchoate or rudimentary States, looking forward to becoming complete States. Nearly all of the States added to the Union since 1791 have passed through a similar stage of organization before their admission as States. When the population of such a Territory becomes equal to that of the average congressional district, its claim to be admitted as a State is strong. When a Territory is to be formed into a State, Congress either passes an Act accepting and ratifying a constitution already adopted by the people, or, more commonly, passes an Enabling Act, under which the inhabitants elect a constitutional convention, which prepares and submits a constitution to the voters of the Territory; and when this constitution has been accepted by the voters the Act of Congress admitting the State takes effect.

Alaska has executive and judicial organs similar to those of the Territories above described, but has no local legislature, since the white population is extremely small and scattered over a vast area. The governor and judges are appointed by the President with the consent of the Senate, and owing to the size of the area there are three separate courts established, each having jurisdiction over part of the Territory.

The *Indian Territory* and the various Reservations occupied by Indian tribes have no single government. Each Indian tribe has its own internal organization, while the external relations of the tribes to the Federal Government are regulated by treaties. The interpretation of these, and the administration of justice between Indians and non-Indians, are performed by the Federal courts.

The *Hawaiian Islands* are governed very much like Territories of the older type, with a governor, secretary, and Supreme Court judges appointed by the President of the United States with the consent of the Senate, and an elected legislature of two houses; but whereas in the older Territories the Territorial legislature has power over the electoral franchise, a Congressional statute regulates this matter for Hawaii, and requires an educational test of ability to read and write the English or Hawaiian language. The population of the islands is very mixed, including a large number of Portuguese, Japanese, and Chinese, as well as native Hawaiians and persons of American and British stock. The heads of the administrative departments are appointed by the governor, a plan which departs from the method used in the States, and which might seem to open the way for a governor's cabinet resembling that of the Federal President.

Porto Rico has received from Congress (Act of 12th April 1900) a government more limited as respects autonomy than that of Hawaii. Not only is the governor appointed by the President of the United States with the consent of the Senate, but also the six principal administrative officials; and these, with five other persons appointed in the same way, form the executive council, which is one chamber of the legislature, and has, moreover, important independent authority in the granting of franchises and concessions. Five members of this council must, however, be native inhabitants of Porto Rico. There is also an assembly elected by the voters of Porto Rico, which, with the executive council, forms the legislature. As in other Territories, the judges and court officers are appointed by the President of the United States with the consent of the Senate.

The *Philippine Islands* were for a time under military rule, and thus governed entirely under the authority of the President of the United States. A commission of five persons, appointed by him, exercised legislative as well as executive functions, and through its action courts and municipal government were established in some districts, others still in rebellion remaining under the control of the military authorities. Under the Law signed by the President, 1st July 1902, and executive proclamation of 4th July, the military government was abolished and civil government substituted. A legislative assembly is to be established consisting of two houses—an upper house of eight members, five Americans and three Filipinos, and a lower house with elected members.

Cuba had for a time a military government, but this was avowedly a temporary system for the maintenance of order until a stable and independent government created by the Cubans themselves could be established. This took place in 1902. A constitution was then adopted, and a president and legislature elected; but the Cuban government is subject to certain conditions which the Federal Congress has imposed.

iii. *Local Government.*

Rural local government.

§ 11. Every State in the Union has its own system of local administrative areas and local authorities, working under its own laws, these systems agreeing in many points with one another, and differing in many others. Three main types of rural local government may be distinguished, prevailing in different regions. The first is characterized by its unit, the town or township, and exists in the six New England States. The second is characterized by a much larger unit, the county, and prevails in the Southern States. The third may be called the mixed system, combining some features of the first with some of the second, and is found under a considerable variety of forms in the Middle and North-western States. The different types spring from the original differences in the character of the colonists who settled on the Atlantic coast, and in the conditions under which the various colonial communities developed. (See *American Commonwealth*, chaps. xlviii. and xlix.)

The *town*, or township, of New England is generally a rural community occupying a comparatively small area, and with a population averaging about 3000, but ranging from 200 in newly-settled districts or thinly-peopled hilly districts to 15,000 in the vicinity of large cities and in manufacturing neighbourhoods. Each town is governed by the town meeting, an assembly of all the qualified voters within the limits, which meets at least once a year in the spring, and also at other times when specially summoned. This assembly elects the town officials at the annual meetings, but it is much more than an electoral body. It is also a deliberative assembly and the legislative authority for local matters. It enacts bye-laws and ordinances, receives the reports of the local officials, passes their accounts, manages the town property, votes appropriations for each item of expenditure, and authorizes the necessary taxation. Every resident has the right to bring forward and to speak in favour of any proposal. The meeting is presided over by a chairman called the moderator. In rural communities the attendance is usually good, the debates are sensible and practical, and a satisfactory administration is generally secured. But when the town meeting has grown to exceed seven or eight hundred persons, and especially when the farming class of native American stock has been replaced by factory operatives of other nationalities, the institution works less perfectly.

The town officials consist of the "selectmen" (usually three, five, or seven, sometimes nine), the town clerk, treasurer, assessors, tax collector, school committeemen, and the holders of divers minor offices according to local needs. These are elected annually, except that in some cases the "selectmen" and school committee have a term of several years, one member of each board being elected annually. The "selectmen," who receive no regular salary, but may charge for expenses actually incurred, form a sort of directory or executive committee, which manages the ordinary administrative and financial business under such instructions as may have been given by the town meeting.

In the Middle and Western States the township is a more artificial organism than the rural town of New England. In one group of States—Pennsylvania, New Jersey, New York, Ohio, Indiana, Iowa—while the township has more or less power, and there are town officials, there is no town meeting. In another group—Michigan, Illinois, Wisconsin, Minnesota, the two Dakotas—the town meeting reappears, though in a less primitive and less perfect form. In the States west of the Alleghanies each township covers an artificial area 6 miles square, and a separate quasi-municipal organization is usually provided for the villages which have grown up in many townships.

The *county* is to be found in every State of the Union, but its importance varies inversely with the position held in the system of local government by that smaller and older organism, the town. In New England the county was originally an aggregation of towns for judicial purposes, and in that part of the Union it is still in the main a judicial district. There is no general representative council or board, but judicial officers, a sheriff and a clerk, are elected in each county, and also a county treasurer and county commissioners. The latter have the management of county buildings, such as court-houses and prisons, have power to lay out new main highways, to grant licences, and to apportion among the towns and cities the taxation necessary to meet county expenses. Besides these officials there are generally to be found in New England a county school superintendent and an overseer of roads. In the Southern States the county is the local administrative unit, and in addition to its original judicial and financial functions, it has now also control over public schools, the care of the poor, and the construction and management of roads. County government is vested in a board of county commissioners, elected (in almost every State) by the people, and in various officials also directly elected. In some Southern States some counties have been subdivided into school districts, each of which elects a school committee, and from this nucleus there may possibly develop something resembling the New England town. In those Middle and Western States where the town meeting is not found, the functions and officials of the county tend to resemble those existing in the Southern States, while even in those parts of the West where the town meeting is found the county remains more important than in New England. Thus in many of these States poor relief is a county and not a town charge. In most States county administration belongs to a small board of three commissioners elected for the county at large, but in New York, Michigan, Illinois, and Wisconsin there is a larger board of supervisors elected by townships and cities within each county. Although local affairs do not now enlist, even in New England, so large a measure of interest and public spirit as the town system used to evoke in Massachusetts, Rhode Island, and Connecticut in the 'thirties, still, broadly speaking, the rural local government of America may be deemed satisfactory. The administration is fairly efficient, most so, on the whole, in the Northern and Western States, while jobbery and corruption are uncommon—indeed, in the agricultural and poorer States seldom met with. The value of local self-government as a training for the duties of citizenship has been very great, and in many parts of the country, especially where the funds dealt with are small, elections are not fought and offices not distributed upon party lines.

City government.

§ 12. The tendency, now so marked in nearly all civilized countries, to the development of urban communities has been nowhere more marked than in the United States. In 1790 there was only one city (Philadelphia) with more than 40,000 inhabitants, and but six with more than 8000. The aggregate population of these six was only 131,472, or 3·35 per cent. of the total population. In 1900 there were 346 cities exceeding 8000 in population, and 38 exceeding 100,000; and the aggregate urban population in cities and towns of over 8000 was 25,031,505, or 32·9 per cent. of the entire population of the country.

The increase in the range and importance of municipal functions has been not less striking than the growth of urban population. This can best be illustrated by the figures of municipal expenditure. In 1810 the annual budget of New York City—with a population of 100,000—was $100,000; to-day an average city of 100,000 population has an annual expenditure of from $1,000,000 to $2,000,000, and the total expenditure of the city of New York is nearly $100,000,000 a year. Municipal government is therefore a matter of high concern to America, and plays a large part in any study of American political institutions. But the diversities of system due to the variations in the laws of different States are so numerous that nothing more than an outline can be presented here.

The historical origin of American municipal government is to be found in certain boroughs which had been chartered in the colonial period, after the fashion of English boroughs. These American corporations had the usual English system of borough government, consisting of a mayor, aldermen, and councilmen, who carried out the simple administrative and judicial functions needed for the then small communities. The basis for the government of each American city is still a charter, but since the Revolution these charters have been granted by the State legislatures, and are subject to constant change by statute. The charters of cities have shown the same process of increasing length and detailed regulation as the State constitutions; and in details there are many differences between different cities. (See *American Commonwealth*, chaps. l.–lii.)

As a rule, one finds (1) a mayor, elected directly by the voters within the city, who is the head of the administration; (2) administrative officers or boards, some directly elected by the city voters, others nominated by the mayor or chosen by the council; (3) a council or assembly, consisting sometimes of two, but more frequently of one chamber, elected directly by the city voters; and (4) judges, usually elected by the city voters, but sometimes appointed by the State.

The mayor is by far the most important official in the city government. He is elected usually for two years, but sometimes for one, three, or four (in New York his term is now two years). He has almost everywhere a veto on all ordinances passed by the council, modelled on the veto of the Federal President and of a State governor. In many cities he appoints some or all of the heads of the administrative departments, usually with the approval of the council, but in some important cities (including New York, Cleveland, Buffalo, Syracuse, and Rochester) the mayor has an absolute power of appointment. As the chief executive officer, he preserves the public peace. In practice he sometimes exerts a certain discretion as to the enforcement of the laws, especially those providing for Sunday closing. He usually receives a considerable salary, varying with the size of the city.

The practical work of municipal administration is carried on by a number of departments, some under single heads, and some under boards or commissions. The number and classification of these departments vary widely in the different cities. The board of education, which controls the public schools, is usually largely independent of the council, and in some important cities has an independent power of taxation. In Boston, St Louis, Baltimore, and some few other cities, the police board is appointed by the governor of the State.

The city councils pass local ordinances, vote appropriations, levy taxes, and generally exert some control over appointments to administrative positions. The recent tendency has been, however, to decrease the powers of the council and to increase those of the mayor. In some cities the mayor has the absolute power of appointment; the departments, especially the boards of health, have large ordinance-making powers; statutes passed by the State legislature determine the principal lines of municipal policy, and the real control over appropriations and taxes is occasionally found vested in a board of estimate, consisting of the mayor, comptroller (the chief financial officer), and a few other administrative officials. In New York City, where the council had lost public confidence, and in some other places, the only important power still possessed by the council is that of granting franchises to street railways, gas companies, and the like. In the smaller cities, however, the councils have retained a wider measure of authority.

The functions of city government may be distributed into three groups:—(*a*) Those which are delegated by the State out of its general coercive and administrative powers, including the police power and the granting of licences; (*b*) those which, though done under general laws, are properly matters of local charge and subject to local regulation, such as education and the relief of the poor; and (*c*) those which involve no questions of policy, but are of a purely business nature, such as the paving and cleansing of streets, the construction and maintenance of drains, the provision of water, &c. None of these, not even the last, is, as a rule, satisfactorily discharged in the larger cities, because municipal government has unfortunately been drawn into the vortex of party politics, and offices have fallen into the hands of unscrupulous professional politicians seeking their own gain. The Tammany Ring in New York City has been only the most conspicuous example of this degradation. In Philadelphia, Chicago, Cincinnati, San Francisco, and some others of the largest cities, municipal government has for many years past been, as a rule, more or less corrupt, while usually inefficient, and always costly; and few of the persons who conduct it have belonged to the solid business part of the community. Happily, there has been of late years a more active spirit of reform at work, and the prospects of improvement have distinctly brightened.

iv. *The Federal System.*

Origin of the Federal Union.

§ 13. The component elements of the American Union, the stones out of which the fabric of the National Government has been raised, are the States, the constitutions, general character, and powers of which have been already described. It must now be shown on what principles and by what devices the originally semi-independent communities have been bound together in a Federation.

When, in 1776, the thirteen colonies threw off their allegiance to the British Crown and took the title of States, they proceeded to unite themselves in a league by the Articles of Confederation of 1781 (see *Ency. Brit.*, vol. xxiii. p. 746). This scheme of union proved defective, for its central authority, an assembly called Congress, was hopelessly weak. It had neither an executive nor a judiciary, nor had it proper means of coercing a recalcitrant State. Its weakness became so apparent, especially after the pressure of the war with Great Britain had been removed, that the opinion of the wisest men called for a closer and more effective union. Thus the present Constitution was drafted by a Convention in 1787, was ratified by nine States (the prescribed number) in 1788, and was set to work under George Washington as first President in 1789 (see *Ency. Brit.*, vol. xxiii. pp. 749–752).

The Federal Constitution.

§ 14. The Constitution is a document of the first importance in the history of the world, because it has not only determined the course of events in the American Republic, but has also influenced, or become a model for, other constitutions, such as those of Switzerland (1848 and 1874), Canada (1867), Australia (1900), besides Mexico and the numerous republics of South and Central America. It was in substance a compromise effected between those who wished for a centralized government and those who desired to leave very wide powers to the component States; and many subsequent difficulties arose from the omission to settle certain points, and from the somewhat vague language in which other points were referred to. Of these omissions and points left vague, some were inevitable, because an agreement could not have been reached, some were due to the impossibility of foreseeing what difficulties the future would bring with it. But they were, considering the conditions under which the instrument was framed, comparatively few, and the Constitution, when one regards it as a piece of drafting, deserves the admiration which it has received from nearly all American and most foreign critics. It is, on the whole, admirably clear, definite, and concise, probably superior in point of technique to all the documents since framed on its model.

As respects substance, the Constitution, being enacted by and expressing the will of the people, who are the ultimate source of political power, is the supreme law of the land over the whole Union, entitled to prevail over all laws passed by Congress, the legislature which it creates, as well as over all State constitutions and all State laws. It can be altered only by the people, in manner to be hereafter mentioned. It is a comparatively short document, and consists of seven articles, subdivided into sections. Art. I. deals with the Federal Legislature, its structure and powers, and imposes certain restrictions upon the States. Art. II. provides for the election of an executive head, the President, and assigns certain powers and duties to him. Art. III. treats of the judicial power, defining its range and the mode of its exercise. Arts. IV., V., and VI. contain certain miscellaneous provisions, including those which regulate the mode of amendment. Two alternative methods of proposing amendments and four of passing them are recognized. They may be proposed either by a two-thirds vote in each House of Congress, or by a Convention called by Congress on the application of the legislatures of two-thirds of the States. They may be passed either by the legislatures of three-fourths of the States, or by conventions in three-fourths of the States. Congress has in every instance preferred the method of itself proposing amendments, and the method of submitting them to the State legislatures for ratification. (For the amendments adopted, see *post*, § 28.)

The provisions of the Constitution, which, be it remembered, is later in date than the creation of the original States, and presupposes the existence and activity of those communities, include two sets of matters, which must be considered separately—(*a*) the Federal system, *i.e.*, the relations of the National Government to the States; and (*b*) the structure of the National Government itself.

Distribution of powers between the nation and the State.

§ 15. In the determination and allotment of the rights and powers of the National Government on one side and of the States on the other, a determination which is the foundation of every Federal system, the American Constitution proceeds upon the principles following:—

1. No powers are expressly allotted to the States, because the States are contemplated as continuing to enjoy those pre-existing powers which they have by their own right, and not as devolved upon them by the nation.

2. The powers allotted to the National Government are those, and those only, which are required for the purposes of the collective life of the nation, *i.e.*, (*a*) powers which relate

to its action in the international sphere; and (*b*) powers which can be exercised within the Union more efficiently and more to the benefit of the people by one Central Government than by a number of separate governments.

3. All powers which are not expressly allotted to the National Government are left to the States, unless specially forbidden to be exercised by the latter, *i.e.*, powers not specifically referred to remain with the States, and if the National Government wishes to claim any particular power, it must show affirmatively that that power has been granted to it by the Constitution. [This principle has been followed in the Constitution of Australia, but not in that of Canada.]

The powers given to the National Government may be described as those which subserve purposes of common national utility.[1] They are the following (see Const., Art. I., § 8):—

To impose and collect taxes, which must be uniform throughout the United States;

To borrow money on the credit of the United States;

To regulate foreign and inter-State commerce;

To establish a uniform rule of naturalization and a uniform bankruptcy law;

To coin money and fix the standard of weights and measures;

To establish post-offices and post-roads;

To secure exclusive rights for limited time by granting patents and copyrights;

To constitute tribunals inferior to the Supreme Court;

To declare war, and regulate captures on land and water;

To raise and maintain an army and a navy;

To provide for calling out the militia, for organizing and arming them, and for governing such part of them as may be in the actual service of the United States;

To exercise exclusive jurisdiction in the area selected for the seat of the National Government;

To make all laws necessary for carrying out the above powers (including laws punishing such offences as fall within Federal jurisdiction as being transgressions of Federal law);

To pass laws protecting citizens of the United States against unjust or discriminating legislation by any State. (Amendments XIII. and XIV.)

Powers withheld from the National Government.

§ 16. The National Government is, however, interdicted from using these powers in certain directions by the following positive prohibitions (Art. I., § 9, and first ten amendments):—

It may not

Suspend the writ of *Habeas corpus* or pass a bill of attainder or an *ex post facto* law; give any State a commercial preference over another; grant any title of nobility; establish or prohibit any religion, or impose any religious test as a condition of holding office; abridge the freedom of speaking or writing, or of public meeting, or of bearing arms; try any person for certain offences except on the presentment of a grand jury, or otherwise than by a jury of his State and district; decide any common law action where the value in dispute exceeds $20 except by a jury. Although *primâ facie* all powers not given to the National Government remain with the States, the latter are expressly debarred from some powers, viz., the following:—

No State may (Art. I., § 10, and Amendments XIII., XIV., and XV.)

Make any treaty or alliance; coin money or make anything, save gold and silver, a legal tender; pass any bill of attainder or *ex post facto* law, or law impairing the obligation of contracts; have any but a republican form of government; grant any title of nobility; maintain slavery; abridge the privileges of any citizen of the United States, or deny to him the right of voting in respect of race, colour, or previous condition of servitude; deprive any person of life, liberty, or property without due process of law; deny to any person the equal protection of the laws.

There are also certain powers which, though not absolutely withdrawn from the States, can be exercised only with the consent of the National Legislature, viz., those of laying duties on exports or imports, keeping troops or warships in time of peace, entering into agreements with another State or a foreign Power, engaging in war unless invaded. And it may be added that there are certain powers which, since they do not lie within the province of the National Government and have been refused to the States, are said to be "reserved to the people." This expression means that it is only the people who can confer them and direct them to be exercised. Should the people wish to confer them, they would have to do so by way of amending the Constitution; and herein lies a remarkable difference between the American system on the one hand and those of some European countries on the other, which, although they have created rigid constitutions, do not expressly debar the legislature from using any and every power of government.

Relations of the National Government to the States.

§ 17. The aim of those who framed the Constitution was to avoid friction between the State Governments and the Federal Government by rendering their respective spheres of action as separate and distinct as possible. They saw that the less contact the less danger of collision. Their wish was to keep the two mechanisms as independent of each other as was compatible with the still higher need of subordinating, for national purposes, the State to the Central Government.

Nevertheless there are, as was unavoidable, certain points of contact between the two, the chief of which are the following:—

The Constitution requires each State Government to direct the choice of, and accredit to the seat of the National Government, two Senators and so many representatives as the State is (in respect of its population) entitled to send; to provide for the election, meeting, and voting of Presidential electors in each State, and to transmit their votes to the national capital; to organize and arm the militia forces of the State, which, when duly summoned for active service, are placed under the command of the President.

Besides these direct services imposed upon the States, each State is of course practically limited in its legislative and executive action by the power of the Federal judiciary (in the exercise of its function of interpreting the Constitution) to declare invalid laws passed or acts done inconsistent with the Federal Constitution, or with statutes passed by the Federal legislature within the scope of the authority which the Constitution gives it.

So, too, when a subject, such as bankruptcy, is one on which a State may legislate in the absence of legislation by Congress, the State law is valid so long as Congress does not legislate, but if and when Congress does legislate, the State law falls to the ground.

Finally, another point of contact exists in the right of a State to call upon the National Government to protect it against invasion or domestic violence. This right has been several times exerted. (See *American Commonwealth*, chap. xxviii.)

§ 18. It is a fundamental principle of the American system that the National Government possesses a direct

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[1] As to the scheme and working of the Federal Government in its relation to the States, see *American Commonwealth*, chaps. xxvii.–xxx.

Direct authority of the National Government over the citizens of the States.

and immediate authority over all its citizens, quite irrespective of their allegiance and duty to their own State. This authority corresponds to and is co-extensive with the sphere of the Federal Government. So far as the functions of that Government extend, it acts upon the citizens not through the States, but as of its own right and by its own officers. Beyond that sphere its authority stops, and State authority, unless inhibited by the Federal Constitution, begins. But Federal authority is always entitled to prevail, as against a State legislature or officer, in all matters specifically allotted to it; and in these its power of direct action has two great advantages. It makes the citizen recognize his allegiance to the power which represents the unity of the nation; and it avoids the necessity of calling upon the State to enforce obedience to Federal authority, for a State might possibly be weak or dilatory, or even itself inclined to disobedience. Thus the indirect taxes of customs and excise which the Federal Government imposes are levied by Federal custom-house collectors and excisemen, and the judgments of Federal courts are carried out by United States marshals distributed over the country. Nothing has done more to give cohesion and vigour to the American Federal system than the direct action of the Federal executive and Federal judiciary everywhere.

v. *The Federal Government.*

§ 19. The Federal or National Government was created *de novo* by the Constitution of 1787–89. It was really a new creation rather than a continuation of the feeble organization of the pre-existing Confederation. But the principles on which it was constructed were old principles, and most of its features were drawn from the State Governments as they then existed. These States themselves had been developed out of the previous colonial governments, and both they and the National Government have owed something to the example of the British Constitution, which had suggested the division of the legislature into two branches and the independent position of the judiciary. It was, however, mainly from the State constitutions, and not from the arrangements prevailing in Great Britain or in any other country, that the men of the Convention of 1787 drew their ideas and precedents.

Following what was then deemed a fundamental maxim of political science, they divided the government into three departments, the Legislative, the Executive, and the Judicial, and sought to keep each of these as far as possible detached from and independent of the other two.

The Federal Legislature.

In 1787 all the States but three had bicameral legislatures; it was therefore natural that the new National Government should follow this example, not to add that the division into two branches seems calculated to reduce the chances of reckless haste, and to increase the chances of finding wisdom in a multitude of counsellors. There was, however, another reason. Much controversy had raged over the conflicting principles of the equal representation of States and of representation on the basis of numbers, the larger States advocating the latter, the smaller States the former principle; and those who made themselves champions of the rights of the States professed to dread the tyrannical power which an assembly representing population might exert. The adoption of a bicameral system made it possible to give due recognition to both principles. One House, the Senate, contains the representatives of the States, every State sending two; the other, the House of Representatives, contains members elected on a basis of population. The two taken together are called Congress, and form the National Legislature of the United States.

House of Representatives.

§ 20. The House of Representatives is composed of members elected by popular vote in each of the various States, the representation of each State being in proportion to its population. Each State is at liberty under the Constitution to adopt either the "general ticket" system, *i.e.*, the plan of electing all its members by one vote over the whole State, or to elect them in one-membered districts (the "district system"). The system of single-member districts now prevails almost everywhere. (Pennsylvania, however, has two representatives elected at large from the entire State, and there have been other similar instances.) The number of members in the House was originally 65, but it has steadily increased until, in October 1902, there were 357. (In and after 1903 the number was for ten years to be 386.) Besides the full members, each of the Territories is allowed to send a delegate, who has, however, no vote. The electoral franchise on which the House is elected is for each State the same as that by which, under the provisions of the State constitution, the members of the more numerous branch of the State legislature are chosen. Originally franchises varied much in different States, but for many years prior to 1890 what was practically manhood suffrage prevailed in nearly all of the States. In that year some of the Southern States began to introduce restrictions which tend to exclude the bulk of the coloured population (see *ante*, § 5). It has already been observed that paupers and persons convicted of crime are excluded in many States, illiterates in some States. Every member must reside in the State which sends him, and custom, rarely broken, requires that he should reside even in the district which he represents. As a rule, members do not hold their seats for more than two or three Congresses.

The House of Representatives is chosen for two years, the terms of all the members expiring together. The election of a new House takes place in November of the even years (*i.e.*, 1904, 1906, &c.). Members enter on their term of service in the March following, but the first regular session does not begin until the following December, or more than a year after the election. In fact, the old House holds its second regular session of three months after the new House has been elected. The rules are very complicated, and considerably limit the power of debate. A remedy against obstruction has been found in a system of closure called the "previous question." Speeches are limited to one hour, and may be confined in Committee of the whole House to five minutes. There is comparatively little good debating in the European sense of the term, and this is due partly to the great size of the hall, partly to the system of legislation by committees.

The committee system.

The organization of the House is entirely different from that of the British House of Commons or of most assemblies on the European continent. The Ministers of the President do not sit, and since there are thus no officials to undertake the leadership of the majority and conduct business, legislative work is shaped and directed by a number of committees in each House. Every Bill when introduced is referred to some committee, and each Bill comes up for consideration by the whole House on the report of the committee which has dealt with it. There are now about 60 regular or standing committees in the House of Representatives, each consisting of from 3 to 16 members. The most important committees are the following: Ways and Means, Rules, Elections, Appropriations (with several committees for different branches of expenditure), Rivers and Harbours, Banking and Currency, and Foreign Affairs. Each committee has complete control of all Bills referred to it, and nineteen-twentieths of the Bills introduced meet their death by the failure of the committee to take action on them. The Bills taken up for action are debated and freely amended by the committees, and sometimes public hearings are held. The committees on the expenditure of the various Government departments conduct minute investigations into the administration of each.

A Bill, as finally agreed on by a committee, is reported to the House, and when taken up for action the fate of most Bills is decided by an hour's discussion, opened by the member of the committee making the report. The more important measures, including taxation and appropriation Bills, receive genuine discussion by the House at large, through special orders submitted by the Committee on Rules. Of the enormous number of Bills brought in very few pass.

The Speaker.

The unifying force in this complicated system of committee legislation is the Speaker of the House of Representatives. Like the Speaker of the British House of Commons, he is primarily the presiding official, but the character of his office has become different from that of the impartial moderator of the British House. The American Speaker, who of course has a vote like other members, always belongs to the party which commands a majority, and is indeed virtually the leader of the majority party in the House of Representatives. He resembles in some respects a European Prime Minister, and is second only to the President in political importance. His power is derived from three main sources. He appoints the members of all the committees, he chooses the chairman of each, and he directs the reference of Bills to the various committees. He is himself chairman of the Committee on Rules (a small committee of only five members), which practically determines the order in which important measures come before the House, and can keep back an objectionable Bill even when it has a favourable committee report. As presiding officer the Speaker exercises a right of discrimination between members rising to speak in debate. He is elected by the House of Representatives at its first session for the whole Congress, and his election is regularly carried by a strict party vote.

The Senate.

§ 21. The Senate at present (1902) consists of 90 members, two persons deputed from each State, be it great or small (New York with 7,200,000 population and Nevada with 42,000 having the same representation), who must be inhabitants of that State and at least thirty years of age. They are elected by the legislature of their State for six years, and are re-eligible. It used to be supposed by many Europeans, following Tocqueville, that this method of election was the cause of the (former) superiority of the Senators to members of the House. This was an error, the true reason being that able men preferred a seat in the Senate owing to its larger powers and longer term. One-third retire every two years, so that the old members are always twice as numerous as the new members, and the body has been continuous ever since its first creation.

The Vice-President of the United States is *ex officio* presiding officer of the Senate, and this is his only active function in the Government. He has, however, no vote in the Senate, except a casting vote when the numbers are equally divided, and his authority on questions of order is very limited.

The methods of procedure in the Senate are somewhat different from those in the House of Representatives. There is a similar committee system, but the Senate committees and their chairmen are chosen, not by the presiding officer, but by the Senate itself voting by ballot. Practically they are selected by caucuses of the majority and minority parties. The Senate rules have no provision for the closure of debate, nor any limitation on the length either of a debate or of a speech. For the consideration of some classes of business the Senate goes into executive or secret session, although what is done at this session usually leaks out, and finds its way to the public through the press.

The functions of the Senate fall into three classes—legislative, executive, and judicial. In legislative matters its powers are identical with those of the House of Representatives, with the single restriction that Bills for raising revenue must originate in the popular assembly. In practice, too, the Senate is at least as influential in legislation as the House. Disagreements, which are frequent, are usually settled by compromise, and in these the Senate is apt to get the better of its antagonist. Serious deadlocks are of comparatively rare occurrence.

The executive functions of the Senate are :—(1) To approve or disapprove the President's nominations of federal officers, including judges, ministers of state, and ambassadors ; (2) to approve, by a majority of two-thirds of those present, of treaties submitted by the President. Through the latter power the Senate secures a general control over foreign policy. Its approval is necessary to any important action, and in general the President finds it advisable to keep the leaders of the Senatorial majority, and in particular the Senate Committee on Foreign Relations, informed of pending negotiations. Through the power of confirming or rejecting the President's nominations to office, the senators of the President's party are able to influence a large amount of patronage. This sort of "dual control" works with less friction and delay than might have been expected, but better appointments would doubtless be secured if responsibility were more fully and more clearly fixed on the President alone.

The judicial function of the Senate is to sit as a high court for the trial of persons impeached by the House of Representatives, a vote of two-thirds of those present being needed for conviction. There have been seven cases of impeachment. The most important was that of President Johnson, whose conviction failed by one vote—35 to 19. Four of the other six cases also ended in acquittal, one for want of jurisdiction,[1] and one by the resignation of the official before the impeachment was preferred in the Senate. Two Federal judges were many years ago thus deprived of office, impeachment being the only process by which a Federal judge can be removed.

Congressional legislation and finance.

§ 22. The procedure of each House in framing and passing Bills has already been noted. When a Bill has passed one Chamber it is sent to the other, and there referred to the appropriate committee. In course of time this committee may report the Bill as received from the other House, but frequently an amended or an entirely new measure is presented, which is discussed and enacted on by the second House. When Bills passed by the two Chambers are not identical, and each persists in its own view, the regular procedure is to appoint a committee of conference, consisting of three members from the Senate and three from the House. These six meet in secret, and generally agree upon a compromise measure, which is forthwith adopted by both chambers. If no compromise can be arranged, the conflict continues until one side yields, or until it ends by the adjournment of Congress. After passing both Houses, the Bill goes to the President, and if approved by him becomes law : if vetoed, it returns to the House in which it originated; and if re-passed by a two-thirds vote, is sent to the other House; and if again passed there by a two-thirds vote, it becomes law without the President's consent.

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[1] This case was that of the impeachment of a senator, and the failure to convict arose from the fact that some of the senators at the time held the now generally accepted opinion that a member of Congress is not subject to impeachment.

The scope of Congressional legislation has been indicated in the list given of the powers of the National Government (see *ante*, § 15). The most important measures are those dealing with the revenues and appropriations; and the procedure on these matters is slightly different from that on other Bills. The Secretary of the Treasury sends annually to Congress a report containing a statement of the national income and expenditure and of the condition of the public debt, together with remarks on the system of taxation and suggestions for its improvement. He also sends what is called his annual letter, enclosing the estimates, framed by the various departments, of the sums needed for the public service of the United States during the coming year. With this the action of the Executive ceases, and the matter passes into the hands of Congress.

Revenue Bills for imposing or continuing the various customs duties and internal taxes are prepared by the House Committee on Ways and Means, whose chairman is always a leading man in the majority party. The report presented by the Secretary of the Treasury has been referred to this committee, but the latter does not necessarily in any way regard that report. Neither does it proceed on estimates of the sums needed to maintain the public service, for, in the first place, it does not know what appropriations will be proposed by the spending committees; and in the second place, a primary object of the customs duties has been for many years past, not the raising of revenue, but the protection of American industries by subjecting foreign imports to a very high tariff. Regular appropriation Bills down to 1883 were all passed by the House Committee on Appropriations, but in that year a new committee—on Rivers and Harbours—received a large field of expenditure; and in 1886 certain other supply Bills were referred to sundry standing committees. These various appropriation committees start from, but are not restricted by and do not in fact adopt, the estimates of the Secretary of the Treasury. Large changes are made both by way of increasing and reducing his estimates.

The financial Bills are discussed, as fully as the pressure of work permits, in committee of the whole House. Fresh items of appropriations are often added, and changes are made in revenue Bills in the interest of particular purposes or localities. If the Senate is controlled by the same party as the House, it is likely to secure the acceptance of many of its amendments. The majorities in the two Houses then labour together to satisfy what they believe to be the wishes of their party. Important legislation is almost impossible when the Houses are controlled by opposite parties.

When finally adopted by the House, the Bills go to the Senate, and are forthwith referred to the Committee on Finance or to that on Appropriations. The Senate committees amend freely both classes of Bills, and further changes may be made by the Senate itself. When the Bills go back to the House, that body usually rejects the amendments: the Senate declines to recede, and a conference committee is appointed by which a compromise is arranged, usually hastily and in secret, often including entirely new items, and this compromise is accepted with little or no discussion, generally in the last days of the session.

Thus it comes that comparatively slight use is made of the experience of the permanent financial officials in the framing of revenue-raising and appropriation Bills. There is little relation between the amounts proposed to be spent in any one year and the amounts proposed to be raised, and there is a strong tendency to deplete the public treasury through special grants secured by individual members. These defects have long been felt, but Congress is not disposed either to admit officials to attend its sittings or to modify the methods to which it has grown accustomed.

The President.

§ 23. The executive power of the nation is vested in a President of the United States of America, who holds office during the term of four years. He, together with the Vice-President, is nominally chosen by a system of double election through an electoral college, but in practice this system operates as a roundabout way of getting the judgment of the people, voting by States.

The electoral college.

The Constitution directs each State to choose a number of "Presidential electors equal to the number of its representatives in Congress" (both Senators and members of the House of Representatives). Members of Congress and holders of Federal offices are ineligible as electors. These electors (in 1902, 447, a number which in 1904 will have increased to 476) meet in each State on a day in November fixed by law, and give their votes in writing for the President and Vice-President. The votes are transmitted to Washington, and there opened by the President of the Senate, in the presence of both Houses of Congress, and counted. A majority of the whole number of electors is necessary to elect. If no person have such majority, the President is chosen by the House of Representatives voting by States, and the Vice-President is chosen by the Senate. This plan of creating an electoral college to select the President was expected to secure the choice by the best citizens of each State, in a tranquil and deliberate way, of the man whom they in their unfettered discretion should deem fittest to be the chief magistrate of the Union. In fact, however, the electors exercise no discretion, and are chosen under a pledge to vote for a particular candidate. Each party during the summer preceding a Presidential election holds a huge party meeting, called a National Convention, which nominates candidates for President and Vice-President. (See *post*, § 33.) Candidates for the office of elector are also nominated by party conventions, and the persons who are in each State chosen to be electors—they are chosen by a strict party vote—are expected to vote, and do in point of fact vote, for the presidential candidates named by their respective parties at the National Conventions. The Constitution leaves the method of choosing electors to each State, but by universal custom they are now everywhere elected by popular vote, and all the electors for each State are voted for on a "general ticket." In the early days the electors were chosen in many States by the legislatures, but by 1832 South Carolina was the only State retaining this method, and in 1868 she also dropped it. Some States also, for a time, chose electors by districts, but by 1832 all had adopted the "general ticket" system. Michigan, however, in the election of 1892 reverted to the "district" system, thereby dividing its electoral vote. Thus the election is virtually an election by States, and the struggle concentrates itself in the large States, where the great parties are often nearly equally divided, *e.g.*, the party which carries New York by even a small majority gains all the 39 electoral votes of that State. The polling for electors takes place early in November on the same day over the whole Union, and when the result is known the contest is over, because the subsequent meeting and voting of the electors is a mere matter of form. Nevertheless, the system here described, being an election by States, is not the same thing as a general popular vote over the Union, for it sometimes happens that a person is chosen President who has received a minority of the popular vote cast.

The Constitution requires the President to be a native-born citizen of the United States, not under thirty-five years of age, and for fourteen years resident in the United States. There is no legal limitation to his re-eligibility any number of times; but tradition, dating from the refusal of George Washington to be nominated for a third term, has established the rule that no person shall be President for more than two four-year terms. If the President dies, the Vice-President steps into his place; and if the latter also dies in office, the succession passes to the Secretary of State. The President receives a salary of $50,000 a year, and has an official residence called the Executive Mansion, or more familiarly the White House.

Functions of the President.—These may be grouped into three classes: (1) those which relate to foreign affairs; (2) those which concern legislation; (3) those which relate to domestic administration.

The President appoints ambassadors and ministers to foreign countries, and receives those sent by foreign countries to the United States. He has, through his Secretary of State, immediate direction of all negotiations with such countries, and an unfettered initiative in all foreign affairs. He does not, however, enjoy a free hand in finally determining the foreign policy of the Government. Treaties require the approval of two-thirds of the Senate, and the Foreign Affairs Committee of that body is usually kept informed of the negotiations which are being conducted by the Executive. The power to declare war formally belongs to Congress; but the Executive may, without an act of Congress, virtually engage in hostilities and thus bring about a state of war (as happened in 1845–46, when war broke out with Mexico; and again, in 1861, at the opening of the War of Secession).

As respects legislation, the position of the President is in marked contrast to that of the British Crown. While nearly all important measures are brought into Parliament by the ministers of the Sovereign, and nominally under his instructions, the American President cannot introduce Bills either directly or through his ministers. All that the Constitution permits him to do in this direction is to inform Congress of the state of the nation and to recommend the measures which he deems to be necessary. This latter function is discharged by written messages addressed by the President to Congress, the message sent at the beginning of each session being usually the most important; but the suggestions made in these messages do not necessarily or directly induce legislation.

Far more effective is the President's part in the last stage of legislation. His so-called "veto power" permits him to return to Congress, within ten days after its passage, any Bill of which he may disapprove, and, unless this Bill re-passes both Houses by a two-thirds vote, it does not become law. Most Presidents have made use of the veto power sparingly. Jackson, however, as well as Tyler, Johnson, and especially Cleveland, employed it pretty boldly. Johnson's vetoes were promptly over-ruled by the large majority opposed to him in both Houses, but the vetoes of all the other Presidents have generally prevented the enactment of the Bills of which they disapproved.

The domestic executive authority of the President in time of peace is small, because by far the larger part of law and administration belongs to the State and local governments, while the Federal administration is regulated by statutes which leave little discretion to the Executive. The power of making appointments to the administrative service would invest him with a vast influence but for the constitutional requirement of securing the consent of the Senate to the more important appointments made. The President is given a free hand in choosing his cabinet ministers; but for most other appointments, whether or not they are by law in his sole gift, the senators belonging to the President's party have practically controlled the selections for offices lying within their respective States, and a nomination made by the President against the will of the senator concerned will generally be disapproved by the Senate. The members of the President's party in the House also demand a share in the bestowal of offices as a price for their co-operation in those matters wherein the Executive may find it necessary to have legislative aid. Nevertheless, the distribution of offices under the so-called "spoils system" remains the most important ordinary function of the President, and the influence he exerts over Congress and legislation is due mainly to his patronage.

In time of war or of public disturbance, however, the domestic authority of the President expands rapidly. This was markedly the case during the Civil War. As commander-in-chief of the army and navy, and as "charged with the faithful execution of all laws," he is likely to assume, and would indeed be expected to assume, all the powers which the emergency requires. In ordinary times the President may be almost compared to the managing clerk in a large business establishment, whose chief function is to select his subordinates, the policy of the concern being in the hands of the board of directors. But when foreign affairs reach a critical stage, or when disorders within the Union require Federal intervention, immense responsibility is then thrown on one who is both commander-in-chief of the army and the head of the civil executive. In no European country is there any personage to whom the President can be said to correspond. He may have to exert more authority, even if he enjoys less dignity, than a European king. He has powers which are in ordinary times narrower than those of a European prime minister; but these powers are more secure, for instead of depending on the pleasure of a parliamentary majority, they run on to the end of his term. Although he is always elected as a party candidate, he generally receives, if he shows tact and dignity, abundant respect and deference from all citizens, and is able to exert influence beyond the strict limits of his legal power.

The Cabinet and administrative officials.

§ 24. There is in the Government of the United States no such thing as a Cabinet, in the British or French or Italian sense of the word. But the term is used to describe a council of the President, composed of the heads of the chief administrative departments—the Secretary of State, the Secretary of the Treasury, Secretary of War, Secretary of the Navy, Postmaster-General, Secretary of the Interior, Secretary of Agriculture, and Attorney-General. Like the British Cabinet, this council is not formally recognized by the law, but it is nevertheless accepted as a permanent feature in the Government. It is really a group of persons, each individually dependent on, and answerable to, the President, but with no joint policy, no collective responsibility. The final decision on all questions rests with the President, who is solely and personally responsible. Moreover, the members of the Cabinet are excluded from Congress, and are entirely independent of that body, so that an American Cabinet has no parliamentary tactics to contrive, no Bills to prepare, and few problems of foreign policy to discuss. It is not a Government, as Europeans understand the term, but a group of heads of departments, whom their chief, though he usually consults them separately, often finds it useful to bring together in one room for a talk about politics, or in order to settle some administrative question which lies on the borderland between the provinces of two ministers.

The principal administrative departments are those already named, whose heads form the President's Cabinet.

Administrative departments.

The most important are the State and Treasury Departments. The former has the conduct of foreign affairs and interests, and directs the diplomatic service, but is obliged to keep in touch with the Senate, because treaties require the consent of the latter. It also has charge of the Great Seal of the United States, keeps the archives, publishes the statutes of Congress, and controls the consular service.

The two main functions of the Treasury Department are the administration of the Government revenues and expenditures, and of the banking and currency laws. The Secretary has, however, a much smaller range of action than a finance minister in European countries, for, as he is excluded from Congress, he has nothing directly to do with the imposition of taxes, and very little with the appropriations for Government expenditure. In addition to its fiscal and currency functions, the Treasury Department has charge of several other bureaus, dealing with the mercantile marine, the lighthouse and life-saving service, commercial statistics, immigration, and the coast and geodetic survey. It is, however, proposed to transfer these to a newly created Department of Commerce.

The Department of the Interior is less important than in France or Italy, since the principal functions which there belong to it lie, in the United States, within the field of State powers. In the United States the principal matters in this department are the management of the public lands, the conduct of Indian affairs, the issue of patents, the administration of pension laws, of the national census, and of the geological survey, together with the collection of educational information.

The Department of War controls the formerly very small, but now largely increased, army of the United States; and its corps of engineers execute the river and harbour improvements ordered by Congress. The Navy Department has charge of the dockyards and vessels of war; and the Post Office Department directs the postal system, including the railway mail service. The Department of Agriculture includes the Meteorological Bureau, the Bureau of Inspection of Animals, and other bureaus which conduct investigations and experiments. The Attorney-General is the legal adviser of the President, public prosecutor, and standing counsel for the United States, and also has general oversight of the Federal judicial administration, especially of the prosecuting officers called district attorneys and of the executive court officers called marshals.

Two commissions not connected with any of the above departments deserve some notice. The Inter-State Commerce Commission, established by statute in 1887, is a semi-judicial, semi-administrative board of five members, with limited powers of control over inter-state railway transportation. The chief duty is to prevent discriminations in freight rates and secret rebates from the published list of charges. The Civil Service Commission, established in 1883, conducts competitive examinations for appointments to subordinate positions under all of the administrative departments. Some 90,000 posts are now filled from the candidates who pass these examinations.

The Federal judiciary.

§ 25. The Federal judicial system is made by the Constitution independent both of the Legislature and of the Executive. It consists of the Supreme Court, the circuit courts, and the district courts.

The Supreme Court is created by the Constitution, and consisted in 1902 of nine judges, who are nominated by the President and confirmed by the Senate. They hold office during good behaviour, *i.e.*, are removable only by impeachment, thus having a tenure even more secure than that of English judges. The court sits at Washington from October to July in every year. The sessions of the court are held in the Capitol. A rule requiring the presence of six judges to pronounce a decision prevents the division of the court into two or more benches; and while this secures a thorough consideration of every case, it also retards the despatch of business. Every case is discussed twice by the whole body, once to ascertain the view of the majority, which is then directed to be set forth in a written opinion; then again, when the written opinion, prepared by one of the judges, is submitted for criticism and adoption by the court as its judgment.

The other Federal courts have been created by Congress under a power in the Constitution to establish "inferior courts." The circuit courts consist of twenty-five circuit judges, acting in nine judicial circuits, while to each circuit there is also allotted one of the justices of the Supreme Court. The judges of each circuit, acting with the justice of the Supreme Court for the circuit, constitute a Circuit Court of Appeals, established to relieve the Supreme Court. Some cases may, however, be appealed to the Supreme Court from the Circuit Court of Appeals, and others directly from the lower courts. The district courts are now seventy in number, each having a single justice. There is also a special tribunal called the Court of Claims, which deals with the claims of private persons against the Federal Government. It is not strictly a part of the general judicial system, but is a creation of Congress designed to relieve that body of a part of its own labours.

The jurisdiction of the Federal courts extends only to those cases in which the Constitution makes Federal law applicable. All other cases are left to the State courts, from which there is no appeal to the Federal courts, unless where some specific point arises which is affected by the Federal Constitution or a Federal law. The classes of cases dealt with by the Federal courts are as follows:—

1. Cases in law and equity arising under the Constitution, the laws of the United States, and treaties made under their authority;
2. Cases affecting ambassadors, other public ministers and consuls;
3. Cases of Admiralty and maritime jurisdiction;
4. Controversies to which the United States shall be a party;
5. Controversies between two or more States, between a State and citizens of another State, between citizens of different States, between citizens of the same State claiming lands under grants of different States, and between a State or the citizens thereof and foreign states, citizens, or subjects (*Const.*, Art. III., § 2). Part of this jurisdiction has, however, been withdrawn by the eleventh Amendment to the Constitution, which declares that "the judicial power of the United States shall not be construed to extend to any suit commenced or prosecuted against one of the United States by citizens of another State, or by citizens or subjects of any foreign State."

The jurisdiction of the Supreme Court is original in cases affecting ambassadors, and wherever a State is a party; in other cases it is appellate. In some matters the jurisdiction of the Federal courts is exclusive; in others it is concurrent with that of the State courts.

As it frequently happens that cases come before State courts in which questions of Federal law arise, a provision has been made whereby due respect for the latter is secured by giving the party to a suit who relies upon Federal law, and whose contention is overruled by a State court, the right of having the suit removed to a Federal court. The Judiciary Act of 1789 (as amended by subsequent legislation) provides for the removal to the Supreme Court of the United States of "a final judgment or decree in any suit rendered in the highest Court of a State in which a decision could be had where is drawn in question the validity of a treaty or statute for an authority exercised under the United States, and the decision is against their validity; or where is drawn in question the validity of a statute of, or an authority exercised under, any State, on the ground of their being repugnant to the Constitution, treaties, or laws of the United States, and the decision is in favour of their validity; or where any title, right, privilege, or immunity is claimed under the Constitution, or any treaty or statute of a commission held, or authority exercised under the United States, and the decision is against the title, right, privilege, or immunity specially set up or claimed by either party under such Constitution, treaty, statute, commission, or authority." If the decision of the State court is in favour of the right claimed under Federal law or against the validity or applicability of the State law set up, there is no ground for removal, because the applicability or authority of Federal law in the particular case could receive no further protection from a Federal court than has in fact been given by the State court.

The power exercised by the Supreme Court in declaring statutes of Congress or of State legislatures (or acts of the Executive) to be invalid because inconsistent with the Federal Constitution, has been deemed by many Europeans a peculiar and striking feature of the American system. There is, however, nothing novel or mysterious about it. As the Federal Constitution, which emanates directly from the people, is the supreme law of the land everywhere, any statute passed by any lower authority (whether the Federal Congress or a State Legislature), which contravenes the Constitution, must necessarily be invalid in point of law, just as in the United Kingdom a railway bye-law which contravened an Act of Parliament would be invalid. Now, the functions of judicial tribunals—of all courts alike, whether Federal or State, whether superior or inferior—is to interpret the law, and if any tribunal finds a Congressional statute or State statute inconsistent with the Constitution, the tribunal is obliged to hold such statute invalid. A tribunal does this not because it has any right or power of its own in the matter, but because the people have, in enacting the Constitution as a supreme law, declared that all other laws inconsistent with it are *ipso jure* void. When a tribunal has ascertained that an inferior law is thus inconsistent, that inferior law is therewith, so far as inconsistent, to be deemed void. The tribunal does not enter any conflict with the Legislature or Executive. All it does is to declare that a conflict exists between two laws of different degrees of authority, whence it necessarily follows that the weaker law is extinct. This duty of interpretation belongs to all tribunals, but as constitutional cases are, if originating in a lower court, usually carried by appeal to the Supreme Court, men have grown accustomed to talk of the Supreme Court as in a special sense the guardian of the Constitution.

The Federal courts never deliver an opinion on any constitutional question unless or until that question is brought before them in the form of a lawsuit. A judgment of the Supreme Court is only a judgment on the particular case before it, and does not prevent a similar question being raised again in an another lawsuit, though of course this seldom happens, because it may be assumed that the Court will adhere to its former opinion. There have, however, been instances in which the Court has virtually changed its view on a constitutional question, and it is understood to be entitled so to do.

Results of Constitutional interpretation.

§ 26. As the Federal Constitution is a short document, which deals very concisely with most of the subjects it touches, a vast number of questions have arisen upon its interpretation in the course of the 113 years which have elapsed since its enactment. The decisions of the Supreme Court upon these questions form a large body of law, a knowledge of which is now indispensable to a mastery of the Constitution itself. By them the Constitution has been so expanded in the points which it expressly treats of, and so filled up in the matters which it covers only by way of implication, that it is now a much more complete instrument than it was when it came from the hands of its framers. Thus the courts have held, that while the National Government can exercise only such powers as have been affirmatively granted, it is not restricted in its choice of the methods for exercising such powers as have been granted. From this doctrine there has been derived a conspicuous activity of the National Government in such fields as taxation, borrowing of money, regulating commerce, and carrying on war. Executive and legislative acts not authorized by the letter of the Constitution have also been allowed to remain unchallenged, and thus precedents have been in fact established, with the tacit recognition of the courts and the people, through which the sphere of the National Government has been enlarged. The purchase of Louisiana from France by President Jefferson is an instance. It may indeed be said that the Constitution as it now stands is the result of a long process of development; and that process is still going on. So recently as 1901, the Supreme Court delivered several judgments in cases arising out of the annexation of Porto Rico, which handled, though they did not fully settle, divers points of novelty and of importance.

Development of the Constitution by usage.

§ 27. It is not, however, only by way of interpretation that the Constitution has been developed. A great many matters which it passed over have become the subject of legislation by Congress; and there has also sprung up a large mass of usages regulating matters not touched either by the Constitution or by any express enactment. These usages have in many cases lasted so long and become so generally accepted, that they may be regarded as parts of the actual or (so to speak) "working" Constitution, although of course they could be at any moment changed. Among the matters that are now thus settled by usage the following may be mentioned :—

The President is limited to two terms of office. The Presidential electors are expected to vote for the candidate of the party which has chosen them, exercising no free will of their own. The Senate always confirms the nominations to a Cabinet office made by the President. Both the Senate and the House conduct their business by means of standing committees. The appointment of committees of the House is left to the Speaker.

It may be added that in respect of one matter assigned by the Constitution to the States a momentous change has taken place since the enactment of the Constitution. This matter is the electoral franchise in Federal elections. In 1789 property qualifications were general, but now in all the Northern and Western States these have been long since abolished, and the electoral suffrage is practically manhood suffrage. In Wyoming, Colorado, Utah, and Idaho universal adult suffrage prevails. Down till 1890 manhood suffrage had prevailed in all the Southern

States also (as to some Southern States now, see *ante*, § 5). As the electoral suffrage for State legislature elections is also that for Federal elections (including the election of Presidential electors), the working of the Federal Constitution has thus been materially affected without any change in the Federal Constitution itself.

Amendments to the Constitution.

§ 28. Besides these changes which have been brought about by judicial interpretation and by usage, the Constitution has also been altered in the regular and formal way which its own provisions permit (see *ante*, § 14). This has happened four times. Ten amendments were enacted immediately after the adoption of the Constitution itself, in order to meet certain objections which had been taken to it. These may be described as a sort of Bill of Rights. Another, the eleventh, was enacted in 1794–98 to negative a construction which the Supreme Court had put upon its own powers. Another, the twelfth (1803–4), corrected a fault in the method of choosing the President; and the last three (1865–70) confirmed and secured some of the results of the War of Secession (1861–65) (see *Ency. Brit.*, vol. xxiii. p. 781). Many other amendments have been from time to time suggested, but very few have passed even the first stage of a formal proposal. This is due not merely to the respect of the Americans for their fundamental law, but also to the difficulties which surround the process of change. It is hard to secure the requisite majorities in Congress, and still harder a majority in three-fourths of the States. The obstacles placed in the way of amendment, which are greater than in the case of almost any other Constitution, may be reckoned among the causes which led to the War of Secession.

General character of the frame of National Government.

§ 29. As compared with the Cabinet system of Great Britain, of the British self-governing colonies, and of such European countries as France, Italy, Holland, and Belgium, the characteristic features of the scheme of the American National Government are the following:—

(*a*) The Legislature and the Executive are independent and disjoined. The Executive does not depend upon the Legislature, but holds its powers by a direct commission from the people. No member of the Executive sits in the Legislature, nor can the Legislature eject any one from office save by impeachment.

(*b*) Both the Legislature and the Executive sit for fixed terms. As some one has said, the American system is an astronomical one—*i.e.*, the action of the people in creating those who are to exercise parts of its sovereign powers takes place at intervals fixed by the calendar.

(*c*) No method is provided for getting rid of deadlocks, either between the Legislature and the Executive or between the two branches of the Legislature. Should action be needed which cannot be legally taken without the concurrence of these different authorities, and should they be unable to concur, the legal situation must remain *in statu quo* until by a new election the people have changed one or more of the conflicting authorities, and so brought them into harmony.

(*d*) The judiciary holds a place of high importance, because it is the proper interpreter of the will of the people expressed in the supreme law, the Federal Constitution, which the people have enacted.

The defects which have been remarked in this system are, broadly speaking, the following:—

There is a danger that prompt action, needed in the interests of the nation, may fail to be taken owing to a deadlock between Legislature and Executive, or between the two branches of the Legislature.

There may be a difficulty in fixing responsibility upon any person, or small group of persons, because cases may arise in which the Executive, being unable to act without the concurrence of the Legislature, can hardly be blamed for failing to act, while yet it is unable to relieve itself by resigning; while on the other hand the Legislature—which consists of two bodies, each of them numerous, and in neither of which are there recognized leaders—contains no person on whom responsibility can be fixed.

On the other hand, the characteristic merits of the system may be summed up as consisting in the safeguards it provides against the undue predominance of any one power or person in the Government, and therewith against any risk there may be that the President should become a despot, and in the full opportunities it secures for the due consideration of all important measures. It is a system amply provided with checks and balances; it recognizes and enforces the principle of popular sovereignty, and it is well calculated to maintain unchanged the relation of its component parts each to the other. There has been, in point of fact, no permanent shifting of weight or strength from any one organ of Government to any other. At some particular epoch the President has seemed to be gaining upon Congress, at other epochs Congress has seemed to be gaining upon the President. Now and then the Senate has been more influential than the House, now and then it has fallen back. The part played by the judiciary has at some moments been of special importance, while at others it has been little noticed. But, taking the history of the Republic as a whole, that equilibrium between the several organs of the Government which the Constitution was intended to secure has been substantially maintained.

vi. *The Party System.*

Influence of the party system upon the working of the Government.

§ 30. The actual working of the Government of the Union and of the governments of the several States cannot be properly understood without some knowledge of the party system as it exists in the United States. That system is, as has been well observed by a recent writer,[1] a sort of link between the executive and the legislative departments of government, and thus the policy and action of the party for the time being in power forms a sort of second and unofficial government of the country, directing the legal government created by the Constitution. In no country have political parties been so carefully and thoroughly organized. In no country does the spirit of party so completely pervade every department of political life; not that party spirit is any more bitter than it is in Europe, for in some respects it is usually less bitter than in France, the United Kingdom, or Austria, but that it penetrates farther into the body of the people, and exerts a more constant influence upon their minds. Party organizations have in the United States a wide range of action, for they exist to accomplish five purposes. Three of these are pursued in other countries also. These three are—first, to influence governmental policy; secondly, to form opinion; and thirdly, to win elections. But the two others are almost (if now not quite) peculiar to the United States, viz., to select candidates for office and to procure places of emolument for party workers. The selecting by a party of its candidates, instead of allowing candidates to start on their own account, is a universal practice in the United States, and rests upon the notion that the supreme authority and constant activity of the people must extend not only to the choice of officials by vote, but even to the selection of those for whom votes shall be cast. So the practice of securing places for persons who have served the party, in however humble a capacity, has sprung from the maxim that in the strife of politics "the spoils belong to the victors," and has furnished a motive of incomparable and ever-present activity ever since the 'thirties. It is chiefly through these two practices that the party organizations have grown so powerful, and have been developed into an extremely complicated system of machinery, firm yet flexible, delicate yet quickly set up, and capable of working efficiently in the newest and roughest communities.

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[1] Mr Henry Jones Ford, in his *Rise and Growth of American Politics.*

Origin and history of the parties.

§ 31. The contests over the adoption of the Federal Constitution by the several States in 1787–91 brought to the surface two opposite tendencies, which may be called the centrifugal and centripetal forces, a tendency to maintain both the freedom of the individual and the independence, in legislation, in administration, and in jurisdiction, of the several States, and an opposite tendency to subordinate the States to the nation, and to vest large powers in the central Federal authority. These tendencies soon arranged themselves in concrete bodies, and thus two great parties were formed. One, which took the name of Republican, became the champion of States' rights, and claimed to be also the champion of freedom. It was led by Thomas Jefferson. The other, led by Alexander Hamilton, became known as the Federalist party, and stood for an energetic exercise, or even a practical extension—of course within the limits of the Constitution—of the powers of the Central Government. One of these two parties has continued ever since to subsist, and the other has, with two apparent breaches of continuity, been in reality nearly as permanent. The Jeffersonian party has had an unbroken continuity of life, though it has been known since about 1830 as the Democratic party. The Federalist party slowly decayed, and ultimately vanished between 1820 and 1830, but out of its ruins a new party arose, practically its heir, which continued powerful, under the name of Whigs, till 1854, when it broke up over questions connected with slavery. Very soon thereafter a party, nominally new, but largely formed out of the Whigs, and maintaining many of its traditions, sprang up, and took the name of Republicans. Since 1856 these two great parties, Democrats and Republicans, have confronted one another, including between them the vast majority of the people, though several smaller parties, such as Greenbackers, Laborists, Populists, and Prohibitionists, have from time to time been formed, and brought some complication into political struggles. It is not easy to describe the distinctive tenets of Democrats and Republicans at this moment, because the old principles which each party would respectively claim as its own have to a large extent disappeared through changes in recent and current political conditions, and each party is apt to be guided in its attitude on an actual issue by what it deems its immediate interest. In general, however, the Republican party has, since the War of Secession, advocated a protective tariff, and since 1898 it has defended the policy of acquiring trans-oceanic possessions; while the Democrats have leant more towards Free Trade, and have, quite recently, censured the annexation of the Philippine Island. (For a full account of the history of the parties and their attitude to various great questions, see *Ency. Brit.*, vol. xxiii. p. 754, *sqq.*, and the section following on AMERICAN HISTORY.)

The Democratic party began to form for itself a regular organization about the time of President Andrew Jackson (1829–37), and the process seems to have been first seriously undertaken in New York State. The Whigs did the same; and when the Republicans organized themselves, shortly after the fall of the Whigs, they created a party machinery on lines resembling those which their predecessors had struck out. The establishment of the system in its general form may be dated from before the Civil War, but it has since been perfected in its details.

Outline of the system of party organization.

§ 32. The machinery of an American party consists of two distinct but intimately connected sets of bodies, the one permanent, the other temporary, or rather intermittent. The function of the former is to manage the general business of the party from month to month and year to year. That of the latter is to nominate candidates for the next ensuing elections, and to make declarations of party opinion intended to indicate the broad lines of party policy.

Party committees.

The permanent organization consists of a system of committees, one for each of the more important election areas. There is a committee for every city, every county, and every congressional district, and in some States even for every township and every State legislature district. There is, of course, a committee for every State, and at the head of the whole stands a National Committee for the whole Union, whose special function it is to make arrangements for the conduct of party work at a Presidential election. Thus the country from ocean to ocean is covered by a network of committees, each having a sphere of action corresponding to some election area, whether a Federal area or a State area. Each committee is independent and responsible so far as regards the local work to be done in connexion with the election in its own area, but is subordinate to the party committees above it as respects work to be done in its own locality for the general purposes of the party. The ordinary duties of these committees are to raise and spend money for electioneering and otherwise in the interests of the party, to organize meetings, to "look after the press," to attend to the admission of immigrants or new-comers as voters, and generally to attract and enrol recruits in the party forces. At election times they also direct and superintend the work of bringing up voters to the polls and of watching the taking and counting of the votes; but in this work they are often aided or superseded by specially appointed temporary bodies called "campaign committees." These party committees are permanent, and though the membership is renewed every year, the same men usually continue to serve. The chairman in particular is generally reappointed, and is often, in a populous area, a person of great and perhaps autocratic power, who has large funds at his disposal, and a regular army of "workers" under his orders.

Party Nominating Conventions.

The other and parallel branch of the party organization consists of the bodies whose function it is to nominate party candidates for elective posts, whether legislative or executive. (It must be remembered that many executive State, county, and city officers are chosen by direct popular vote.) These bodies are meetings of the members of the party resident in each election area. In the smallest areas, such as the township or city ward, the meeting is composed of all the recognized members of the party who are entitled to vote, and it is then called a Primary. In the larger election areas, such as a county or city, the number of voters who would be entitled to be present renders it impossible to admit all, so the nominating meetings in these areas are composed of delegates elected in the various Primaries included in the area, and the meeting is called a Nominating Convention. This is the rule, but in some parts of the South and West nominations for members of the State legislature and county officials, and even for members of Congress, are made by Primary assemblies meeting over the entire area, which all the party voters are entitled to attend. Where candidates are to be nominated for a State election, the number of delegates from Primaries would be too large, so the State

Nominating Convention is composed of delegates chosen at representative conventions held in smaller areas.

Every registered voter belonging to the party in the local election area for which party candidates are to be nominated is presumably entitled to vote in the Primary. In rural districts little difficulty arises, because it is known what citizens belong to each party; but in cities, and especially in large cities, where men do not know their neighbours by sight, it becomes necessary to have regular lists of the party voters entitled to attend a Primary; and these lists are either prepared and kept by the local party committee, or are settled by the votes of the persons previously on the party rolls. The composition of these lists is of course a serious matter, because the Primary is the foundation of the whole party edifice. Accordingly, those who control the local organizations usually take pains to keep on the lists all the voters whom they can trust, and are apt to keep off those whom they think likely to show a dangerous independence. By their constant activity in this direction, and by their influence over the pliable members of the party, they are generally able to have a Primary subservient to their will, which is ready to nominate those whom they may suggest as suitable candidates, and to choose as delegates to the conventions persons on whom they can rely. In this way a few leaders may sometimes be able to obtain control of the nominating machinery of a city, or even of a State, for the local committees usually obey instructions received from the committees above them. (See as to the details of party machinery, *American Commonwealth*, chaps. lix.–lxiv., and the recently published book of M. Ostrogorski on *Democracy in England and America.*)

The great importance of these nominating bodies lies in the fact that in the United States a candidate has scarcely any chance of being elected unless he is regularly nominated by his party, that is to say, by the recognized Primary or Convention. To control the Primary or the Convention (as the case may be) of the party which is strongest in any given area is therefore, in ninety-nine cases out of a hundred, to control the election itself. As the desire to dominate Primaries was found to lead to many abuses, both in the way of manipulating the lists of party voters and in the unfair management of the Primary meetings themselves, reformers have made many proposals for controlling by law the procedure of these meetings, although they are theoretically mere private party meetings, which form no part of the legal machinery of government. And in several States, as notably in Massachusetts and New York, statutes have been enacted regulating the Primaries, so as to permit all the voters of a party to be enrolled, and subjecting the conduct of the voting and counting of votes to safeguards similar to those provided for the regular public elections. The Primaries have in some cases indeed ceased to be meetings in the physical sense, and have become preliminary elections.

The National Nominating Convention.

§ 33. One nominating body is of such conspicuous magnitude as to need special notice. For the selection of party candidates for the offices of President and Vice-President of the United States there is held once every four years, in the summer preceding the election (in November) of the President, a huge party assembly of delegates from conventions held in the several States, each State having twice as many delegates as it has electoral votes to cast (*i.e.*, twice as many as its Federal Senators and Federal Representatives). Two delegates are chosen for each congressional district by a District Convention, and four delegates for the State at large by a State Convention. Each State delegation usually keeps together during the National Convention, and holds private meetings from time to time to decide on the course which it should as a whole adopt.

When the National Convention has been duly organized by the appointment of committees and of a chairman, its first business is to discuss and adopt a series of resolutions (prepared by the Committee on Resolutions, but subject to amendment by the Convention as a whole), which, taken together, embody the views, programme, and policy of the party, and constitute what is called its "platform" for the ensuing election. It then proceeds to receive the nomination of various aspirants to the position of party candidate for the Presidency. The roll of States is called alphabetically, and each State, as reached in the roll, is entitled to present a candidate. Thereafter a vote is taken between the several aspirants. The roll of States is again called, and the chairman of each State delegation announces the vote of the State. In Democratic Conventions a State delegation, when instructed by the State Convention to cast its whole vote solid for the particular aspirant favoured by the majority of the delegation, must do so (this is called the unit rule): in the Conventions of the other parties individual delegates may vote as they please. If one aspirant has obtained on the first roll-call an absolute majority of the whole number of delegates voting—or, in Democratic Conventions, a majority of two-thirds of those voting—he is held to have been duly chosen, and the choice is then made unanimous. If, however, no one obtains the requisite majority, the roll is again called until some one competitor secures the requisite number of votes. Sometimes one or two votings are sufficient, but sometimes the process has to be repeated many times—it may even continue for several days—before a result is reached. Where this happens, there is much room for the display of tactical skill by the party managers in persuading delegates who favour one of the less prominent aspirants to transfer their votes to the person who seems most likely to unite the party. Scenes of great excitement sometimes occur.

When one aspirant has been duly selected as the party candidate for the Presidency, the Convention proceeds to choose in the same way a person to be candidate for the Vice-Presidency. This is a much simpler matter, because the post is much less sought after, and it is usually despatched with ease and promptitude. The two nominees are then deemed to be the candidates of the whole party, entitled to the support, at the ensuing election, of the party organizations and of all sound party men throughout the Union, and the Convention thereupon dissolves.

Influences which guide the parties.

§ 34. It is hardly too much to say that in the United States the parties work the Government, and that the party organizations are to the legal organs of Government what the motor nerves are to the muscles, sinews, and bones of the human body. The question follows, Who work the parties?

The action of the parties depends upon and is the resultant of three factors, which are indeed more or less present in all constitutional representative governments. These are (*a*) individual leaders, who are powerful either by their talents or by the influence they enjoy over the citizens; (*b*) rich men, who can supply the party with the very large sums of money needed for maintaining the party machinery in efficiency and for fighting the elections; and (*c*) the opinion of the mass of the citizens, who, though generally disposed to adhere to the traditions and follow the leaders of the party to which they belong, do, especially in the more educated classes and in the most advanced sections of the country, exert a certain measure of independence, and may refuse to vote for the party candidates if they either distrust those candidates personally or disapprove of the policy which the party seems to be following. It need hardly be said that the relative importance of these three factors varies from time to time.

General results of the power of the party system.

§ 35. The national parties have been so pervasive in their influence, and the working of their machinery has formed so important a part of the political history of the United States, that it is necessary here to call attention to the high significance of this element in the system of the Republic, although limits of space make it impossible to describe the way in which the party system has coloured the actual working of the Government as well as the politics of the country. Among its chief results the following may be noted:—

It has made nearly all elections, including those for State offices and city offices, the functions of which have, as a rule, nothing whatever to do with national party issues, matters of party strife fought upon party lines. It has disposed voters in State and city elections to support party candidates whom they might otherwise have disapproved of, for the sake of maintaining in full strength for national purposes the local party organization, and it has thereby become a fruitful source of municipal misgovernment. It has thrown great power into the hands of party managers, because where the strife between the two great parties is keen and the result of a contest doubtful, discipline and obedience are deemed needful for success. It has tended to efface State lines, and to diminish the interest in State issues, and has thus helped to make the nation overshadow the States.

Strong as is the sentiment of party loyalty in the United States, the spirit of faction is not at present violent. Many persons regret the enormous power which party exerts, and would like to reduce the part it plays in the system of government. But no one has yet discovered any method by which the associative force of party as a motive power in government can be dispensed with.

(J. BR.)

IV. History since 1885.

The historical article on the United States in the ninth edition of the *Encyclopædia Britannica* brought its account down to the period of President Cleveland's first accession to office, and it will therefore be the object of the following sketch to indicate the important movements of events since 1885.

Political tendency, 1865-85.

The Republican party, increased by loyal accessions, and doubly triumphant under President Lincoln in preserving the American Union while destroying slavery, did not, after the tragic death of that great political chieftain, pursue his proposed policy of forbearance towards those impoverished fellow-citizens who had laid down their arms in honourable submission. Besides a prolonged military occupation new guarantees, new pledges, were made the price of State admission; and while the Southern people and their late leaders were treated with distrust, the dominant party faction, whose brain was in Congress, sought to build up influence by means of an alliance between new settlers from the north and the negro freedmen, upon whom the right to vote had been promiscuously bestowed. Such inversion of State autonomy could not last long. The white majority of the South, under leaders no longer for disunion, regained local control, while negro suffrage was largely suppressed. In the North the Democrats had meanwhile reorganized on national lines, and northern Democratic candidates for the Presidency received the solid vote of the South. National elections soon went by narrow margins, the "Empire State" of New York deciding the majority. Again and again Democratic opposition carried the lower house of Congress; and had all the Southern States regained by 1876 their normal condition in the Union, the opposition candidate for the Presidency, Mr Tilden, would have been declared elected. Later, in 1884, Mr Cleveland, the Democratic nominee, won by the electoral vote of New York, which was cast in his favour; and the Republican party, despite all historical claims to public gratitude, had henceforth to contend for the favour of the people as one of two great national parties rather than as sole survivor and regenerator.

President Cleveland, 1885-89.

Mr Grover Cleveland had only come into prominence after the Civil War. A lawyer by profession, he had risen in the State of New York by successive steps, as county sheriff, mayor of Buffalo, and governor, and gained wide renown as an administrator; he was in favour of economies, honestly devoted to the public welfare, courageous, industrious, and discreet. These qualities he carried (March 1885) to the Presidency. The reactionary change predicted of an administration which was brought into favour so largely by Southern votes was not realized. President Cleveland surrounded himself with counsellors of his Democratic creed in whom the whole country might confide. He respected the principle of civil service stability, though yielding in some cases to local party pressure for removals, so that for the first time in more than half a century a radical change of national parties in the United States was followed by no general sweep of the offices. At the same time he firmly held, as Washington had done, to the constitutional authority of a chief executive over both appointments and removals; and when Senate opponents sought to elicit reasons from him as to certain changes he had seen fit to make, he positively refused to give them. His exercise, moreover, of the veto power was prompt and fearless, and the more so, since the Senate remained against him. No Bill for a private pension or bounty was too petty in amount to elude scrutiny as to the justice involved, while vast appropriation Bills which tended to paternalism or pauperism by the Government he promptly returned to Congress with his negative.

Forty-ninth Congress, 1885-87.

Inspired by such an example, though Cleveland's party strength lay only in the House, the forty-ninth Congress made a sound and sensible record. To adjust better the relations of executive and legislature, the Tenure of Office Act, passed in 1867 to restrain an obnoxious President, was finally repealed; the order of Presidential succession in case of death or inability in the two highest offices was so changed as to devolve authority strictly in the executive line; and definite provision was made for counting the electoral votes should Senate and House disagree. Other wise measures were the Inter-State Commerce Act, which placed common carriers under national supervision for foreign and inter-State traffic; the grant of lands in severalty to Indians, in pursuance of a just civilizing experiment; and an appropriation for the noble and commodious building of the Congressional Library, since erected.

A prosperous administration.

The happy spectacle was now presented of national prosperity, peace, and harmony. The Southern States were once more contented within the Union, and capital poured in to exploit their mineral resources and develop new industries. The public revenues far exceeded all reasonable demands for the efficient support of Government, and a surplus was piled up in the Treasury beyond immediate wants. So far as possible, outstanding issues of the public debt were called in for redemption; and while Union pensions of the Civil War required a large and increasing outlay beyond the normal expenses of the nation, yet the surplus grew, and constituted a temptation to extravagance, which the administration, however, sought to avoid. The postal service, well managed, became nearly self-supporting. The naval establishment was modernized and its efficiency increased. The finances of the Union were prudently cared for, gold payments were maintained, the circulation of the national banks was gradually contracted; and while the authorized purchase of silver was somewhat of a menace to stability, Congress refused to sanction an unlimited coinage. The wheels of routine went smoothly, and in September 1887 Philadelphia celebrated the first centenary of the Constitution in a three-days' public festival, at which the President bore official part.

Fiftieth Congress meets.

The autumn elections of 1886 had gone favourably to the administration, and the new House of Representatives, like its predecessor, was controlled by the Democrats. All things betokened Cleveland's nomination for a new term and his re-election. The Senate opposition, though strong enough to defeat important treaties, for which a two-thirds vote was essential, showed an increasing respect. But Cleveland jeopardized all chances of re-election by attempting to lead his party to the higher plane of aggressive principle. Recognizing an intelligent demand to reduce the increasing Treasury surplus, not by wasteful expenditure but through a reform in the tariff, he threw down the gauntlet, when the fiftieth Congress first met (December 1887), and discarding precedent devoted his whole annual message to that subject, instead of reviewing the general current of the year.

Cleveland's tariff reform issue.

By this time the idle surplus revenue amounted to upwards of $55,000,000, and would by the end of the summer increase probably threefold; all the outstanding public debt, moreover, which admitted of immediate retirement had been paid off. Hence the message proposed radical relief from the hardships and inequalities of existing tariff laws—the legacy of Civil War, the worst defects of which remained after twenty years of peace. "It is a condition which confronts us, not a theory," observed the President, deprecating all theorizing upon opposing ideas of protection and free trade, and proposing simply to reduce taxation to the essential wants of an economical public establishment. The House majority set to work to carry out the policy thus outlined; and a Bill known as the "Mills Tariff," from its author and champion, the chairman of the Ways and Means Committee, passed that body in July after an exhaustive debate, and then was suspended in the Senate.

Defeat for re-election.

Upon this issue of tariff reform, so suddenly projected into the canvass, was fought the Presidential campaign of 1888. At the National Democratic Convention held at St Louis in June, Cleveland was unanimously renamed for President. The Republican Convention at Chicago, during the same month, made Mr Benjamin Harrison its nominee after prolonged balloting, and pronounced for protection as the true doctrine for American industries. There had now passed from the scene that generation which, under President Polk in 1846, tried a low-tariff policy and sustained it with satisfaction, regardless of party or of former predilections, until Civil War with its ravenous necessities forced up once more the scale of duties, thereby reviving those older Whig tenets of Clay and Webster which came by inheritance to the new Republican party. Northern manufacturers had now come to demand of Congress more than ever a sedulous monopoly of the home market. The campaign was vigorously fought, but while Cleveland's own supporters were doubtful and divided over the new platform he had forced upon them—since recent party contests had been fought upon sentimental issues—the Republicans rallied the vested interests on their side, while capitalists contributed largely from their means to keep trade and their own special interests undisturbed. Cleveland was hindered, moreover, partly by the prejudice still strong in Northern States against the party of the once disloyal South, and partly by his own honest bluntness and want of tact, which had made secret enemies among the party managers. The efforts of both parties were directed mainly to the four doubtful Northern States which held the balance of power—all the once slave-holding States being still clearly Democratic. Two of those doubtful States, New Jersey and Connecticut, voted in November for Cleveland; but Harrison won his own State of Indiana, and carried New York by some 15,000 votes, notwithstanding that a Democratic State governor was chosen. The result was that Cleveland was defeated by a narrow electoral margin, though the vote through the entire country showed a popular majority in his favour.

Close of fiftieth Congress.

The final session of the fiftieth Congress that winter completed the first century of national existence under the Constitution of the United States. Four new States now found admission — North Dakota and South Dakota (two States from a single Territory), Montana, and Washington. President Cleveland retired in March 1889 with the respect and confidence of a re-united people, to whom he had demonstrated that national patriotism and capacity were not monopolized by one great party or another, and that the Union had regained at length a salutary condition of political equilibrium.

President Harrison, 1889-93.

Benjamin Harrison was of an illustrious ancestry, which dated back in England to the Regicides. He was the grandson of a former President of the United States, and the great-grandson of a Virginian who had signed the Declaration of Independence. His strength lay rather in his steadfast loyalty to his political associates than in any individual traits of character; he was a sure exponent of the Republican principles now prevalent, and one unlikely to perplex his party by a headstrong independence. He was small of stature, a lawyer of repute, a ready speaker, and influential in the close State of Indiana, with which he had been identified from childhood. During the Civil War he had led a volunteer regiment to the front, and from 1880 to 1886 he had served a term in the United States Senate; and though not very conspicuous in either career, his record had been an honourable one.

A protective tariff.

In March 1889 he organized a creditable administration, and followed the good example set by his predecessor in awarding the civil patronage; and when the fifty-first Congress met in December, with a working Republican majority in both branches, he recommended a new protective tariff law. Mr McKinley (afterwards President) reported accordingly from the Ways and Means Committee a Bill, soon styled by his own name, which, though nominally for equalizing duties and reducing the revenue, fixed high rates and promised bounties. At the later instance of the State department, the measure, as finally passed, provided for reciprocity through special treaty with other countries.

Fifty-first Congress, 1889-91.

This Congress in its two sessions was wasteful of the Treasury surplus, reversing the economies of the preceding administration, and was unchecked by executive veto. A general Pension Bill, lavish in its allowances, passed without hindrance, and private pension Bills by the score. Under a gradual pressure, moreover, from silver-mining States, using their equal suffrage in the Senate, the purchase of silver bullion was now increased to $4,500,000 a month, thus loading up the Treasury vaults, and, through depreciation of the white metal, threatening a ruinous exchange in the common standard of value from gold to silver. Idaho and Wyoming, formerly Territories, were brought into the Union as States. Postal subsidies were carried, also a refund to loyal States of the direct tax levied in 1861. After much discussion a "force Bill" for controlling Federal elections at the South failed, as also a measure for the free coinage of silver, for which was substituted the bullion purchase just mentioned. To the credit of this Congress were enactments for relieving the Supreme Court by constituting lower tribunals of appeal, for international copyright, and for restraining the growing monopoly of trusts and combinations in trade. The surplus was spent, and so largely did appropriations exceed all former precedent in times of peace, that this was stigmatized as "the billion dollar Congress."

Foreign relations.

Among the treaties of Harrison's term was a tripartite arrangement concerning the Samoan Islands with Germany and Great Britain, which gave omen of a coming departure from the traditional policy of continental confinement, so as to extend American influence, conjointly with that of European Powers, far across the Pacific. Negotiations were also begun with Russia and Great Britain as to Alaska and Bering Sea.

Census of 1890.

The census of 1890 brought some interesting facts to light concerning the population of the United States. From 50,155,783 in 1880 the total had now reached 62,622,250; but the rate of increase was less than that of the previous decade, less than that normal advance which had doubled the aggregate numbers of the American people about once in thirty years. Males had increased in number more rapidly than females during the past ten years, owing probably to an excessive influx of adult manual labourers from abroad. The proportion of inhabitants of foreign parentage of both sexes was approximately one-third of the whole population. Notwithstanding the enormous territorial expansion of the Union in the course of a hundred years, the density of its population was now more than four times that of 1790, when the national experiment fairly began.

Political discontent.

The autumn elections of 1890 throughout the country showed great discontent with this administration and Congress. It showed, too, an irresistible popular drift towards ex-President Cleveland, regardless of election precedents or the schemes of party managers for shelving him permanently. When the fifty-first Congress came together in December 1891 after the usual long interval, the Democrats had a majority in the House and the Republicans only in the Senate. In such a condition legislation was at a deadlock, and discussions took the place of business. Labour disturbances had begun in various parts of the country; a riot broke out at the Carnegie steel-works in Pennsylvania, which private detectives were hired to resist. Free coinage was once more pressed in Congress by the silver advocates, and test votes showed that the Democrats themselves were greatly divided upon that issue. By an Act of 1892 the immigration of Chinese labourers was forbidden.

Cleveland elected over Harrison.

A new Presidential campaign was opened; the Republicans (June 1892) in Minneapolis renominated Harrison, while affirming protection linked with reciprocity as the true tariff creed. At the Democratic Convention, held in Chicago the same month, underhand political efforts had been made to suppress Cleveland's candidacy, but such was the popular pressure that his renomination was carried on the first ballot by more than the needful two-thirds vote. While party Democrats made issue against the McKinley tariff and wasteful expenditure, they showed that, like the Republicans to a certain extent, they were susceptible to a new wave of Socialistic sentiment which was now sweeping over the West. A "Farmers' Alliance," formed in 1891, had merged into a "People's Party," which called for free silver coinage, Government railways and banking, a graduated income tax, and public lands for settlers only. With these "Populists," as they were called in the West, the Democrats inclined to fuse. Cleveland swept the country with an unexpectedly large electoral and popular vote, and was in fact chosen President without needing New York, which nevertheless went for him. For the first time since 1861 the Republicans lost control of the executive and both branches of Congress.

President Cleveland's second term, 1893–97.

On 4th March 1893, for the first time in history, a President returned to the White House which he had once vacated, to resume official authority and succeed his own successor. Cleveland's new inaugural address was in a serious strain, as though foreboding the business distress of the country now near at hand, and his own doubts about uniting upon a judicious line of policy the new and incongruous elements that had borne him back to power.

President Cleveland now recalled from the Senate, convened in extra session, a treaty for annexing the Hawaiian Islands, which his predecessor had recently submitted. Americans at Honolulu, long ambitious of annexing those islands to the United States, had (January 1893) precipitated a revolution against the Hawaiian race and monarchy, probably aided actively by an American naval force under the advice of the United States consul. With Queen Liliuokalani summarily deposed, a provisional republic was set up, and a gift of the islands tendered by the white oligarchy to the United States. Meanwhile the stars and stripes had been hoisted at Honolulu as symbol of an American protectorate. But the President now despatched a special commissioner, who, after a full investigation, hauled down the flag as an act of reparation, ordered the garrison of American marines back to their ship, and brought the protectorate and annexation to a summary end. Mediation for restoring the deposed queen proved impracticable, however, and the new republic of Hawaii was left to itself during Cleveland's administration, Congress taking no action on the subject.

The World's Fair at Chicago.

Chicago opened in May its "World's Columbian Exposition," an enterprise commemorative of the discovery of America, to which Congress had generously contributed. The President took part in the opening ceremonies, and a marvellous white city of delicate creation and with fine landscape effects drew for six months increasing crowds from the continent and abroad, making a signal success.

Financial distress.

But dark clouds were already closing upon the financial horizon. Already the political canvass of 1892 had disclosed dulness, distress, wage reductions, and riotous strikes in various quarters; houses and farms in the West and centre of the Union were heavily burdened with mortgage debts. Investment companies had placed loans recklessly; railway building had been pushed too far into the wilderness. Trade had overleaped its limits, and now receded. Waste and corruption had grown with enterprise. The old cycle of boastful prosperity rounding to an end, contraction and pinching want were inevitably to follow. In the painful reorganization of industries which presently set in with bankruptcy and liquidation, Western cities of late promise were sharply arrested in development, the Western farmer was heavily indebted to the Eastern investor, and the whole broad region beyond the Mississippi, with its rich resources, seemed almost literally mortgaged through corporations to the old Northern States of the Atlantic coast. All had to suffer loss; but the great debtor class grew hostile to their less impoverished creditors, and turned to desperate expedients for bettering their own condition.

Fifty-third Congress; silver repeal.

To deal with so perilous a situation, President Cleveland convened the fifty-third Congress for a special session; and when that body met early in August he sent a message which charged the new financial crisis largely to the forced purchase of silver bullion by Government under the compromise legislation of 1890. He urged the immediate repeal of that measure, and he now appealed, as to men above the plane of party politics, that experiments opposed to a sound and stable currency should be abandoned. Though Cleveland's views were entertained by financiers, and were strongly prevalent Eastwards, it was hard to bring his party supporters into line, so largely was the Democratic majority in sympathy with debtor constituencies or with such as favoured free silver. Even in the House only a minority of the President's own party sustained him, and repeal was only carried by the aid of the "sound money" Republicans; while in the Senate the disposition was to dally and postpone, until by dint of earnest executive pressure Cleveland at length carried his point, aided by Republican opponents and deserted by many of his professed partisans. The new Bill was signed, silver purchases ceased, and this extra session closed on the 3rd of November.

Reform Tariff Act.

At the second or long session, which followed a month later, with both branches organized by a Democratic majority, the President found himself again at issue with a large part of his nominal followers. "After a hard struggle," observed the opening message, "tariff reform is directly before us"; and Cleveland made heroic efforts to fulfil his party pledges. The Wilson Tariff Bill (named from the committee chairman who championed the Bill in the House) finally became law, with an income-tax amendment. It relieved in large measure raw materials from taxation. The measure in its final shape was a great disappointment to tariff reformers, though something in the new direction had been gained. The President himself concluded neither to veto nor approve, but allowed it to become a law without his signature.

Fifty-third Congress incapable.

In other respects this heterogeneous Congress showed incapacity for enacting good measures, though it repealed some that were bad—the remnant of federal election laws, for instance, which was a legacy of reconstruction. In the second session a partial free silver Bill passed both branches of the Legislature by large majorities under the specious design of "coining the seigniorage," but the President's veto killed it. Utah was in 1894 admitted as a State. Currency and finance engaged the third and final session of this Congress, but the controlling influence of both Houses had set at length so strongly against the administration policy of a gold standard, and in favour of at least some form of bimetallism, that no acceptable measure could be passed. To add to Democratic discomfiture, the Supreme Court now pronounced the income-tax illegal, unless apportioned as the Constitution prescribed for "direct taxes." Times continued hard, trade was depressed, current revenues under the new tariff failed to meet current expenses. Heavy drafts, too, were made upon the gold reserve of the Government. The President asked Congress to permit an issue of bonds payable expressly in gold, and he made evident the economy of making such assurance to the lender; but permission was not given, and under an earlier and defective law the administration borrowed in order to uphold the gold standard.

Fifty-fourth Congress, 1895-97.

In the autumn elections of 1894 business distress and dissensions, which showed that the Democratic Congress and Democratic administration had drifted far apart, caused a heavy defeat at the polls; and the fifty-fourth Congress accordingly met (December 1895) with a large Republican majority in the House and an almost even division of parties in the Senate. No legislation of consequence could be carried for the rest of Cleveland's term. A restless war spirit had been engendered, while Cuba, near at hand, was seen in violent revolt against Spain. For a brief space the President turned this disposition against Great Britain, when a boundary dispute sprang up between the British Government and Venezuela; but arbitration soon followed, and the excitement ceased. When, in the course of a great railway riot in Illinois, danger arose of an organized assault upon vested property, and the governor was nerveless, Cleveland despatched Federal troops to the scene and courageously restored order.

Democratic defeat in 1896.

The Presidential canvass of 1896 showed Socialistic effort against not plutocracy alone, but the plain business interests of the people. So greatly had the Democracy now yielded to new influences, that its party Convention at Chicago, refusing by a large majority to praise the retiring leader for his course as President, demanded silver coinage at a ratio of 16 to 1 for gold, and made close fusion with Populists of various shades of opinion. Mr William J. Bryan, of Nebraska, became the candidate of three party Conventions, whose common purpose was the free coinage of silver at the ratio of 16 to 1. The Republicans at St Louis nominated Mr William McKinley, framing a platform looking to gold and sound currency, while renewing their adhesion to a tariff of protection with reciprocity; and the "gold Democrats," the last of President Cleveland's unflinching friends, named independent candidates. Such was the menacing industrial danger in Bryan's candidature that the conservative vote of the Union drifted to the Republican side, and by a decisive electoral and popular majority McKinley was chosen in November, carrying all the Northern states east of the Rocky Mountains, hitherto doubtful, together with those usually classed as Republican. Cleveland retired in the following March, with general respect for the courage and honesty he had so signally displayed, as some solace for the political submersion of his most cherished plans.

President McKinley's first term; protective tariff.

Mr William McKinley, whose term of Presidential office now began (4th March 1897), had honourably served in the Civil War, in the House of Representatives, and later as governor of Ohio. A Republican of good standing, and author of the tariff Bill passed under President Harrison, he was quite unlike his predecessor in temperament. He watched carefully the current of public sentiment, rarely expressed positive opinions, and showed considerable tact and political suavity in his public conduct. Senators were now deferred to, and Congress was kept in easy touch so that legislation might move harmoniously. In finance McKinley showed at the outset a disposition to conciliate the silver advocates by pressing bimetallism upon the notice of European Powers, and sending delegates to an international conference on that subject; all this in the end, however, proved barren of results. Congress met in extra session, March 1897, under his proclamation, with a House overwhelmingly Republican, to legislate for the emergency created by Government receipts falling far short of expenditure. The Dingley Tariff Bill (once more named after the House chairman of the Ways and Means Committee) was reported in the House, embodying anew the Republican doctrine of high protection and reciprocity, and after passing the usual ordeal of Senate amendments which were adjusted in conference, it became law in the summer. Appropriation Bills, too, which had failed towards the close of Cleveland's term, were promptly renewed and passed.

Fifty-fifth Congress; war with Spain.

The second and long session of this fifty-fifth Congress, which began in December, proved an important one by launching the United States into a war with Spain over Cuba, and providing strenuously for the emergency. Sympathizers with the Cuban revolution combined with those who were still eager for national exploit and aggrandizement and weary of prosaic peace. Congress showed a peremptory disposition to intervene in Cuba, and just at the time when the negotiations with Spain tended towards a hostile issue, the U.S. battleship *Maine* was blown up in Havana harbour, probably by some submarine mine, on the night of 15th February 1898, and 260 American seamen lost their lives. This vessel's visit had been ostensibly received by the island authorities of Spain in a friendly manner, and they denied all complicity in the outrage; but Americans disbelieved this, and such was the popular outburst of indignation that intervention in Cuba followed almost of necessity. President McKinley sent his ultimatum to Spain, despite that Government's disclaimer and its earnest efforts to meet all objections recited against its insular policy short of relinquishing sovereignty. McKinley's war message, 11th April, proposed intervention in the name of humanity in order to secure to the Cubans a stable government of their own. But that message did not recognize the revolutionary government on the island as a rightful republic or as a belligerent. With a like reservation Congress in both branches strongly sustained the President, and on the 25th a joint resolution declared war as already existing by Spain's rupture of official relations. As early as March large appropriations had been made for national defence, and now an ample war revenue Bill, which imposed stamp, licence, and succession duties, with increased taxation on liquor, beer, and tobacco, and in various other directions, passed both Houses by immense majorities, and became law with executive approval. To unite the military capacity of all sections, the last of the disabilities placed upon the South after the Civil War were now removed, Confederate heroes still alive receiving national commissions; and while both volunteers and regulars were enrolled for a hostile army force, the navy was increased in efficiency at corresponding outlay.

Conduct of the war.

The war with Spain began and ended at distant Manila, the capital of the Philippines. Commodore Dewey, of the U.S. Asiatic squadron, sailed under the President's order from Hong Kong to strike a blow at the Spanish possessions in the Pacific islands. At early dawn of 1st May, Dewey's squadron entered Manila harbour, sighted the Spanish fleet at the other end of the bay, and after a brisk encounter of several hours succeeded in destroying all the enemy's vessels and disabling the shore battery at Cavite, without the loss of a ship or a seaman. It was a remarkable victory, due largely to superior gunnery on the American side. In other respects this war with Spain was largely a naval one, signal superiority being shown by the United States. Cervera, the Spanish admiral, having sailed in April from Cadiz for the Cuban waters with a considerable fleet, brought his vessels into the narrow harbour of Santiago de Cuba, where they were bottled up, unable to elude the vigilance of acting-Admiral Sampson, who blockaded the coast with an American fleet. An American military force under General Shafter landed in Cuba and threatened Santiago, so that Cervera made a desperate effort (3rd July) to dash out of the harbour and escape, but in so doing he lost all his vessels by capture or destruction, and Santiago soon after surrendered. General Miles, the American general commanding, made dispositions in July for the capture of the island of Porto Rico, but the inhabitants yielded themselves joyfully to American control. Finally, in the Philippines, where Dewey remained with his fleet, land reinforcements arrived under General Merritt from the Californian coast; Manila capitulated in August just as the peace protocol was signed at Washington. A Spanish relieving fleet seeking to approach the Philippines by way of the Suez Canal had already been forced to return home.

Peace arranged with Spain.

Peace negotiations were opened in the latter part of July through the French ambassador at Washington, acting on behalf of Spain. In accordance with a protocol agreed upon, commissioners from the two belligerents met by-and-by in Paris to arrange a treaty. The American administration had by this time become fully possessed with the idea of commercial expansion towards China and colonial acquisition. During the summer of 1897 the President had submitted a treaty with the republic of Hawaii for incorporating those islands as an integral part of the United States, but public sentiment appeared reluctant, and Congress only yielded consent when in the midst of this war the President urged annexation as essential to naval operations. And now the administration demanded from Spain as the price of peace the cession of the Philippines as well as Porto Rico and the relinquishment of all sovereignty in Cuba. Spain argued in vain against the requirement of the Philippines, but was appeased by the present of $20,000,000 from the United States, while all other claims of war indemnity were forborne on either side. The treaty was signed by the commissioners in Paris, 10th December 1898, and ratified by their Governments early in the following year. In the entire four months' campaign which brought this war to a practical end, the United States lost in fight not a flag or a vessel, and, except for the one daring instance of a naval exploit by Lieutenant Hobson at Santiago, not one of its soldiers or sailors was taken prisoner.

Cuba, Porto Rico, and the Philippines.

When Congress met in final session (December 1898), the Philippine acquisition provoked great controversy; and though the needful votes were gained in the Senate for confirming the treaty as submitted, a war now followed with the native races of the Philippines. McKinley's administration treated them as virtually bought from Spain with the soil, and a struggle for racial independence broke out. The struggle continued, though President McKinley sent a commission to deal with the insurgents, whose constituted government had placed Aguinaldo at the head of affairs. Congress took no definite action, but virtually left the whole matter in the hands of the President. Towards Cuba the pledge of autonomy was renewed, and a constitutional convention was called; but the United States remained in military control as protector until 1902, when the American military governor-general and the American troops were recalled, and the government was turned over to the new Cuban Republic. Porto Rico became by cession a territorial domain of the United States.

The fifty-sixth Congress was convened in December 1899, with a working Republican majority in both

Fifty-sixth Congress; currency and finance, &c.

branches, and an unusual spirit of harmony with the Executive. With a new commercial expansion, improving business conditions among the people, and a large surplus accumulating through war taxation in the Treasury, the opportunity now came for legislation favourable to a permanent gold standard and currency reform. A Bill with this object passed Congress and was approved by the President (March 1900); it also refunded a considerable part of the public debt at the rate of 2 per cent., and promoted the absorption by banks of the new loan. Dissension, however, arose over the unequal tariff Bill for Porto Rico, but the Act, as finally passed, levied light duties for a short time upon imports into the United States from Porto Rico, but made a gift to that island of the customs already collected there. Hawaii, on the other hand, received from Congress equal trading rights.

Presidential campaign of 1900.

Appropriation Bills having been passed, this session closed in June, a date unusually early, so as to prepare for a new Presidential campaign, in which McKinley and Bryan were to be the chief opposing candidates, as in 1896. The former was nominated in June for a second term by the Republican Convention at Philadelphia, the latter at Kansas City in July by the Democrats, with such Populistic and "free silver" alliance as still remained to unite in his personal support. To this was added a small anti-imperialist element which strongly protested against the new policy of acquisitions of distant territory. An anti-foreign uprising in China led, during this summer, to a joint military relief movement towards Peking, in which the United States took part with the chief European Powers. The aim of American diplomacy has been to bring about the "open door" policy in Chinese commerce, without disturbing Chinese autonomy.

Trusts had been a recent outgrowth in the industrial world against which both parties were nominally arrayed, amalgamation into colossal corporations being the latest phase of such combinations. How to check and control fundamentally such combinations was left unsettled by this Presidential campaign, but the Democrats made chief use of the issue in their canvass.

President McKinley re-elected.

Mr Bryan, a remarkable orator, made an unprecedented stumping tour on behalf of his own candidature, while Theodore Roosevelt, the Republican nominee for Vice-President, canvassed quite as strenuously for the administration ticket. But the young leader of the Democrats still repelled the Independents and most of those of his party who had supported Cleveland; the more so since he had insisted upon a positive declaration for "free silver" in the party platform of 1900, as in that of 1896. The fact that trade had reacted from its long depression was against his candidature once more, and prosperity rallied voters to the Republicans. The November ballots showed McKinley victorious for re-election to a second term, with a larger electoral vote and with a larger following in Congress than before. The majority of McKinley over Bryan in the electoral college was 137, the former receiving 292 votes and the latter 155. The total popular vote cast was 13,970,300, of which McKinley received 7,206,677 votes and Bryan 6,374,397 votes.

Hay-Pauncefote treaty.

In the course of the short final session of Congress the Hay–Pauncefote treaty, negotiated with Great Britain, and dealing with the construction of an inter-oceanic canal near the Isthmus of Panama, was discussed by the Senate in executive session, and in December was amended by eliminating the neutrality clause and declaring the old Clayton–Bulwer convention superseded. This amendment Great Britain declined to accept; but a new treaty was negotiated between the United States and Great Britain, and ratified 16th December 1901 by the Senate. Army reorganization, an apportionment of representatives under the new census, and a reduction of the war taxation which had created a large surplus in the treasury were leading results of legislation at this final session. Both Houses (January 1901) adopted resolutions of sympathy with the British people on the death of Queen Victoria. By an amendment to the army appropriation Bill (known from its mover in the Senate as the "Platt Amendment"), the potential control of the United States in Cuban affairs was asserted more strongly than before. To this amendment the constitutional Convention of Cuba acceded after some reluctance (see CUBA).

President McKinley's second term.

At the second inauguration of President McKinley (4th March 1901), there was a great military and civic pageant at the Capitol, beyond former example. No breach was made in the former group of Cabinet advisers, all of whom were confirmed by the Senate, except for a change occasioned somewhat later for private reasons in the office of Attorney-General. During a brief executive session of the Senate, the new Vice-President, Theodore Roosevelt, occupied the chair for the first and only time. The United States Supreme Court, shortly before adjourning in May, announced its position on the question whether the Constitution of the United States extended *ex proprio vigore* to the new insular dependencies. In the case of De Lima *et al. v.* Bidwell action was brought to recover rebate of customs duties collected on goods imported into the United States from Porto Rico after the cession of the island by the treaty of Paris in 1899, and before Congress passed the Foraker Act imposing a new schedule of duties on such imports. The Court decided that the collection of duties in the given instance was unconstitutional. In the case of Downes *v.* Bidwell, suit was brought to recover similar duties collected after the passage of the Foraker Act. In this case the duties were declared constitutional, the Court holding that although after the treaty of Paris Porto Rico was a territory appurtenant and belonging to the United States, still it was not a part of the United States within the revenue clauses of the Constitution, which provide that duties shall be uniform throughout the United States. In each of these cases the decision was by a bare majority of the Court, four of the nine judges dissenting. The decisions in these test cases, and in others brought in this Court with reference to the new revenue establishments in Porto Rico, Hawaii, and the Philippines, together with further decisions under the new doctrine, which were rendered in the succeeding term, have apparently determined that Congress has the power to discriminate among constitutional rights in Territories belonging to the United States, so as to withhold the equal conditions hitherto enjoyed in such annexations, until the Territory has been admitted into full Statehood. In other words, the Constitution in its entirety does not necessarily apply to Territories of the United States, but they are rather under the control of Congress; yet "where the Constitution has been once formally extended by Congress to Territories, neither Congress nor the Territorial legislature can enact laws inconsistent therewith."

With military aid a civil Territorial government was started by President McKinley, 4th July, in the Philippine Islands, Aguinaldo, the chief of the natives fighting for independence, having been captured by stratagem during March, and placed in confinement. On the anniversary of the American occupation of Porto Rico, 25th July, President McKinley proclaimed free trade between that island and the United States, and the organization of a local Territorial establishment followed, with a governor appointed at Washington.

Assassination of President McKinley.

In September 1901 the President visited the Pan-American Exposition in Buffalo, and on the 6th, while holding a public reception in one of its buildings, he was shot twice with a revolver by one Leon Czolgosz, a native of the United States, but of European parentage. One bullet glanced from his right breast, but the other, after passing through the stomach, lodged in the muscles of the back, and could not be extracted. He died from the effects of this wound in Buffalo, on the 14th of September. Impressive funeral services were held at the Capitol in Washington on the 17th, where the body lay in state in the rotunda; and afterwards the remains were borne by train to Canton, Ohio, the President's home, where the last services were held and the final interment took place. The popular grief and sorrow were universal, and expressions of profound sympathy came from foreign countries. The assassin, a professed anarchist, was indicted in Buffalo for murder of the President, and, being found guilty after a short trial, was executed in Auburn prison, N.Y., on the 29th of October.

President Roosevelt's accession.

Vice-President Theodore Roosevelt had meanwhile succeeded to the Presidency upon McKinley's death, taking unostentatiously, on the 14th of September, the oath of office prescribed in the Constitution. At his request, all the members of his predecessor's Cabinet retained their portfolios, but in January changes were made for personal reasons. The fifty-seventh Congress assembled 2nd December. The message of the new President was well received, and the long session opened with the Executive and the two branches of Congress firmly controlled by the Republican party. The result of the November elections was, on the whole, highly favourable to the administration in most of the important States, excepting the Southern section, which continued Democratic. Efforts to reunite the national Democracy met with little apparent success north of Maryland and Kentucky. In Pennsylvania, inclusive of Philadelphia, a fusion of the local voting elements for putting down Republican corruption failed; while in New York City a corresponding fusion of the voters against the local Tammany (or Democratic) misrule carried Seth Low, a Republican in national and an independent in local politics, triumphantly into the mayor's chair, and secured the election of his associates on the Independent Reform ticket.

Fifty-seventh Congress.

Various important matters of legislation occupied the attention of Congress during its long session. By one of the earliest measures which passed both Houses and became law, a tariff was imposed upon imports to the Philippines, superseding the military regulations in that respect, which the Supreme Court of the United States (2nd December 1901) had pronounced invalid on the ground that, until Congress asserts its own will towards new Territorial possessions, no tariff barrier is presumed to exist. The question of an Isthmian canal provoked much discussion. The commission of 1899, after prolonged investigation, reported, shortly before Congress met, in favour of the Nicaragua route as on the whole the most feasible and practicable for construction and ownership by the United States. This report was transmitted to Congress when that body met in December. Later, however, the French Panama Company, whose previous demands for their unfinished works and goodwill had been deemed inadmissible, made a definite offer to sell out to the United States for $40,000,000, conveying a good title; whereupon the Canal Commission made a supplementary report on 18th January 1902 declaring their preference for this rival route under terms so favourable. This report was referred at once by the President, and Congress at the end of June passed an Act which empowered the President, in case the French company could and would pass a good title to all their property and work at Panama for not more than $40,000,000, and in case the Colombian Government would make a satisfactory grant of authority to the United States over the territory through which the canal would run, to have work begun at once on a canal at Panama. In case of failure of the French company to pass a good title, or of the Colombian Government to make the necessary concession, the President was to open negotiations for a canal at Nicaragua, and begin construction. It is hoped that under this Act active work on the canal will soon be begun.

Another topic of immediate interest was that of reciprocity with the Republic of Cuba in matters of tariff revenue. President Roosevelt, like his predecessor in office, espoused earnestly such a policy on the ground of plighted faith by the Government and the liberal dealing to which the Cuban people were justly entitled from the nation by whose arms and intervention their independence had been won. But as reciprocity called for the immediate reduction by Congress of the high duties imposed upon sugar and tobacco imported into the United States, strong pressure adverse to such reduction was brought to bear upon the two Houses by American protected interests, and notably by those engaged in the new native industry of beet-sugar; hence the sentiment of the Republican majority in Congress was greatly divided, and no Bill was passed. At the first Cuban election, 31st December 1901, the Liberal candidate, Mr Tomas Estrada Palma, was chosen President of the new and independent republic, and the experiment of self-government in that island under the friendly auspices of the United States was begun.

Another important Bill passed by the Congress was that for the civil government of the Philippines. This provided for a census, and two years later, in case peace prevailed, for an Assembly or Congress in the Philippines composed of two houses; an upper house of eight members, five Americans and three Filipinos, all appointed by the President, and a lower house of representatives chosen by property-owners and those who could speak Spanish or English. The rebellion in the Philippines had been so far crushed that on the 1st July 1902 the President abolished the office of military governor-general, recalled a considerable part of the troops, and placed those left under the control of the civil authorities. At the same time he issued a general pardon to all rebels and political prisoners who would take the oath of allegiance to the United States. (J. SCH.)

V. LITERATURE.

The literature of the United States in the last quarter of the 19th century was distinguished by no name equal in eminence to those of the authors who established their fame in the preceding period, and by no work which made the impression of a classic either at home or abroad. Lowell's "Commemoration Ode," which is not more defective than many another great ceremonial poem, and which, as the loftiest and most interesting literary memorial of a momentous crisis, must retain historical prominence, was the last American work in verse that can lay claim to that distinction; and, in serious prose, Parkman's histories, already begun by 1864, have a similar commanding position. Parkman and Lowell belong, together with Whittier and Holmes, who lived into the later time, to the elder group of which Emerson, Hawthorne, and Longfellow were, in *belles lettres*, the memorable names. The generation that came to the front in succession to these, and for the most part still survives, has not struck so deeply into the minds or the affections of their countrymen. Especially is this true of the fine art of literature, the imaginative and critical work, whether novel, essay, or poem. In the large departments of science, theology, and learning there has been a steady gain in systematic knowledge and scholarship and the results of research, and the putting forth of these in books has enhanced the national reputation in these fields of intellectual labour; but literature, in the narrower and polite sense, has had a less favourable fortune.

The broad social conditions which have influenced literary production are perhaps too general in scope and too subtle in operation to be recognized clearly or stated briefly. There may have been some exhaustion in moral motives after the Civil War, and there appears to be a change in culture among the educated classes, which for the purposes of literature amounts to a decline, and it may seem to some observers that the objects that receive attention are inferior in worth. The literature actually produced, however, possesses definite marks which indicate traits of its environment. Its miscellaneous nature, the blended pursuit of prose and poetry and of higher and inferior kinds by the same authors, the brevity and temporary effectiveness of much of their work, are obvious characteristics; and there may be reasonably associated with these the great expansion of journalism, the power of the magazines in dictating limits of taste and of treatment as well as objects of attention, and—what is another phase of both these agencies—the democratization of the reading public. Journals and magazines have been the chief promoters of literature in the sphere of the essay, novel, and poem, nor has the pursuit of history been unindebted to them. Their position has been a cardinal one; they make, so to speak, the literary climate. They have affected the productions of authors, as a class, more than the colleges have formed their minds. Few, indeed, are the imaginative and critical writers who have not habitually been in touch with the public most directly through periodicals and papers. Condensed views and rapid writing have been stimulated. The short story, the cameo forms of verse, reminiscences, nature-studies, scenes from abroad —all that can be packed into little room—have thriven; and if longer works have been sought, they are such as could partake of the same brief and concentrated literary form by virtue of effective arrangement as serials. Authors have turned from one to another of these with versatility; but a general sense of something small in the results is unavoidable. The magazine and journal cannot supplant the book as a governing mould of artistic thought; and the extent to which they have displaced it is one measure of general inferiority. It may reasonably be suggested that some connexion exists between an environment which encourages clever versatility by material gains and ready notoriety, and the remarkable absence of that singleness of aim which belonged to Emerson, Hawthorne, and Longfellow. It may be observed also that neither race-heredity nor the tradition of academic culture, so controlling in these three, is noticeable in the men of the later period. The prevalent insistence in the novel on accuracy of observation and truth to actual fact, as if these by themselves were sufficient for literature, and the interest in provincial life which produced the most characteristic *genre* of the period in the dialect novel, are also to be reckoned limiting influences, though they were favourable to the multiplication of books. An immense popular demand for the novel, and also for anything touching the national history, has had great determining power on the attention of authors to theme and treatment; and the increased employment of women as writers is a factor of consequence. For the most part, authors have written out of and for the present hour, in the most temporary sense. Fecundity, versatility, and miscellaneousness characterize the general product; historians, essayists, novelists, and poets have afforded an interesting and voluminous mass of writing; but an average of excellence which, regarded as an average, is high, has been found consistent with a lower degree of individual eminence.

The historians.

In the historical field the increase of value in the substance is quite as notable as the decline in the power of style; and here, if anywhere, an exception should be made to the general characterization of the literature of the period as an inferior kind. The later writers have fallen heir to a deeper national self-consciousness, and respond to an overwhelming popular demand for knowledge of American beginnings, of the spread through the wilderness, of the lives of the founders, and of military and civil heroes. The history of the Civil War makes up a special literature in which the period has been rich, largely the work—like the *Memoirs* of General Grant (1822–1885)—of those who participated in it. The most important work in the general field is the *History of the United States*, 1801–1817, by Henry Adams (born 1838); in it the research of many years is stored by a mind distinguished by political acumen, incisive power, and firm judgment, experienced in state affairs; here is shown on the broad scale what the author's lives of Gallatin and Randolph evinced by way of monograph in capacity of detail, as well as that understanding of American statesmanship in which Mr Adams is unrivalled. The popular side of the nation's history was strikingly set forth in the *History of the People of the United States* by John Bach MacMaster (born 1852), on the lines of Green's *History of the English People*; but popular favour has been more variously cultivated by John Fiske (1842–1901), who united to the breadth of view and social interest developed in his philosophical studies a vivid and familiar style well fitted for narration, as in *The Critical Period of American History*, *The Beginnings of New England*, *The American Revolution*, *The Discovery of America*, &c. A sounder historian, in the sense of embodying the more learned results of research, was Justin Winsor (1831–1897), as is exemplified in his *Geographical Discovery in the Interior of North America*, *Cartier to Frontenac*, *Christopher Columbus*, and *The Mississippi Basin*. James Ford Rhodes (born 1848), in his *History of the United States from the Compromise of 1850*, able, discriminating, and disinterested, gathers the fruit of toilsome investigation. John Codman Ropes (1836–1899), especially distinguished as a military critic, and Henry Cabot Lodge (born 1850) and John Torrey Morse, Jr. (born 1840), have worked successfully in the American field; and other younger men, especially connected with the universities, contribute to the continuation of a subject which must increase and multiply indefinitely. In the foreign field, James Breck Perkins (born 1847), for his volumes on the history of France, and William Milligan Sloane (born 1850), for his *Life of Napoleon*, are noteworthy. The various works on the *Influence of Sea Power*, by Captain Alfred Thayer Mahan (born 1840), have received wide recognition as original presentations of fact and theory. The *History of Life in the United States*, by Edward Eggleston (1837–1902), though incomplete, deserves to be included, from the fact of its being confined to the social phase, and from the novelty of its research. The national development of historical interest in the United States has thus been many-sided; it has been broadly felt among the people, and served by painstaking students rather than great historians.

The essayists.

Of the older writers in the department of the essay, Dr Edward Everett Hale (born 1822), at the close of a long and hard-working literary career still interests his audience, and his later writings have the currency and also the contemporary prepossession of literature for the time. Even more distinctly the books of Thomas Wentworth Higginson (born 1823), which he has put forth in the later days of his long career as reformer, soldier, orator, and poet, have the stamp of the daily or monthly press which has normally been his means of public communication by the pen. His close association with leaders of thought and action, his participation in many causes of reform, and especially his eye for human nature and his resources of lively narrative, together with the mixture of geniality and irony in his style, make his autobiographical works attractive and valuable, such as *Cheerful Yesterdays*, *Contemporaries*, and *Life in a Black Regiment*. Several of the portraits of men of the past age, contained in these volumes, are the best that have yet been given in compact, virile, and lifelike power. He is the last of the group of Cambridge authors to write much and variously, and with Charles Eliot Norton (born 1827), best known as the translator of Dante and editor of the papers of Lowell, Carlyle, and Emerson, brings to a conclusion the activity of that brilliant and noble company which conferred literary distinction and pre-eminence on Massachusetts in the 19th century.

With Edmund Clarence Stedman (born 1833) a new period of literary activity on the part of a younger generation, more broadly national in representation, began. Mr Stedman first became known by several volumes of verse, but the work of his later years has been diverted into critical prose, which, however, grew out of his love of poetry and was its natural fruition. Sympathy with excellence in many kinds, sense of style, and wide information underlaid his critical energies, and gradually widened their scope and increased their productiveness. He first attempted a judgment of the modern poetry nearest to him, in *Victorian Poets*, being a pioneer in the subject by virtue of his scope and method. He continued his labour in the more delicate task of estimating the work of his fellow-countrymen in *Poets of America*. A third volume, *The Nature and Elements of Poetry*, set forth the general principles of the art, and concluded his direct critical writing on the broad scale. Two collections of verse, *A Victorian Anthology* and *An American Anthology*, were a fitting supplement to these volumes, and disclose the broad foundation of knowledge on which his criticism rested; and, together with *A Library of American Literature*, these important and laborious compilations are of historical value as memorials of the general literary activity which they represent with fulness and justice. Mr Stedman is also distinguished by a formal quality in his thought, a conception of the subject on large lines, and an adherence to the logic of the development of his theme, which harmonize with a certain carefulness of composition. His vocabulary implies classical tradition. He is one of the few writers of current English whose style is still distinctly literary and student-like, with the reminiscence of old books and the aroma of the library, and yet has suppled itself to modernity of expression and the will of the spoken word. His later essay on the difficult subject of Poe exhibits his qualities at their highest efficiency. There is no finality in any criticism, and Mr Stedman's view of the English and American poetry of his time is a contemporary one; but in comprehensiveness, appreciative power, and grace of presentation it holds the first place; and, in connexion with the more theoretic third volume of the series, it forms the most elaborate and important work of pure criticism produced in America in its time.

Charles Dudley Warner (1829–1900), though he has written novels, biography, and books of travel, is characteristically an essayist. His writing is touched by temperament, and derives its charm from personality playing in a genial and frequently humorous way about the men, books, and things in the vicinity. Humour is the distinctive part in his literary fame. This gave flavour to his earliest essays, and made popular *My Summer in a Garden* and *Backlog Studies*. It is a refined humour, quiet, evasive, communicative, with a feeling for the oddity of human nature and its affairs, and given to novel and interesting remarks; it has a touch of confidential conversation, and a slightly-felt background of sentiment, and it is used as a delicate instrument of truth, and not merely to raise a laugh; it is of the New England character and soil, and is perhaps a third shoot from the same native stem that produced Donald Grant Mitchell ("Ik Marvel") and Oliver Wendell Holmes.

John Burroughs (born 1837) continues the type of which Thoreau is the eminent example in the older generation; but he is less characteristic of the type. His volumes are as naturally annual as seed-time and harvest. They are sympathetic and accurate studies of external nature, and take minute observations of the animate and inanimate, sky, weather, and field; and they find the other half of life, as Thoreau did, in an abstract and Emersonian thought which gives cadence to their prose. Mr Burroughs is also a critic of literature, but the naturalist in him, rather than the critic, is the salt of his work and gives its savour. Of the score or more of contemporary writers of nature-studies, he has most literary grace, and has correspondingly won most on popular favour. *Wake Robin*, *Locusts and Wild Honey*, and *Indoor Studies* represent his work.

The novelists.

William Dean Howells (born 1837) stands highest among the novelists; and he is besides, by virtue of the copiousness and variety of his work, and his power to arrest public attention in many ways, the most conspicuous literary figure of his generation. He has been, by example and precept, an apostle of realism in fiction, and of a democratic gospel of Socialistic sentiment hard to define; but in these two aspects he is placed most vividly in the public mind as the adverse critic of Scott and Thackeray, and as the eulogist of Tolstoy. His art came to mark a complete break with the American tradition that had reached its culmination in Hawthorne. Mr Howells occupied a position with respect to Continental fiction not unlike that of Longfellow in the field of poetry. He was familiar with fiction as it was written by his contemporaries, not only in France, but in every foreign country from Madrid to St Petersburg, and from Naples to Stockholm; and he was, in general, more appreciative of Continental than of English literature. He was eventually subdued to these foreign examples, and felt himself in the world-current by his participation in their ways. He endeavoured to make these foreign authors known to his countrymen, and made them the subject of a literary crusade in which he displayed a lack of historical perspective that seriously impaired his critical influence. This diminution of his reputation as a critic was unfortunate and, to some extent, undeserved; for, on the positive side as an interpreter of the present, as a writer who popularized the great reputations of his contemporaries abroad, Mr Howells did distinguished and useful service by virtue of his thorough understanding of the aims and methods of these authors, his acute sympathy with them in broad humanitarian and definitely artistic ways, and his generous and enlightened appreciation of their greatness. Led thus into the Continental schools of art, what he found in their transcript of life naturally bred in his sensitive and democratic feelings that pessimism of outlook, that sentimentality in political and social thought, and that preoccupation with the barrenness and tedium and the narrowing limitations of life, which weigh upon his imaginative and reflective prose alike. Such views seem rather the outcome of Continental than American conditions; the theories, both social and artistic, that foster them, are large and important, and in certain environments are natural and fruitful of great work, as foreign literatures amply show; but it is doubtful if an American novelist can at present find sufficient native material to illustrate them in a commanding way. For this reason, possibly, in the numerous novels that Mr Howells has written, especially since *The Lady of the Aroostook*, the difference between the material and the art expended upon it is acutely felt. There is no great difference in their quality; *The Rise of Silas Lapham* is regarded as typical of his work, and together with *A Modern Instance* and *A Hazard of New Fortunes*, illustrates his methods and aims. His attractiveness in other fields of composition, travel, criticism, and reminiscence has continued undiminished, while his fiction has shown less vitality.

Henry James (born 1843) is commonly named with Mr Howells as the second leading novelist of American birth. In his activity as a critic, principally of French subjects, he has shown skill in the modern, refined, somewhat super-subtle, modes of praising a favourite author, and he has kept within lines of academic suavity and correctness of judgment. His ways are, in fact, Gallic, and his essays seem like translations from the French. In his novels, similarly, he shows the direct results of Parisian models in treatment. He has carried to the extreme the analysis of character and motive, and almost resolved both into meaninglessness, ending in a complexity of results, in inexplicability, rather than in any moral synthesis of character or of action. Of his later and maturer work, *The Portrait of a Lady* and *The Princess Casamassima* are important examples; in both there is an effect of great elaborateness, of much forethought in the making, and especially of a long-winded pursuit of the small game of conversation and incident which no pains taken with the stage setting can successfully counteract. The whole of his work in fiction is of an intellectual kind predominantly, and in that sphere is essentially analytic and logical, minutely subtle in movement and often evasive in meaning, as rich in variety as in inconclusiveness. The style sympathizes with the matter, and shows that high development of the mastery of words which makes saying nothing seem as clever as saying something. His contribution to our knowledge of some phases of human nature is interesting to a few of the specially placed men and women of the world, and the intellectual force manifest in his more important novels is impressive; but he has cultivated evasiveness to the point of such success as to discourage his readers in their attempt to accompany him, and as he has gone on he has departed farther from what is welcome to American taste.

Francis Marion Crawford (born 1854), as an author seems neither American nor British, but writes for the English-speaking world. His first volumes were indebted to romantic elements of marvel, distance, and costume for the quick popularity they won; and, though he is characteristically a story-teller, in his later work there has been a greater attention to character. His residence in Italy has helped him to his best subjects, and it is generally agreed that the Roman series, of which *Saracinesca* was the first published, exceeds in interest, scope, and power his other novels, and stands apart from them on a superior plane. He is excellent in his handling of plot, and in giving intense interest to his main characters, and his scenes are well ordered and lively; he is, too, a good narrator. He has given forth, year after year, a series of attractive and wholesome tales of great variety in atmosphere and in the kind of human appeal they make, and has held successfully a place originally won by more popular and less artistic work. He undoubtedly represented a reaction from the realistic taste among readers, and was the forerunner of the later school of pseudo-adventure; but his better novels exceed any of these in romantic breadth and historic vitality.

Another author who illustrates the popular revival of romance in closer connexion with history, and whose work is laboriously executed and conceived with nobility of aim, is Lew Wallace (born 1827), whose three stories, *The Fair God*, *Ben-Hur*, and *The Prince of India*, were remarkable achievements of a native genius for romance, though imperfectly developed by literary cultivation, and successful largely through spectacular elements.

Besides the novelists who dealt with modern society in various forms, and carried on the art of fiction as it developed in the last years of the 19th century in city life, there has flourished a more numerous school of the provincial tale in one or another form. It has achieved historical importance as well as popular success, because of the record that has been made of manners and customs, and also character, in nearly all parts of the country. The exploitation of locality and adherence to the rude or picturesque phases of American life was not altogether a new thing, but the general devotion of writers to the aspects of special phases of life in different parts of the country resulted in a great volume and variety of such writing, till the dialect novel seemed almost to absorb all new literary energy. Edward Eggleston (1837–1902), already mentioned as a historian, led the way with *The Hoosier Schoolmaster*, a study of life in Indiana in the second generation of the settlement of that state; and his portrayal revealed to others that there existed a wealth of material in the human nature and environment of the newer portions of the country, similar to that which had so long and so successfully been used in the New England field. He continued in the vein he had opened, and wrote several other novels describing the earlier life of the Ohio river people and their neighbours, *The End of the World*, *The Circuit Rider*, and *Roxy* being the best of these.

Equal in fidelity to the past of a local community, and touched with a more poetic charm, were the novels of George Washington Cable (born 1844), who found in the Creole nature and traditions of Louisiana a mine of literature; and aided by an uncommonly graceful gift of speech, and a nature-background that was itself a marvel of fascination, he rapidly produced a group of novels and tales which in certain subtle and rare qualities of appreciation and presentation, and in the touching power of their characters, are scarcely equalled in the fiction of his generation; they are a treasure of the past of old Southern days, with a climate, a race, a distillation all their own. *Old Creole Days*, *The Grandissimes*, *Madame Delphine*, *Dr Sevier*, and *Bonaventure* compose this group, which easily wins precedence in literary quality over all others of the provincial novels. The life of the mountaineers on the borders of Tennessee and North Carolina was depicted in its turn by Mary Noailles Murfree (born 1850), whose books appeared under the pen name of "Charles Egbert Craddock." *In the Tennessee Mountains* and *Where the Battle was Fought* are good examples of her work. Mary Hallock Foote (born 1847) has used the local material of the Rocky Mountains; Thomas Nelson Page (born 1853) has performed a similar service for Virginia; and James Lane Allen (born 1849) for Kentucky. The vogue of this species of novel has, in general, fallen off, and in its place a new movement in the direction of the half-military, half-historical romance of costume and adventure has begun in *Hugh Wynne*, by S. Weir Mitchell (born 1829), the ablest of his varied works of fiction.

Somewhat apart from the pure novelists stand Francis Richard Stockton (1834–1902), who invented an idiosyncratic novel of his own, full of entertainment, surprising and widely popular, which is in essence extravaganza; and also three notable authors of fiction in different veins—Bret Harte (1839–1902), Thomas Bailey Aldrich (born 1836), and Samuel Langhorne Clemens, "Mark Twain" (born 1835). Bret Harte, whose early reputation was won by tales of California, which introduced a new *genre* into fiction, continued to write most successfully in the manner which he first made popular, but with less effect in America, possibly because of his prolonged residence abroad. As is the case with several American authors, his reputation is greater in England than at home. Mr Aldrich, better known as a poet, has won highest regard in prose as a writer of short stories, in which department he stands at the head of his contemporaries, both in art and wit, and especially in the deftness of constructive power, in speed of narration, and in capacity to conceal the conclusion. As a humorist Mark Twain has sustained the fame won by *The Innocents Abroad* and *Life on the Mississippi* without developing any new traits, although as a lecturer and public character he has carried his reputation far and wide, and is the most popularly known man of the writers contemporary with him. His work in all its forms partakes of that huge caricature of America of which Walt Whitman was in the last generation the great example. It is perhaps more esteemed abroad than at home, where his earlier books retain a consideration, especially in relation to Western life, that has not been won by his more recent writings; but the influence of his personality still renders any judgment on his works doubtful.

The poets.

Among the few poets of this literary generation none has been so exclusively devoted to the art as the men of the former time, and with hardly an exception their prose seems equally as important to the public. All have been miscellaneous writers or concerned in practical affairs, and they have not obtained a national vogue comparable with that of their predecessors. Mr Stedman is pre-eminently a critic, for the reading world of his countrymen, and his verse is subordinated in their thoughts to his essays on the poets. He has written much verse, but in his later years has been less a producer of poetry than an admirer and collector of it; yet in the ballad, in some of the stately forms of the art, and in poems of character, he obtained early recognition. He has published sparingly, but with great variety of subject and style, with masterly technique and with power of phrase, in language eloquent rather than impassioned, and preferring the ballad to the lyric. Thomas Bailey Aldrich, already referred to as a novelist and writer of short stories, holds in popular estimation the most conspicuous position among the literary poets of the period. He is most widely recognized as skilful in the short lyric, the sonnet, and epigram and quatrain, forms of verse especially favourable to sentiment, wit, grace, and the refinements of technique. In lyrical purity and melodiousness he reaches true distinction, and in spontaneity within the limits of artistic restraint he reveals the poetic impulse of a cultivated mind open to the world of nature and the heart; while, on the worldly side of interest in human affairs, in history and travel, and the thoughts of men, he finds an opening into reflective, narrative, and dramatic composition. From very early in his career he betrayed a love for the Orient, its colour and dreaminess, and he often sought in the East effects of reverie and atmosphere, and even a setting for wit. Spain and England have left their mark in *Mercedes*, a play written to be acted rather than read, and *Wyndham Towers*. *Friar Jerome's Beautiful Book* is the most popular example of his use of mediæval legend. His verse was essentially urban, and most at home among the tastes of a refined society. It is, in a literary sense, aristocratic verse, unemphatic, self-possessed, artistically content with the perfection of its class, and has habitually more the classic stamp than any of American poetry except Longfellow's.

The only companion of Mr Aldrich in the public mind, as a frequent producer of literary verse, is Richard Watson Gilder (born 1844), whose *Five Books of Song* contain his collected poems. He, too, prefers the short flights of poesy. His work is usually so brief as to give the impression of fragmentariness, and of slightness in the mass. In his earlier volumes, *The New Day* and *The Celestial Passion*, the tone was that of Rossetti and Italian mysticism and sentiment, and in his management of the love theme and the sonnet form his art was plainly of that school, a predilection for which was also indicated by his interest in pictorial symbolism and arrangement. Music as well as painting has been a source of poetic impulse; and, in general, his muse has often been the handmaid of the other arts. His temperament exhibits that sensitive impressibility under colour, tone, and shadow which is associated with the artistic nature. In his later work he freed himself from the traditions which he had at first felt so dominating, and gained in reality, in breadth of treatment, and in contact with modern life. *The Great Remembrance*, a memorial poem of the Civil War, not only in scale and style but also in its humanity, its rendering of the national passion, and its high-thoughted appeal, illustrates the later manner; but in many of the memorial tributes, and frequently in sonnet and lyric, there was a deeper chord struck, though it might be only for a single note. The humanitarianism of much of this later verse, its spirit of democratic philosophy, is marked; the presence of New York as a world-city, its characteristic features, interests, and intellectual and moral appeals, and its general life-movement, are elements in the verse, and, in fact, the civic feeling is almost as strong in the poet as the patriotic ardour. This has given substance and significance to Mr Gilder's verse as a whole; but it still remains in general brief poetry of personal expression, the product of a poetic sensitiveness rather than of conscious and masterful art.

Of others who have attracted special attention, without being popularly accepted as poets of distinction, Dr S. Weir Mitchell, eminent as a physician and distinguished as a novelist, has found in verse the most subtle and most condensed expression of his literary faculty: his dramatic sketches, slight as they are, stand wholly apart from the poetic work of his contemporaries. Two poets, Sidney Lanier (1842–1881) and Edward Rowland Sill (1841–1887), have obtained and still hold a certain intellectual vogue.

(G. E. W.)

UNIVERSITIES.

DURING the years which have intervened since the publication of the ninth edition of the *Encyclopædia Britannica* there has been a good deal of research on all that concerns the history of the mediæval universities, and much new material is now available in a printed form.

Meaning of studium generale.

The first point on which it seems desirable to supplement the earlier article is as to the exact meaning of the terms *universitas* and *studium generale.* In the north of Europe teaching had become in the Dark Ages the monopoly of the Church; in the south of Europe there was more liberty in educational matters. In the north licences to teach were granted by the Chancellor Scholasticus, or other officer of some cathedral church; in the south it is probable that the gilds of masters (when these came to be formed) were at first free to grant their own licences, without any ecclesiastical or other supervision. But in all cases such permissions were of a purely local character. Gradually, however, towards the end of the 12th century, a few great schools obtained a certain œcumenical prestige. Practically a doctor of Paris or Bologna would be allowed to teach anywhere. These great schools were styled *studia generalia*, *i.e.*, places resorted to by scholars from all parts. Eventually the term came to have a more definite and technical signification. The Emperor Frederick II. set the example of attempting to confer by an authoritative bull upon his new school at Naples the prestige which the earlier *studia* had acquired by reputation and general consent. In 1229 Gregory IX. did the same for Toulouse, and in 1233 added to its original privileges a bull by which any one who had been admitted to the doctorate or mastership in that university should have the right to teach anywhere without further examination. Other *studia generalia* were subsequently founded by papal or imperial bulls; and in 1292 even the oldest universities, Paris and Bologna, found it desirable to obtain similar bulls from Nicolas IV. From this time the notion began to prevail among the jurists that the essence of the *studium generale* was the privilege of conferring the *jus ubicunque docendi*, and that no new *studium* could acquire that position without a papal or imperial bull. By this time, however, there were a few *studia generalia* (*e.g.*, Oxford) whose position was too well established to be seriously questioned, although they had never obtained such a bull; these were held to be *studia generalia ex consuetudine.* A few Spanish universities founded by royal charter were held to be *studia generalia respectu regni.* The word *universitas* was originally applied only to the scholastic gild (or gilds) within the *studium*, and was at first not used absolutely; the phrase was always *universitas magistrorum*, or *scholarium* or *magistrorum et scholarium.* By the close of the mediæval period, however, the distinction between the terms *studium generale* and *universitas* was more or less lost sight of, and the term *universitas* was sometimes used alone.

Salerno.

The researches of de Renzi and others have made it clear that the origin of the medical school at Salerno had nothing to do with the Saracens. Its medical system was originally an outcome of the Græco-Roman tradition of the old Roman world, and the Arabic medicine was not introduced till the highest fame of the Civitas Hippocratica was passing away. It *may* have been influenced by the late survival of the Greek language in southern Italy, though this cannot be proved. It is an interesting fact that some of the earliest medical doctors at Salerno were women.

Bologna.

Further research has tended to throw back to a somewhat earlier date the origin of the great law revival which ultimately centred in Bologna. This revival began at Pavia, where there was a famous school of Lombard law, and at Ravenna, which was the most important school of Roman law before the rise of Bologna. Bologna began to be famous as a school of the liberal arts about the year A.D. 1000; even the Digest was known considerably before the time of Irnerius (1100–30), and the name of one of his predecessors, a certain Pepo (*fl. circa* 1076), has come down to us. The traditional story about the "discovery" of the Pandects at Amalfi in 1135 was disproved even before the time of Savigny. Schulte has shown that the publication of the *Decretum* of Gratian must be placed earlier than the traditional date, *i.e.*, not later than 1142. In the case both of the Civil and the Canon Law, the gradual and evolutionary character of the legal renaissance has been strongly emphasized by recent investigation. The Roman law had never been entirely forgotten even in the Dark Ages, and it was not by any catastrophic "discovery" or invention that the Middle Ages emerged out of the darkness.

The universities at Bologna.

It should be made plain that the two *universitates* of *ultramontani* and *citramontani* (9th ed., vol. xxiii. p. 833) were composed exclusively of students in law. Besides these closely allied gilds there was a rector and university of medicine and arts, originally subordinate to the Jurist rectors, but completely independent from the year 1306. The *universitates* of students must be distinguished from the Collegia of Doctors—the College of Doctors of Civil Law, the College of Doctors of Canon Law, the College of Doctors in Medicine and Arts, and (from 1352) the College of Doctors in Theology. Though the professors were largely dependent upon the students, they had separate organizations of their own; the college alone was concerned in the conferment of degrees. Each faculty was therefore at Bologna entirely independent of every other (except for the union of medicine and arts): the only connecting link between them was the necessity of obtaining their degrees (after 1219) from the same chancellor, the Archdeacon of Bologna. The decline in the reputation of the *studium* from about 1250 was largely due to the successful efforts of the doctors to exclude all but Bolognese citizens from membership of the doctoral colleges (which alone possessed the valuable "right of promotion"), and from the more valuable salaried chairs. They even attempted and partially succeeded in restricting these privileges to members of their own families. The democratic character of the universities and the power of the rectors gradually diminished after the mediæval period. From 1742 the rectorship was held by the Cardinal-legate, but the student universities maintained a somewhat shadowy existence down to the time of the French Revolution.

Paris.

It seems well to give a somewhat more detailed account of the organization of the university, the gradual growth of which is sufficiently described in the ninth edition. The completed mediæval university was a federation of four distinct bodies, one of which was also itself a federation. There were the three "superior" faculties of theology, canon law, and medicine, and the "inferior" faculty of arts, which was divided into the four nations—France, England (later, Germany), Picardy, and Normandy. Each superior faculty was presided over by its dean, each nation by its proctor. The whole faculty of arts was presided over by the rector, who by the middle of the 14th century had become the acknowledged head of the entire university. In congregations of the university matters were decided by a majority of faculties; the vote of the faculty of arts was determined by a majority of nations. The chancellor of Notre Dame, whose functions were now limited to the conferment of the licence, stood as such outside the university or gild altogether, though as a doctor of theology he was always a member of that faculty. In the course of the 16th and 17th centuries this democratic constitution of the Middle Ages was largely superseded by the growth of a small oligarchy of officials. The tribunal of the university—the rector, deans, and proctors—came to occupy a somewhat similar position to the old "Hebdomadal Board" of heads of colleges at Oxford. Moreover, the teaching functions of the university, or rather of the faculty of arts, owing chiefly to the absence of any endowment for the regents or teaching graduates, practically passed to the colleges. Almost as much as the English universities, Paris came to be virtually reduced to a federation of colleges, though the colleges were at Paris less independent of university authority, while the smaller colleges sent their members to receive instruction in the larger ones (*collèges de plein exercise*), which received large numbers of non-foundation members. This state of things lasted till the French Revolution swept away the whole university system of the Middle Ages. It may be remarked that the famous Sorbonne was really the most celebrated college of Paris—founded by Robert de Sorbonne *circa* 1257—but as this college and the college of Navarre were the only college foundations which provided for students in theology, the close connexion of the former with the faculty and the use of its hall for the disputations of that body led to the word Sorbonne becoming a popular term for the theological faculty of Paris.

English universities.

The present writer believes that he has made it seem probable (*Universities of Europe in the Middle Ages*, ii. p. 328 *seq.*) that the sudden growth of the school of Oxford into a *studium generale* was connected with a migration or secession of English students from Paris, which may be inferred to have taken place about the year 1167 or 1168. In the first-mentioned year we are told by John of Salisbury that "France, the mildest and most civil of nations," has "expelled her foreign scholars" (*Materials for the History of Thomas Becket*, ed. Robertson, vi. pp. 235–36). At about the same time we hear of an edict of Henry II., during the quarrel with Becket, recalling all clerks holding benefices in England (as they loved their benefices), and forbidding all clerks in England to cross the Channel (*ibid.*, i. pp. 53–54). The archbishop himself remarks that "The king wills that all scholars shall be compelled to return to their country or be deprived of their benefices (*ibid.*, vii. p. 146). Paris was at this time the great place of higher education for English students. No English school was a recognized *studium generale*. There are only three earlier allusions to Oxford, and each of them only reveals the existence of one famous master teaching at the same time. The first allusion to the schools of Oxford is contained in the statement that Theobaldus Stampensis (formerly a doctor of Caen) taught here about 1110 (Rashdall, *Universities of Europe*, ii. p. 333); Pullen is mentioned in 1133; Vacarius may have taught about 1149 (but was possibly later). Immediately after 1168 allusions to Oxford as a *studium* and a *studium generale* begin to multiply. The natural inference is that the breaking off of relations between England and Paris in 1167 or 1168 led to the growth of a *studium generale* in Oxford, formed no doubt in the first instance of seceders from Paris. The first allusion to Cambridge is the secession of a body of Oxford students to that place in 1209, and there is no reason to believe in any earlier origin of the university. The traditional constitution of the English universities was in its origin an imitation of the Parisian chancellor, modified by the absence of the cathedral chancellor. As Oxford was not in the 12th century a bishop's see, the bishop (in 1214, if not earlier) appointed a chancellor for the express purpose of granting degrees and governing the *studium*. But he was from the first elected by the masters, and early obtained recognition as the head of the university as well as the representative of the bishop. The *procuratores* (originally also *rectores*) remained representatives of the faculty of arts and (there being at Oxford no deans) of the whole university. The Cambridge constitution was in the main the same as that of Oxford. The higher faculties in England never developed the same distinct organization as at Paris, and, though the two proctors were originally the representatives of the north countrymen and south countrymen respectively, the nations had hardly any separate existence. There are traces of an original "voting by faculties," but it passed away before the close of the mediæval period. By the statutes drawn up under the chancellorship of Archbishop Laud in 1631, the Hebdomadal Board obtained the sole right of initiative in university matters, and this state of things continued till the middle of the 19th century. At Cambridge there was a somewhat similar but smaller oligarchy, called the Caput Senatus.

The Oxford halls.

Recent research tends to show that at Oxford and Cambridge, as in other mediæval universities, the halls or hostels in which the bulk of mediæval students once resided were democratic institutions electing their own principals. Before the close of the mediæval period the whole government of the hall had practically passed to the principal. The few halls at Oxford which survived into modern times (at Cambridge they disappeared earlier) were doomed to destruction by the legislation of 1877, and have now ceased to exist, with the exception of St Edmund Hall, which, on a vacancy occurring in the principalship, will be closely connected with Queen's College.

Numbers in mediæval universities.

Immensely exaggerated statements were made by mediæval writers as to the number of students attending the universities, not generally in their own time, but at some period in the past. Thus Richard of Armagh declares that the numbers at Oxford had fallen from 30,000 to 6000, while Wycliffe almost at the same time asserts that they had fallen from 60,000 to 3000 (Rashdall, *Universities in the Middle Ages*, ii. p. 581). It is probable that there could not at any time have been more than 3000 students at Oxford. It is possible that at Bologna in the height of its fame there may have been some 6000, and conceivably a somewhat larger number at Paris. The numbers at the great *studia* must have fallen off in the later mediæval period through the multiplication of universities. In some of the later and less famous universities we have complete matriculation books, and some of them show a membership of 1000 or 2000. This by itself tends to prove that the numbers at Paris and Bologna must once have been much larger.

Recent changes in France.

In France the most remarkable change in the university system since 1888 has been the restoration of the provincial schools, which have, since the Napoleonic reorganization of education, formed merely "academies" within the University of France as compared with their ancient position as independent universities. This was done by a decree of 10th July 1896. There are now, therefore, the following universities in France: Paris, Aix, Marseilles, Besançon, Bordeaux, Caen, Clermont, Dijons, Grenoble, Lille, Lyons, Montpellier, Nancy, Poitiers, Rennes, and Toulouse. This formal change was accompanied and preceded by several measures tending to give more real existence and power to the whole university, as distinct from either (*a*) the once independent "faculties" in each place, and (*b*) the Minister of Public Instruction. By these measures a real step has been taken towards a restoration of the ancient university autonomy, though the universities of France still remain under the direct supervision and control of the State.

Higher commercial and technical education.

One of the most remarkable educational movements on the Continent has been the growth of institutes for higher commercial education. The Institut Supérieur de Commerce at Antwerp was founded in 1852; at Paris the École des Hautes Études Commerciales was established in 1881. There is also an Institut Commercial at Paris, and Écoles Supérieures de Commerce at Paris, Bordeaux, Havre, Lille, Lyons, Marseilles, Dijon, Montpellier, Nantes, Nancy, and Rouen. In Germany Handelhochschulen have been established at Leipzig, Köln, Aachen, Hanover, and Frankfurt-am-Main. None of the French or Belgian schools have been admitted to university privileges, but the German Handelshochschulen have been granted the privilege of conferring the doctoral degree.

Changes in Great Britain.

In Great Britain the period which has elapsed since 1888 has been marked by the gradual carrying into effect of the reforms enacted in 1877, by considerable reforms in the Scottish universities, by the incorporation of the three Welsh colleges into a new University of Wales in 1893; by the establishment of a new university at Birmingham (1900), and by the issue of an entirely new charter, by which the University of London has become a teaching university instead of a mere examining body.

Oxford and Cambridge.

The general effect of the changes introduced by the legislation of 1877 was sufficiently indicated in the ninth edition. They have been gradually carried out as the occurrence of vacancies in the colleges has made possible the appropriation of portions of their revenue for the foundation of professorships and other university purposes, though in some cases the intentions of the commissioners have been frustrated by the effects of agricultural depression upon college revenues. The general effect of the revolution has been a marked diminution in the clerical character of the college teaching bodies, the conversion of the college teaching staff from a temporary employment for bachelors awaiting livings or other preferment into a permanent profession, and the growth of a resident and working university professoriate. At the same time a change of almost equal significance has taken place in the teaching system of the university through the gradual growth of "inter-collegiate lectures." At Oxford nearly all honour lectures given by college tutors and lecturers have been thrown open to all members of the university: the college tutor is now recognized by the university as a teacher in the faculty to which he belongs, and the institution of boards of faculties has done something to bring the organization of the University into harmony with that of universities outside the British Isles. At Cambridge the system of inter-collegiate lectures has also developed itself, but to a considerably smaller extent. At both the old English universities the great widening of the courses of study open to senior students (honour men), which began about the middle of the 19th century, has been continued, while there has been some widening and modernizing of the studies by which a pass or "poll" degree can be obtained. At Oxford there are now the following "Final Honour Schools": Litteræ Humaniores (Classics, Ancient History, and Philosophy), Mathematics, Natural Science, Jurisprudence, Modern History, Theology, Oriental Languages, English Literature; and at Cambridge there are the following "Triposes": Mathematics, Classics, Moral Sciences, Natural Sciences, Theology, Law, History, Oriental Languages, Mediæval and Modern Languages, Mechanical Sciences (Engineering). Degrees in letters and science have also been instituted at both Oxford and Cambridge. The doctorate is given for original work. At Oxford the B.Litt. and B.Sc. can be taken by dissertation or original research, without passing the examination for B.A. At Cambridge the B.A. can be obtained in a similar manner by advanced students.

The Rhodes scholarships.

By the will of the South African statesman, Mr Cecil Rhodes, who died in 1902, a large portion of his great fortune has been devoted to the provision of scholarships to be held in Oxford by colonial and foreign students. A large number of these scholarships are to be held by students from the various colonies of the British Empire, while others are assigned to students from Germany (selected by the German Emperor) and from the United States. The founder has expressed a desire that the selection of the students shall be governed by moral and athletic considerations as well as intellectual, but the trustees appointed by the will have not yet drawn up a detailed scheme for their administration. The object of the bequest was to promote the unity of the British Empire and friendship with certain other countries. A considerable endowment was also left to Oriel College.

The Scottish universities.

For about thirty years after the Act of 1858, the constitution of the Scottish universities remained practically undisturbed. In 1889 a new Commission was appointed, which sat for nearly ten years, and completely transformed the organization and the curriculum alike. The government of the universities was transferred from the Senatus to the Courts, which were enlarged so as to include representatives from the Senatus, the General Councils of Graduates, and the municipality within which the university is situated. In addition to these representatives, the principal, the Lord Rector, his assessor, the Chancellor's assessor, and the lord provosts of the cities of Aberdeen, Edinburgh, and Glasgow, and the provost of St Andrews have seats in the Courts of their respective universities. The provost of Dundee occupies a seat in the University Court of St Andrews in virtue of the incorporation of University College, Dundee, with the University of St Andrews by an ordinance of the Commission. The Lord Rector is the President of the Court. To the Court is entrusted the management of the property and finances of a Scottish university, and, in most cases, such patronage as does not belong to the Crown; but in the case of Edinburgh, the patronage of some of the older chairs is in the hands of a body of curators. Disciplinary powers are retained by the Senatus, and the General Council remains, as under the Act of 1858, a purely advisory body. Another advisory body—the Students' Representative Council—was added by the Commission. The curriculum of all the faculties (except Divinity) was reorganized: the most important alterations consisted in the abolition of the once sacred six as compulsory subjects in Arts (Latin, Greek, Mathematics, Natural Philosophy, Logic, and Moral Philosophy). The curriculum was greatly widened, an elaborate scheme of "options" introduced, and a new system of honours degrees was established. The length of residence required was reduced from four years to three, and the Courts were empowered to institute summer sessions, and to admit women to lectures and degrees in all faculties.

A large number of new chairs and lectureships have been created in all the universities in accordance with these ordinances, and a considerable amount of building operations has also been necessitated. At Aberdeen, Marischal College has been more than trebled in size to accommodate new lecture-rooms and laboratories. The finances of the universities, which suffered greatly from the pressure of these new requirements, have been relieved by the gift of Mr Andrew Carnegie, who in 1901 handed over to a body of trustees securities amounting to two millions sterling, the interest of which is partially devoted to the equipment of the universities and partially to the payment of the fees of such students as may desire such assistance. The trustees in July 1902 prepared a preliminary scheme of allotment which should remain in force for five years.

There has been since the Act of 1858 a great development of student life, illustrated by the institution of students' unions in all four universities, by the publication of undergraduate magazines, and by the growth, in Edinburgh, of combined residences and settlements.

University of Wales.

By a royal charter, granted in 1893, the three university colleges at Aberystwyth, Cardiff, and Bangor were incorporated into a University of Wales. The University Court was constituted of the Chancellor, persons nominated by the Lord President of the Council, and representatives of the county council and county boroughs of Wales, of the Central Intermediate Education Board, the Courts, Councils, and Senates of Constituent Councils, the teachers of Welsh schools, and the Guild of Graduates. The government of the University is mainly in the hands of the Court, but the Senate, consisting of professors and lecturers, may make recommendations to the Court. There are faculties of arts, letters, science, music, law, and theology.

Birmingham.

The University of Birmingham was established by Act of Parliament and royal charter in the year 1900, the previously existing Mason College being dissolved and merged in the new institution. The university is governed by a Chancellor (the first Chancellor being the Right Hon. Joseph Chamberlain), Principal, a Court of Governors (consisting of a large number of persons, mostly *ex officio*, appointed by various public bodies), and a Council (consisting of the Principal, Vice-Principal, deans of faculties, and professors). There are faculties of science, arts, medicine, and commerce. It is a special aim of the university to bring the higher academic studies into closer relation with industry and commerce. Departments of brewing and engineering have been organized, and a department of commerce has just been formed. Degrees in science are given for engineering, and a diploma is granted for brewing. For the degree of Bachelor of Commerce the course includes (1) languages and history; (2) accounting; (3) applied science and business technique; (4) commerce. The faculty of commerce began its work on 1st October 1902.

University of London.

By the University of London Act, 1898, and the statutes of the commissioners named therein (issued in 1900), the University of London has been reconstituted. The senate is to be composed of the chancellor and fifty-four members, of whom four are appointed by the King in council, sixteen by the convocation (*i.e.*, doctors and proctors) of the university, sixteen by the various faculties, and the remainder by various public bodies or institutions. The senate is the supreme governing body, and has three standing committees, of which one is the academic council for "internal students," another the council for "external students," and the third a board to promote the extension of university teaching. Provision is made for the appointment of professors and other teachers by the university itself, and also for the recognition as teachers of professors and others teaching in such institutions in or near London as may be recognized as schools of the university. The following bodies are constituted schools of the university: University College and King's College, London; the Royal Holloway College, Egham, and Bedford College, London (both colleges for women); the Royal College of Sciences; the medical schools of the principal London hospitals; the London School of Economics and Political Science; the South-Eastern Agricultural College, Wye; the Central Technical College of the City and Guilds of London Institute; and several theological colleges. The "appointed" and "recognized" teachers in each group of subjects form the various faculties of the university. Of these there are eight—theology, arts, law, music, medicine, science, engineering, economics and political science (including commerce and industry). Each faculty elects its dean. Courses of study are to be provided by the university for its "internal" students, *i.e.*, those who pursue their studies in one of the schools of the university. Its degrees remain open to "external" students as heretofore, but separate examinations are in future to be held for "internal" and for "external" students respectively, and the senate is to "provide that the degrees conferred upon both classes of students shall represent, as far as possible, the same standard of knowledge and attainments." The whole scheme may be described as a compromise between the views of various schools of reformers—as an attempt to create a teaching university without destroying the existing purely examining university or erecting two distinct universities of London, and at the same time, without any immediate endowments, to create a university which might hereafter expand by utilizing existing institutions. One of the most important of these, King's College, it may be observed, has, without losing its connexion with the Church of England, abandoned its theological test for members of its teaching body. The Inns of Court have, so far, refused the invitation of the commissioners to co-operate with the university in the creation of an academic school of law.

University education for women in Great Britain.

The history of university education for women begins with the foundation of Girton College at Hitchin in 1869, or its removal to Cambridge in 1873. The college was originally in no official connexion with the university, but its erection made it possible for women to receive a university education, lectures being given at the college, partly by their own lady lecturers, and partly by university professors or tutors of the colleges. Other colleges have since been opened at Cambridge and at Oxford. The actual degrees and formal membership of those universities have not been opened to women, but they are practically permitted to attend most of the university and college lectures, and to enjoy most other advantages of the university, while nearly all university examinations have been thrown open to them. Separate honour lists are issued of women who have entered for the same examinations and been examined by the same examiners as men. These lists have appeared in the calendar at Cambridge since 1882, at Oxford since 1893. In 1878 the University of London obtained a new charter to enable it to confer degrees upon women, and a similar step was taken by Durham in 1895. In all the new British universities women are admissible to all the same privileges (with the exception, in some cases of medical lectures) as men. Within the last ten years of the 19th century the degrees in arts, science, and medicine were opened to women in all the Scottish universities. At Dublin a limited number of lectures have been opened to women, and in 1895 it was resolved to admit women to some of the honours examinations as an experiment.

Women's colleges and halls.

To enable women to avail themselves of these advantages, halls of residence have been opened for women in the university towns, and other colleges have been opened elsewhere, the students of which enter for the examinations at London or other universities. The following is a list of the more important of these colleges. At Oxford: Somerville College (1879); Lady Margaret Hall (1879); St Hugh's Hall (1886); St Hilda's Hall (1893). At Cambridge: Girton College (1873) and Newnham College (1880). In London are Queen's (1848), Bedford (1849), and Westfield (1882) Colleges. At Glasgow Queen Margaret College for women was incorporated with the University in 1893, and there are now colleges or halls for women in all the Scottish universities and at Durham. A college for women on a magnificent scale, known as Holloway College, was established in 1886 at Egham, Surrey, under the will of Mr Holloway.

Position of women in foreign universities.

In the universities of France, Belgium (except in the Catholic university of Louvain), Holland, Denmark, Norway, Sweden, Switzerland, Italy (by law of 1890), Greece, Rumania, Canada, Australasia, and in most of those in the United States, students are admitted to all or most of the advantages enjoyed by men. In Germany an increasing number of universities allow women to attend some of the lectures by special permission. At Göttingen and Heidelberg they are admissible to degrees. In Austria and Russia (with the exception of Finland) the universities offer fewer facilities to women. In Spain the universities were opened to women in 1868, but the privilege is rarely claimed.

The following is a list of universities not mentioned in the ninth edition, or founded since that date:—

Adelaide (1872).
Aix-en-Provence (1409).
Allahabad (1887).
Amsterdam (free university, 1880).
Barcelona (1450).
Besançon (transferred from Dôle in 1422).
Buenos Aires.
Bucharest (1864).
Cadiz (Medical Faculty of Seville, 1748).
Cagliari (1596; re-founded 1720 and 1764).
Camerino (1727; since 1860 a "free university").
Caracas.
Catania (1444).
Córdoba (Argentina).
Dijon (1722).
Freiburg (Switzerland, 1889).
Gothenburg (a "Högskola" founded in 1841, which now grants degrees in the philosophical faculty).
Granada (1531).
Havana (1721).
Kingston, Queen's University (1840).
Kyôtô (Japan, 1897).
Lahore, Punjab University (1882).
Lausanne (founded as academy, 1537; university, 1890).
Lima (1551; reorganized 1561).
Macerata (1540).
Manila, University of St Thomas (1605).
Messina (1838).
Modena (1683).
Montevideo (1876).
Münster (Papal bull in 1629; erected in 1771–73. Since 1818 it has been a "Königliche Akademie," conferring degrees in theology and philosophy).
New Zealand (1877; colleges at Auckland, Canterbury, Dunedin, and Wellington).
Oviedo (1574).
Palermo (1779).
Parma (1422; reorganized 1855).
Pisa (1343).
Pressburg (1465, but soon extinguished; since 1875 a Faculty of Law only).
Quebec (Université Laval, 1852).
Reykjavik (in course of foundation).
Santiago (Spain; 1504).
Santiago (S. America; Universidad de Chile, 1743).
Saragossa (1474).
Sassari (1556).
Seville (1502).
Tôkyô (Imperial University of Japan, 1868).
Tomsk (1888).
Turin (1412).
Urbino (1671; now a free university).
Valencia (1501).
Warsaw (1816; suspended 1832; re-founded 1869).
Würzburg (1402; revived in 1582).

This list is not to be regarded as complete as regards schools which have once been granted but have now lost university rank or ceased to exist altogether. In particular large numbers of Jesuit colleges in Spain and elsewhere obtained recognition as universities in the 16th or 17th century, but lost it in the course of the 18th or 19th. It may be observed that in Spain the degree of B.A. is now given at the *institutos* (secondary schools), the M.A. at all universities, while the degree of Doctor can only be conferred by the Universidad Central at Madrid.

Additional Authorities.—The following are a few of the more important works which have appeared since the publication of the ninth edition, or were not noticed in it:—Rashdall, *The Universities of Europe in the Middle Ages*, 2 vols., Oxford, 1895, deals with the whole subject down to 1500. To this work the reader may be referred for a fuller bibliography. Denifle and Chatelain have carried their splendid *Chartularium Universitatis Parisiensis* in successive volumes down to 1452. The later history of Paris is dealt with by Jourdain, *Hist. de l'Univ. de Paris aux XVII^e. and XVIII^e. Siècles*, Paris, 1862, and by Gréard, *Nos adieux à la vieille Sorbonne*, Paris, 1893. The *origines* of Bologna are dealt with by Chiapelli, *Lo Studio Bolognese*, Pistoia, 1888; Fitting, *Die Anfänge der Rechtsschule zu Bologna*, Bologna and Leipzig, 1888; Ricci, *I primordi d. Studio di Bologna*, 2nd ed., Bologna, 1888. All the extant statutes are published by Malagola, *Statuti d. univ. e dei collegi d. studio bolognese*, Bologna, 1888; and a new edition has appeared of the learned Sarti's *De claris Archigymnasii Bononiensis Professoribus*, Bologna, 1888, &c. The statutes of all the French universities have been edited by Fournier, *Statutes et Privilèges des Univ. françaises*, Paris, 1890. Kaufmann is publishing a very thorough *Geschichte d. deutschen Universitäten*, &c., 1888, &c. There is a history of the Spanish universities, De la Fuente, *Hist. des las Universidades, collegios y demas Establimentos de Enseñanza en España*, Madrid, 1855. At Oxford most important work has appeared in the successive publications of the Oxford Historical Society, and a generally excellent series of Oxford and Cambridge *College Histories* is now nearly complete.

For information as to the recent universities the reader may be referred to the successive annual editions of a general Directory of Universities known as *Minerva*, published at Strasburg, some of which contain valuable historical notes. See also Mr Sadler's Special Reports (to the Education Office) on *The Admission of Women to Universities* and on *Higher Commercial Education.*

(H. Rl.)

Universities in the United States.

In the United States the word "university" has been applied to institutions of the most diverse character, and it is only since 1880 or thereabouts that an effort has been seriously made to distinguish between collegiate and university instruction; nor has that effort yet completely succeeded. Harvard, William and Mary, and Yale, the three pioneers of Colonial times, were organized in the days of Colonial poverty, on the plans of the English colleges which constitute the universities of Oxford and Cambridge. Graduates of Harvard and Yale carried these British traditions to other places, and similar

Origins.

colleges grew up in New York, New Jersey, Pennsylvania, New Hampshire, and Rhode Island, and later in many other states. The underlying principle in these institutions was discipline—mental, moral, and religious. Dormitories and commons were provided, and attendance upon religious worship in the chapel was enforced. Harvard and Yale were the children of the Congregational churches, Columbia was fostered by the Episcopalians, Princeton by the Presbyterians, Rutgers by the Dutch Reformed, and Brown by the Baptists. Around or near these nuclei, during the course of the 19th century, one or more professional schools were frequently attached, and so the word "university" was naturally applied to a group of schools associated more or less closely with a central school or "college." Harvard, for example, most comprehensive of all, has seventeen distinct departments, and Yale has almost as many. Columbia and Pennsylvania have a similar scope. In the latter part of the 19th century Yale, Columbia, Princeton, and Brown, in recognition of their enlargement, formally changed their titles from colleges to universities. The ecclesiastical, or religious, note was a strong characteristic of these foundations. Protestant evangelical doctrines were taught with authority, especially among the undergraduates, who were spoken of as constituting "the college proper." In the oldest and largest colleges this denominational influence has ceased to have the importance it once possessed. Noteworthy innovations came when Thomas Jefferson, the philosophical statesman, returned to the United States from France, emancipated from some of the narrow views by which his countrymen were bound. He led the Virginians to establish, on a new plan, the university of Virginia as a child of the state; and the freshness of his advice, the importation of distinguished foreign teachers, and the freedom of the student from an enforced curriculum awakened admiration and emulation on the one hand, and animadversion on the other. But this university unquestionably led to broad conceptions of academic work, which appeared foreign and even questionable, if not irreligious, to the colonial universities already mentioned, although many of the features which were then regarded as doubtful peculiarities are now familiar everywhere. Following Virginia's example, many of the new States in the West established State universities, most of which included a central college of the colonial type and afterwards one or more professional schools. Freedom from ecclesiastical control is found in all the foundations that make up this second group — the State universities. Michigan, Wisconsin, Minnesota, and California present distinguished examples of such organizations. In earlier days, Maryland, North and South Carolina, Georgia, and other States of the South had anticipated in a limited way the State support of higher education which was made so conspicuous in Virginia. In their plans of education, intellectual and moral, they adhered closely to the college methods which the Northern institutions had introduced from English antecedents. Since 1870 another class of universities has arisen, quite distinct from the colonial establishments and from the wards of the State. These are independent foundations due to individual generosity. The gifts of Cornell, Johns Hopkins, Rockefeller, Tulane, De Pauw, Clark, and Stanford have brought into being universities which for want of a better name may be called private foundations. They have no dependence upon State control, and when a denominational character is assured (as it is in at least one instance), this fact is not made prominent.

Thus, looking at their origin, we see three impulses given to American high schools, from Churches, States, and individuals. It is true that all receive from the State some degree of authority as incorporations, but this authority is so easily obtained that in a single city there may be, and in some places there are, several incorporations authorized to bestow degrees and to bear the name of universities. A foreigner cannot understand nor can an American justify this anomaly. The most that can be said for it is that there is complete freedom of organization, and that the best, and only the best, are likely to survive. Another influence, proceeding from the national government, must also be borne in mind. During the Civil War, Congress, led by Senator Morrill of Vermont, bestowed upon every State a certain portion of the public domain in the Far West—"land-scrip," as it was called—the proceeds of its sale to be devoted to the establishment and maintenance of one or more colleges in each State, where instruction should be given in agriculture and the mechanic arts, not excluding liberal studies, and including military tactics. In some States this bounty was directed to existing universities. New departments were organized in old institutions. Elsewhere new institutions were created. While all these schools were regarded as practical and technical at the first, most of them as they developed became liberal and scientific; and when Congress made later large appropriations for "experiment stations" in the sciences relating to agriculture, an impulse of the most valuable character was given to many departments of scientific research.

This sketch would not be complete without the mention of two foundations, each unique. The Catholic University in Washington has been created by the Pope, and in its government the hierarchy of the Roman Catholic Church is made dominant. Already the Roman Catholics had established, especially under the charge of the Jesuit fathers and of the Sulpicians, excellent colleges for liberal education, as well as schools of theology; but the newer metropolitan university was distinctly organized on a broader plan, in closer accordance with the universities of continental Europe, and with a pronounced recognition of the importance of science.

The University of the State of New York is a supervisory body exercising a general control over all the schools of higher instruction in the State, and especially guarding the conditions upon which their degrees are conferred. It does not give instruction directly.

Organization.

The interior organization of these institutions may now be considered. Some of them have but one department, the philosophical, which includes the liberal arts and sciences; others have two, three, or many correlated departments. Clark University, for example, has but one faculty, the philosophical; Harvard, as already stated, has many departments, including philosophy, law, medicine, and theology. So has Yale. Princeton has but one. Johns Hopkins has two, the philosophical and the medical. In most American universities a sharp distinction is made between undergraduates and graduates, between those who are candidates for the baccalaureate degree (A.B., S.B., and Ph.B.) and those who are engaged in higher professional study, like law, medicine, and theology, or in the manifold branches of modern science, like philology, historical and political science (including economics), philosophy (including logic, ethics, and psychology), mathematics, physics, chemistry, biology, geology, &c. In certain places, as at Johns Hopkins, since 1876, emphasis is given to the idea that college instruction is disciplinary, requiring definite, but not uniform methods, and a certain deference to the authority of a master; while university instruction is much freer, and the scholar is encouraged to inquire rather than to accept; to test and observe rather than to hear and recite; to walk with a friendly guide rather than to obey a commander. This distinction is not universally recognized. Indeed, it has been made but recently in American institutions, so that older men are often heard asking, "What is the difference between a college and a university?" But generally it is admitted that college training is one thing, and work in a university is another; that thorough instruction in language, history, mathematics, natural and physical sciences, and in morals, should precede the discipline of professional schools and the pursuit of the higher and more advanced studies in letters and science. In a complete university provision should be made, according to ancient and widespread usages, for the study of law, medicine, and theology; but unfortunately the development of such schools in the United States has been fettered by narrow conditions. The schools of theology, with rare exceptions, are under denominational control; and so established is this usage, that in the State universities, and in most of the private foundations (Chicago being an exception), theological departments are not encouraged, because of the dread of religious rivalries and dogmatism. Until recently there have been no endowments for medical schools to any adequate extent, and consequently the fees paid by students have been distributed among the teachers, who have usually been the real managers of the institution, although acting under the name of some university. It is nearly the same in law. There are many indications that changes are at hand in these particulars. Theological schools make their denominational characteristics less pronounced, and the old colleges no longer speak of the schools of law and medicine as "outside" departments. The rapid growth of the physical and natural sciences during the 19th century, and the extension of scientific methods of inquiry and verification to subjects which were formerly taught by the traditional methods of authority, have led to the development of laboratories and libraries. Everywhere special buildings, well equipped with the latest and best apparatus, are springing up, where the students of chemistry, physics, biology (in its numerous sub-departments—bacteriology among them), and electricity have every facility for study and research. The introduction of laboratories for psychology is specially noteworthy. Pathological laboratories have become essential in schools of medicine.

Professional schools.

Libraries are—as they always have been and always will be—storehouses where the books and manuscripts of the past are preserved; but in American universities they have taken on another characteristic. Subdivided into special departments, or supplemented by fresh additions, they are the working-rooms of "seminaries," where capable teachers, surrounded by scholars properly qualified, are engaged in teaching, studying, and writing. Seminaries and laboratories distinguish the modern philosophical departments from those of old, where the lecture-room was the seat of instruction. Numerous memoirs and monographs proceed from this active life. Books, periodicals, and dissertations are contributions to the advancement of knowledge. Two agencies have effected these changes, most of which are the product of the last quarter of the 19th century. In the first place, gifts for higher education have been munificent, sometimes, especially in the East, from private citizens—often, especially in the West, from the treasuries of separate States. Quite as important has been the growth of liberal ideas. Very many of the foremost professors in American universities are the scholars of European teachers, especially Germans. Candidates for professorships are resuming the usages which prevailed early in the 19th century, of studying in France and Great Britain. On their return it is essential that they should keep themselves familiar with the latest literature in their departments, whatsoever may be the language in which it appears. Hence the American universities are no longer provincial. They must be judged, for better or for worse, by the standard of universities established in Europe. The bestowal of academic degrees ought to be strictly governed by some recognized authority, and according to ancient usages it is one of the highest functions of a university. In the United States there is but little restraint proceeding from law, tradition, or public opinion. Every "college" is at liberty to exercise this privilege. Hence the variety of academic titles that have been introduced; hence, also, occasional and scandalous frauds in the issue of diplomas. The best institutions exercise due diligence; the public may be protected by requiring that every one who claims the privileges of his degree, or who appends to his name the usual abbreviations indicative of professional or academic authority, should make it clear where, when, and how he received his title.

The institutions in the United States which claim to be universities, in the world-wide use of that designation, recognize these principles and, so far as their means allow, adhere to these methods: 1. There is a disciplinary stage in education which is the requisite introduction to the higher and freer work of the university. This is the sphere of the colleges. 2. The success of the higher work depends upon the intellectual and moral qualities of the professors. No amount of material prosperity is of value unless the dominant authorities are able to discover, secure, and retain as teachers men of rare gifts, resolute will, superior training, and an indomitable love of learning. 3. The professors in a university should be free from all pecuniary anxiety, so that their lives may be consecrated to their several callings. Pensions should be given them in cases of disability, and, in case of premature death, to their families. In methods of instruction they should have as large an amount of freedom as may be consistent with due regard for the co-operation of their colleagues and the plans of the foundation. 4. The steady improvement of the libraries and laboratories is essential if the institution is to keep in the front line. The newest books and the best apparatus are indispensable, for instruments and books quickly deteriorate and must be superseded. 5. For all these outlays large endowments are required. To a considerable extent reliance must be placed on wealthy and public-spirited citizens. In order to enlist such support, and also for higher consideration of the public welfare, the members of a faculty should manifest their interest in public affairs, and by books, lectures, and addresses should inform the public and interest them in the progress of knowledge. 6. Publication is one of the duties of a professor. He owes it not only to his reputation but also to his science, to his colleagues, to the public, to put together and set forth, for the information and criticism of the world, the results of his inquiries, discoveries, reflections, and investigations. Qualified students should also be encouraged, under his guidance, to print and publish their dissertations. 7. As a general rule, those who are most alert in their own intellectual life, those who know how to suggest difficult and fundamental inquiries, and who know how and where to seek for their solution, those who relish the high delights of investigation and production, will be found to be the most helpful and most inspiring teachers of youth. Research and instruction are so closely affiliated that the best teachers are always adding to their knowledge, while the best investigators and thinkers afford examples and inspiration to the youth around them. 8. There is at present great danger that the number of specialists will become too large for the United States to support—that is to say, too many young men are now aiming at professorships. Such persons are usually dependent upon salaries. But salaries, in good environment, cannot be commanded at will. The development, within the last quarter of the 19th century, of several new and strong foundations and the enlargement of older universities, has opened many doors to the more recently promoted doctors of philosophy, but it is a serious question whether the supply of candidates will not soon surpass the demand. This, however, is certain. In so vast a country there are innumerable positions, in addition to professorial chairs, which should be given to those who have had university residences long enough to become familiar with the principles and methods, the books and instruments, by which modern civilization is promoted. The superintendents of public schools, the heads of academies and high schools, the editors of newspapers, the leaders in philanthropic work, and the aspirants for consular and diplomatic service should all be men of liberal education.

College improvements.

Closely associated with the development of the university idea since 1875 is the improvement of the American college. Complaints are often made that the number of colleges is too large, and it is undoubtedly true that some institutions, inferior to city high schools, have usurped the names, the forms, and some of the functions that should be restricted to establishments with larger endowments and better facilities for the promotion of scholarship; but while this is admitted, the great benefits which have resulted from the recognition, far and wide over the vast domain of the United States, of the value of higher education, must not be forgotten. The support of churches of every name, and the gifts of States, cities, and private citizens, have been everywhere enlisted in behalf of learning. In every college worthy of the name mathematics, ancient and modern languages, and the elements at least of modern science, are taught. More or less choice is permitted in the courses requisite to a bachelor's degree. Moral and religious influences are brought to bear on the formation of character. All this is favourable to the enlightenment of the people, and excuses, if it does not justify, the multiplication which is so often deprecated. The establishment of colleges for women, fully equal to the colleges for men, and in many places the admission of women to colleges and universities not originally intended for women, is one of the most noteworthy of the advances in higher education. Opinions are still divided in respect of the wisdom of co-education, especially in the undergraduate period, but there is no longer any question as to the wisdom of giving to women the very best opportunities for intellectual culture; while the success that women have shown in the pursuit of many branches of science has led in many universities to their admission to the established laboratories and lecture-rooms. Separate colleges for women are now maintained in close connexion with Harvard, Columbia, Cornell, Tulane, and other institutions, and this mode of procedure seems likely to be introduced elsewhere. At the same time, independent foundations like Vassar, Smith, Wellesley, Bryn Mawr, and Baltimore are supported with so much vigour, and with such able faculties, that it is not easy to say which organization is the best, and indeed there is no occasion to raise the question. In the Western universities generally, as in Michigan, Wisconsin, California, Chicago, &c., women are admitted to all courses on the same terms as men.

For the statistics of attendance, endowments, &c., of the universities and colleges of the United States, reference should be made to the accurate and comprehensive reports of the United States Commissioner of Education and to the articles under the various headings in these volumes. The difficulty in using these tables is that of nomenclature. Universities of the highest character are described in the same schedule with those which, to say the least, are quite inferior. The *World Almanac* also publishes an excellent and trustworthy compendium of facts. (D. C. G.)

Unna, a town of Prussia, province of Westphalia, 15 miles by rail east of Dortmund. It is the seat of iron foundries, salt works, and coal mines, and has also machine-shops, a chemical factory, brickmaking, and brewing. Population (1885), 8904; (1900), 14,918.

Unterwalden, one of the Swiss cantons subdivided into Obwalden and Nidwalden. The total area of Obwalden is 183·2 square miles, and of Nidwalden 112·1 square miles. The population of the canton is as follows:—Obwalden (1888), 15,043; (1900), 15,270. Nidwalden (1888), 12,538; (1900), 13,017. In 1900 there were in Obwalden 83 inhabitants, and in Nidwalden 116 inhabitants to the square mile. Most of the inhabitants are Roman Catholic and German-speaking. The capitals are Sarnen (population 3974), Obwalden, and Stans 2762. In 1900 Kerns, in Obwalden, had 2362, and Beckenried, in Nidwalden, 1659 inhabitants. Obwalden contains 7 and Nidwalden 11 "political communes," which are also administrative districts. In 1897 the cantonal finances were as follows:—

	Revenue.	Expenditure.	Public Debt.
Obwalden	238,969 francs (a rise of 75¾ per cent. since 1885).	237,724 francs (a rise of 90 per cent. since 1885).	15,000 francs.
Nidwalden	199,676 francs (a rise of 45¼ per cent. since 1885).	189,444 francs (a rise of 56 per cent. since 1885).	48,199 francs.

In 1898 Obwalden had a deficit of 11,738 francs, but Nidwalden a surplus of 9760 francs. The existing cantonal constitutions date from 1867 for Obwalden, and from 1877 for Nidwalden. Besides the railway from Alpnachstad over the Brünig Pass to Meiringen, and that from Stansstad up to Engelberg, there are also mountain railways from Alpnachstad up Pilatus, and from Stans up the Stanserhorn. In 1896 the mountain pastures in Nidwalden numbered 166, supporting 5207 cows.

See *Beiträge z. Geschichte Nidwaldens.* Stans. Annually since 1884.—BLUMER. *Staats- u. Rechtsgeschichte d. Schweiz. Demokratien*, 3 vols. St Gall, 1850–59.—LUTOLF. *Sagen, Bräuche, Legenden, aus den Fünf Orten.* Lucerne, 1862.—*Obwaldner Geschichtsblätter.* Zürich. From 1901.—SOWERBY. *The Forest Cantons of Switzerland.* London, 1892. (W. A. B. C.)

Unyoro. See UGANDA.

Upper Sind Frontier, the name of a district of British India, in the Sind province of Bombay, with administrative headquarters at Jacobabad. Area, 2549 square miles. Population (1881), 145,810; (1891), 174,584, showing an increase of 20 per cent., which has been continuous since 1872; average density, 68 persons per square mile. In 1901 the population was 232,462, showing a further increase of 33 per cent. The land revenue is Rs.10,16,681, the incidence of assessment being Rs.2.4.4 per acre. The cultivated area in 1897–98 was 416,487 acres, of which 372,508 were irrigated from Government canals; number of police, 279; children at school (1897–98), 2343, being 1·7 per cent. of the total population; registered death-rate (1897), 22 per 1000. The principal crops are millet, oil-seeds, pulse, wheat, and rice. The district is crossed for about 30 miles by the Quetta branch of the North-Western Railway. The wild Baluchi inhabitants were pacified by General John Jacob between 1847 and his death in 1858.

Upsala, a town of Sweden, on the navigable river Fyris, 41 miles north of Stockholm by rail. The restoration of the venerable cathedral, which was begun in 1885, was finished in 1893. In 1897 the Museum of Northern (Scandinavian) Antiquities was housed in Linnæus's garden. There is a new Victoria museum for Egyptian antiquities. In 1898 a part of the ruined castle was equipped for the custody of the provincial archives. In 1901 the number of students attending the university was 1384, the number of professors and lectors over 130; whilst the library contained 300,000 volumes and 12,000 MSS. There is a university astronomical observatory (59° 51′ 31″ N., 17° 37′ 30″ E.), founded in 1730, though there was a professorial chair in the preceding century. Some 10 miles south of the city is the fine château of Skokloster, built by Marshal Wrangel, and stored with the booty he brought home from Germany in the Thirty Years' War, including a valuable library, a unique armoury, and a great accumulation of curios. Immediately south of the city stands the important Ultuna agricultural institute. Population (1890), 21,511; (1900), 22,855.

Ural Mountains, a complex mountain system in the Russian Empire, extending from the Arctic Ocean nearly to the Caspian Sea, and generally considered as the geographical boundary between Europe and Asia. The full physical description in the ninth edition of this work leaves only their present economic value to be discussed here. It need only be added that during the years 1880–90 nearly the whole of the middle Ural mining region was mapped by the Geological Committee, and a number of still more detailed geological maps were made by private owners of their mines; while in the northern Urals, the territory from 60° 40′ to 64° 50′ N. was well explored by the expedition of Fedoroff, who has published a geological map of the region. He distinguishes three zones in that part of the Urals: (i.) the eastern hill region, where one finds Mesozoic rocks (Chalk, Jurassic) in the north, and Devonian limestones, porphyrites, and quartz porphyries farther south; in this zone most gold placers are found; (ii.) the central mountain zone consists of various amphibolitic metamorphic slates, and also of syenite and gabbro; granites, gneisses, and occasionally serpentines and porphyrites are found only subordinated to the former; and (iii.) the western hilly zone consists chiefly of Carboniferous and Permo-Carboniferous deposits; Middle and Upper Devonian limestones and, occasionally, crystalline slates are only found in a few meridional ridges.

Mining.

Not only are the Urals very rich in minerals, but the vast areas covered with forests afford an almost inexhaustible supply of cheap fuel for smelting purposes. Thus for a long time the Urals were the chief mining region in Russia. But when coal began to be used for smelting purposes, South Russia generally, and Ekaterinoslav in particular, became the chief iron-producing region, and the Urals lost their primary importance. Attention has, however, again been directed to the great mineral wealth latent in the mountain region, and the last two years of the 19th century witnessed a "boom" in the purchase of iron and gold mines by foreign companies. The Urals possess, indeed, very rich mines of magnetic ore in Mount Blagodat, where the stock is estimated at 12,000,000 tons; in Mount Vysokaya, in the central Urals; and in Mount Magnitnaya, in the southern Urals; of limonite ores in the Zlatoust district, which is capable of yielding several million tons; and of hæmatite, which has been discovered in the basin of the Vishera river in the Cherdyñ district. In 1898 only 1,417,000 tons of iron ore, chiefly limonite, was extracted in the Urals, while the production of pig-iron in 1898 was 714,000 tons, as against 394,000 tons in 1888, out of a total of 2,229,000 tons obtained in all Russia, and it is considered that this might easily be doubled without resorting to the use of coal. The Urals are especially renowned for sheet-iron, and the production of iron goods in 1898 was 248,000 tons, and of steel goods 170,000 tons. The chief pig-iron and iron-works are at Nizhne-Taghilsk, and the principal steel-works at Bogoslovsk. It is interesting to note that several large iron-works have been built in the basin of the Volga with the object of testing the value of naphtha for smelting purposes in the production of pig-iron. The manufacture of agricultural machinery has increased in the southern Urals, especially at Krasnoufimsk, and the manufacture of tea-urns has grown in importance at Perm. But the iron and machinery works are nearly all of the old type—small and for the most part provided only with water motors; and the lack of technical schools is a great obstacle in the way of the development of the iron industry. However, four parallel railways, which Professor Mendeléeff advocated, are to be built across the mountains, and these should develop the industry considerably.

Gold is met with in the Urals both in veins and in placers, and 10,179 kilogrammes (25 per cent. of all the gold obtained in Russia) were extracted in 1897. The Urals have also rich placers of platinum, often mixed with gold, iridium, osmium, and other rare metals, and now supply 6020 kilogrammes, *i.e.*, 90 per cent. of all the platinum obtained in the world. Silver, mercury, nickel, zinc, and cobalt ores are also found. Rich mines of copper are found at Turinsk, Gumishev, and other places, yielding as much as 5 per cent. of pure copper; nickel is obtained at Revdinsk, and the extraction of iron chromates has also developed. Coal is found in many places on the western slope of the Urals, mainly on the Yaiva river, in the basin of the Kama, and the Usva (basin of the Chusovaya), but less than 350,000 tons are raised annually. Several layers of coal have also been found on the eastern slope, and though a definite opinion cannot yet be passed as to their value, it is known that excellent anthracite is found at Irbit and good coal at Kamyshloff; only 5000 tons were extracted in 1900. Sapphires, emeralds, beryls, chrysoberyls, tourmalines, aquamarines, topaz, amethysts, rock-crystal, garnets, and many kinds of jade, malachite, and marble are found and cut and polished at several stone-cutting works, especially at Ekaterinburg; and diamond mining may prove successful. Good asbestos is found and extracted, and pyrites is worked for the manufacture of sulphuric acid (16,000 tons). Many varieties of mineral waters are found in the Urals, the best being those at Serghinsk, Kluchevsk, and Elovsk.

The production of the principal minerals in the Urals (governments of Perm, Orenburg, Vyatka, and Ufa) in 1898 was as follows:—Gold, 11,137 kilogrammes (2562 kilogrammes from veins and 8575 from placers); platinum, 6020 kilogrammes; copper, 3813 tons; pig-iron, 714,000 tons; iron, 248,245 tons; steel, 170,840 tons; manganese ore, 3240 tons; amiant, 1006 tons; iron chromates, 13,220 tons; sulphates, 15,660 tons; coal, 350,650 tons in Perm only; and salt, 170,840 tons (also 8065 tons obtained in Uralsk).

Agriculture

The provinces of the Urals are being rapidly colonized by immigrants from the rest of Russia, and the production of grain rose till in 1895–99 it averaged 5,220,000 tons per annum. Cattle-breeding also yields rich results. The chief towns of the Urals are Ekaterinburg and Perm. There are several iron-works, round which towns of over 10,000 inhabitants have grown; such are Nizhne-Taghilsk (30,000), Neviansk (12,355), Kyshtym (10,000), and Berezovsky (10,190). Numerous villages have over 3000 inhabitants.

AUTHORITIES.—FEDOROFF. *Geological Researches in Northern Urals*, 1884–96; and *Bogoslovsk District*, 1901; as also all publications of the Russian Geological Committee, the Mineralogical Society, and the Geographical Society.—CHUPIN. *Geogr. and Stat. Dict. of the Government of Perm; Permskiy Sbornik*, published by the Perm *Zemstvo*; Statistical Documents about Mining in Russia, published for the Nijni-Novgorod Exhibition in 1896.—MENDELÉEFF. *The Ural Iron Industry*, 1900. (P. A. K.)

Uralsk, a province of Asiatic Russia, belonging to the general-governorship of the Steppes, lying to the S.E. of the Ural river, which separates it from European Russia, and bordering on both the Caspian Sea and the

Sea of Aral. It has an area of 141,174 square miles, and its population, which was 525,330 in 1882, numbered 644,001 (domiciled only) in 1897, of whom 309,642 were women, and 53,714 lived in towns. Four years later (1901) it was 691,687 (327,933 women). Of these the nomads numbered 452,974, and the non-Cossack Russian settlers 5930. The province is divided into four districts, the chief towns of which are Uralsk, Gurieff (9316), Kalmykoff (2847), and Temirsk, a small port on the Caspian. About 10,000 tons of salt are extracted annually from the lakes. Agriculture begins to develop among the Kirghiz, and besides the 569,900 acres which were under culture in 1900 among the Ural Cossacks, the Kirghiz had 203,000 acres under crops. Rye, wheat, oats, barley, millet, flax, and potatoes are the principal crops. The growth of agriculture is best seen from the increasing demand for improved agricultural machinery. Cattle-breeding is, however, the chief industry, and in 1900 there were about 680,000 horses, 844,800 horned cattle, 2,364,200 sheep, 144,600 goats, and 198,400 camels. The export of cattle is considerable, the figures for 1900 being 16,470 horses, 117,500 horned cattle, 416,500 sheep and goats, and 27,100 camels. Fishing is carried on by the Ural Cossacks, who treat their fisheries—the richest in the world—as the common property of the whole Cossack community, and allot them among the different villages under a rational system of administration. In 1901 the export of fish attained 710,000 cwt., and was valued at 3,000,000 roubles, but the Caspian Sea fisheries along the Kirghiz Steppe coasts (about 100,000,000 fishes a year) are not included in the above. Gardening has increased greatly, as also the field culture of melons, sunflowers, &c. The export of corn, fish, living animals, hides, and tallow is considerable.

See Theletnoff. *The Uralians*, 1887.—Danilevsky. "Uralian Fishing," in vols. iii. and v. of *Russian Fisheries*, ed. by Min. State's Domains.—N. Borodin, in *Russ. Encycl. Dict.*, vol. lxviii., where a full bibliography is given. (P. A. K.)

Uralsk, the capital of the above province, on Ural river, 210 miles W.S.W. of Orenburg. It is now connected by a railway with Saratoff (273 miles), and is rapidly developing owing to its trade with the nomad Kirghiz in cattle, sheep, and animal products, all of which are exported to Russia; it is also a great centre for trade in grain. It has a *real*-school, a gymnasium for girls, a school farm, a people's palace, two free libraries, a good theatre, and branches of the Geographical and the Fisheries Society. Population (1897), 36,597; (1901), 38,919.

Ura-tyube, or Ora-tepe, formerly the chief town of an independent bekdom, now a town of Russian Turkestan, in the province of Samarkand, lying 55 miles S.W. of Khojent, on the road from Fergana to Jizak across the Zerafshan range; altitude 3000 feet. It is surrounded by a wall, and has a Russian citadel, round which grows a small Russian town. Its inhabitants carry on trade in horses and camel-wool cloth. Ura-tyube is supposed to have been founded by Cyrus under the name of Cyropol, and was taken in 329 B.C. by Alexander of Macedon. Later it was the capital of a kingdom, and received its present name from the Uzbek in the 15th century. The Russians took it in 1866. Population (1897), 20,837, chiefly Uzbek.

Urbana, a city of Illinois, U.S.A., capital of Champaign county, on the Embarras river, opposite Champaign, and on the Cleveland, Cincinnati, Chicago and St Louis, and the Wabash railways, in the eastern part of the state, at an altitude of 725 feet. It is the headquarters of the Illinois State University, a non-sectarian, co-educational institution, opened in 1868. In 1898 its faculty numbered 183, and it was attended by 1582 students, including 245 women. Of the total number of students, 199 were in the preparatory department, 696 in the collegiate department, 78 were pursuing graduate courses, and 587 were in the professional departments. The property of the university was valued at $1,544,000, and its income was $355,000. Population (1890), 3511; (1900), 5728, of whom 300 were foreign-born.

Urbana, a city of Ohio, U.S.A., capital of Champaign county, west of the centre of the state, on the Cleveland, Cincinnati, Chicago and St Louis, the Erie, and the Pittsburg, Cincinnati, Chicago, and St Louis railways, at an altitude of 1031 feet. It is the seat of Urbana University, a New Church institution opened in 1850. It has machine-shops, agricultural implement works, carriage and waggon factories, and other manufacturing establishments. Population (1890), 6510; (1900), 6808, of whom 405 were foreign-born and 796 negroes.

Urbino, a town and archiepiscopal see in the province of Pesaro and Urbino, The Marches, Italy, standing amongst the eastern spurs of the Apennines, 23 miles south of Rimini. The ducal palace contains the picture gallery (including a "Resurrection" by Titian), a collection of ancient inscriptions, and a gallery of sculpture. In the principal square was erected in 1897 a handsome monument to Raphael by Belli; it consists of a bronze statue (12½ feet high) of the painter, mounted on a base of Carrara marble, with two reliefs and allegorical figures, the whole being 36 feet high. The free university (1564) has two faculties, and in 1900–01 had 148 students and 14 teachers. There is a technical school, and the town has manufactures of silk, majolica, and bricks. Population (1900), 5000.

Urfahr, a town in the government district of Linz, Lower Austria, on the left bank of the Danube opposite Linz, with which it is connected by an iron bridge. It has considerable manufactures and trade in corn and agricultural produce. Population (1890), 8289; (1900), 12,827.

Uri, one of the Swiss cantons. Its total area is 415·3 square miles. The population in 1880 was 23,744, and in 1888 17,249, while in 1900 it was 19,732. In 1900 there were 48 inhabitants per square mile, the lowest rate of density in Switzerland save the Grisons (38). The inhabitants are nearly all Roman Catholic and German-speaking. The capital is Altdorf. In 1900 Silenen (1885 inhabitants) was the third most populous village, and Erstfeld the second (2404); Wassen had but 991 and Goeschenen 792 inhabitants, all these variations being due to the fact that on the completion of the St Gothard railway the floating labour population disappeared. In 1898 Uri had 102 mountain pastures, supporting 10,354 cows. There are 20 "political communes" in Uri, which are also administrative districts. In 1897 the cantonal revenue was 360,626 francs (78,000 francs less than in 1885), and the expenditure 350,538 francs (71,000 francs less than in 1885), while in 1898 there was a surplus of 4122 francs. In 1897 the public debt was 709,000 francs.

See *Historisches Neujahrsblatt* (published by the Cant. Hist. Soc.). Altdorf. From 1895.—Lusser. *Der Kant. Uri.* St Gall, 1834.—Casimir Nager. *Die Alpwirthschaft im Kant. Uri.* Soleure, 1898.—Oechsli. *Die Anfänge d. Schweiz. Eidgenossenschaft.* Zürich, 1891.—Schmid. *Allgem. Geschichte d. Freystaates Uri*, 2 vols. Zug, 1788–90.—Wanner. *Geschichte d. Baues d. Gothardbahn.* Lucerne, 1885. (W. A. B. C.)

Uruguay, a country of South America, extending from 30° to 35° S., and from 53° to 58° 30′ W. It lies on the north bank of the Rio de la Plata, its inland boundary on the east and north being the Brazilian frontier, and on the west the river Uruguay, which separates it from Argentine territory. The republic enjoys the reputation of possessing one of the most healthy climates in the world. The geographical position ensures uniformity of temperature throughout the year, the summer heat being tempered by the Atlantic breezes, and severe cold in the winter season being unknown. The southern half of the country is for the most part undulating grass land, well watered by streams and springs. The northern section is more broken and rugged; barren ridges and low, rocky mountain ranges, interspersed with fertile valleys, being its characteristic features. There is no forest, timber of any size being found only in the valleys near running water.

Area and population.

The area comprised within the limits of the republic is estimated at 72,151 square miles, and has a population of about 930,600. The country is divided into 19 departments, the area and the population of which, according to official estimates for 31st December 1900, are given in the subjoined table.

Departments.	Area. Sq. Miles.	Population 1900.	Pop. per Sq. Mile.
Artigas	4,390	26,004	5·9
Canelones	1,835	84,749	46·1
Cerro Largo	5,765	36,396	6·3
Durazno	5,525	37,141	6·7
Flores	1,745	15,874	9·1
Florida	4,675	44,054	9·4
La Colonia	2,195	50,275	22·4
Maldonado	1,590	26,439	16·6
Minas	4,795	36,085	7·5
Montevideo	256	268,334	1048·1
Paysandu	5,115	43,121	8·4
Rio Negro	3,270	21,202	6·4
Rivera	3,795	24,792	6·5
Rocha	4,280	29,550	6·9
Salto	4,865	44,675	9·2
San José	2,690	41,055	15·2
Soriano	3,565	38,047	10·6
Tacuarembo	8,115	37,851	4·6
Treinta y Tres	3,685	25,036	6·8
Total	72,151	930,680	12·9

Of 597,289 persons whose nationality was ascertained, 509,165 were Uruguayan; 23,352, Spanish; 24,349, Italian; 24,720, Brazilian; 9140, Argentine; 4186, French; 675, English; 708, German; 994, Swiss.

The natives of Uruguay, though living in conditions similar to those of the Argentine population, are in general more reserved, showing more of the Indian type and less of the Spaniard. In the north there is a strong Brazilian element, and the people are intensely conservative, their mode of life having undergone little change during the last 50 years.

The marriages, births, and deaths registered in four years were:—

Year.	Marriages.	Births.	Deaths.	Natural Increase.
1897	2746	27,763	13,013	14,750
1898	4318	29,870	13,255	16,615
1899	4463	31,613	12,343	19,270
1900	4549	31,593	13,882	17,711

The numbers of births and deaths include still-births, of which there were in 1899, 894, and in 1900, 1004, the proportion to total births being 3·2 per cent. The illegitimate births in 1899 numbered 7857, and in 1900, 8021, their proportion to the total births being 25·4 per cent.

The number of immigrants into the republic in the years 1891–1897 was 74,008; in 1898, 9467; in 1899, 9006; in 1900, 8892. The emigrants in 1891–97 numbered 60,075; in 1898, 6411; in 1899, 5830; in 1900, 6705. The immigrants in 1900 comprised 3211 Italians, 2815 Spaniards, 685 Brazilians, 451 French, 252 Germans, and 290 English. The principal towns, with their population, are Montevideo, 268,000; Salto, 10,000; Paysandu, 7000; San José, 7000.

Administration and justice.

There has been no recent change in the political constitution of the republic. The senators number 19, and the deputies 69. Each department or province of the republic has a governor appointed by the executive, and an administrative council, whose members are chosen by popular vote. The judicial power is vested in a high court and many subordinate courts. There are three civil courts for ordinary and two for commercial cases; one for cases affecting the Treasury; two criminal courts, besides police and local courts. The administration of justice, however, is in a lamentable condition. Crime is practically unchecked, and murder and violence are common. The civil courts are little better than the criminal, and corruption exists in every branch.

Education.

Education is much neglected, and the public school system is inefficient. The attendance of children at the schools is small, and the instruction they receive is a smattering of superficial knowledge, of little use to them in after-life, and worthless in the formation of character. In 1900 the number of public schools was 571, with 52,474 pupils. Of private schools there were 344, with an attendance of 22,267. Thus the attendance at public and private schools combined is only equal to 8 per cent. of the total population, as compared with 21 per cent. in the United Kingdom, and 23 per cent. in the United States. The number of teachers employed in the public schools was 242 male and 889 female. The cost per pupil was $14·51, or about £3 sterling. There is a school of arts, with, in 1900, 157 students. At the University of Montevideo in 1900, 233 students were matriculated.

Finance.

Of the national revenue nearly two-thirds is derived from customs duties, taxes being levied also on real estate, licences, tobacco, stamped paper, and in other ways. More than half the expenditure goes to meet debt charges, while government, internal development, and defence absorb most of the remainder. The receipts for the years specified were as follows, Uruguayan dollars being converted into sterling at the par value, 4·7=£1:—

Years.	Revenue.	Years.	Revenue.
1894–1895	£3,403,324	1897–1898	£3,213,180
1895–1896	3,606,273	1898–1899	3,351,000
1896–1897	3,319,748	1899–1900	3,236,300

Of expenditure for these years there is no authoritative statement. The estimated revenue and expenditure for the year 1901–02 balanced at $16,160,000, or £3,439,500. In 1891, when the debt of the republic amounted to $87,789,973, or about £18,678,710, the Government suspended payment of interest, and an arrangement was made with the bondholders. A new consolidated debt of £20,500,000 was issued at 3½ per cent. interest, and, as security for payment of interest, 45 per cent. of the customs receipts at Montevideo was assigned. At the same time the interest guaranteed to the railway companies was reduced from 7 to 3½ per cent. In 1896 a 5 per cent. loan of £1,667,000 was issued, and in other ways the debt has increased, so that on 31st December 1901 it stood as follows:—

External debt	$99,195,380
Internal debt	22,193,282
International debt	3,414,625
	$124,803,287
	=£26,554,000

In 1901–02 the annual debt charge amounted to $9,036,420, or about £1,923,000.

Agriculture.

In recent years the progress of agriculture has been fairly satisfactory. In 1885 Uruguay imported most of her breadstuffs; now, not only are wheat and maize grown in sufficient quantities to meet the local demand, but a surplus is annually available for export. Land for farming purposes is expensive, and wages are high, leaving small profit, unless it happens that a man, with his family to assist him, works his own land. The farmers are chiefly Italians, Canary Islanders, and Frenchmen. The export of grain and flour during the six years 1896 to 1900 was:—

Year.	Wheat.	Flour.	Maize.
	Tons.	Tons.	Tons.
1896	6,390	17,714	89,895
1897	12,548	11,454	1,377
1898	77,231	11,296	12,575
1899	62,673	20,726	10,926
1900	39,871	18,128	485

Since 1890 the cultivation of the grape and the manufacture of wine have considerably extended, especially in the neighbourhood of Salto. The number of vineyards in 1898 was 824; the produce disposed of was returned as 4,498,900 ℔ of grapes sold as fresh fruit, and 11,786,000 ℔ made into wine. The quantity of wine manufactured was 710,100 gallons of red and 27,200 gallons of white. Grape alcohol to the amount of 5320 gallons, and 2050 gallons of wine alcohol, were also produced. The olive-planting industry is becoming important; the trees thrive well, and the area devoted to their cultivation is annually increasing.

Cattle-breeding and sheep-farming, however, are the principal industries in Uruguay. In 1899 the number of cattle in the republic was 5,218,948, as shown by returns in the annual statistical report. The lands are admirably adapted for cattle-breeding purposes, although not capable of fattening animals. The cattle are destined chiefly for the *saladero* establishments for the preparation of *tasajo*, or jerked beef, for the Brazilian and Cuban markets, and for the Liebig factory, where very large quantities of extract of meat are prepared for the European trade. The total number of animals slaughtered in these establishments in the season 1900 was 698,900. In the southern districts, where the farmers are Europeans, the breed of cattle is being steadily improved by the introduction of Durham and Hereford bulls. Dairy-farming is making some progress, especially in the Swiss colony near San José.

In 1899 Uruguay contained 15,111,739 sheep, and the industry of sheep-farming was in a very flourishing condition. Uruguayan wool is favourably regarded in foreign markets, on account of the clean state in which it is shipped, this being largely due to the natural conditions of the land and climate. In 1900 the quantity of wool exported was 26,755 tons. The business of shipping live sheep and frozen mutton has not yet been attempted on a large scale, owing principally to the lack of facilities for loading at the port of Montevideo or elsewhere.

Minerals are known to exist in the northern section of the republic, and gold-mining is carried on to a small extent. At Cuñapiru some foreign capital has been invested in mining undertakings, but not with very satisfactory results up to the present time. Expert opinions have, however, been advanced stating that the gold-mining industry in Uruguay can be made to yield dividends when the work is conducted under competent direction. In 1895 the output of gold was 1965 ounces; in 1898, 2402 ounces; in 1900, 2290 ounces. The other minerals found are silver, copper, magnesium, and lignite coal.

Commerce.

The economic development of Uruguay has been retarded by the corruption of successive governments, by revolutionary outbreaks, by the seizure of farm stock, without adequate compensation, for the support of military forces, by the consequences of reckless borrowing and over-trading in 1889 and 1890, and also by the transference of commercial undertakings from Montevideo to Buenos Aires between 1890 and 1897, on the opening of the harbour and docks at that port. The annual value of the imports and exports in 1889 and in later years (4·7 dollars taken at £1) was as follows:—

Year.	Imports.	Exports.
1889	£7,834,860	£5,522,150
1891	4,037,110	5,744,310
1899	5,458,000	7,781,750
1900	5,101,740	6,257,600
1901	5,040,800	5,900,240

The principal imports consist of machinery, textiles, and clothing, food substances and beverages, and live-stock. The chief exports are animal products, £5,660,900, and agricultural products, £355,200 in 1900. Of the imports, 27 per cent. in value are from Great Britain, 14 per cent. from Germany, and smaller proportions from France, Argentina, Italy, Spain, the United States, and Belgium. Of the exports, Brazil takes 26 per cent., Belgium 17 per cent., and France 16 per cent. Trade is controlled by foreigners, the British being prominent in banking, finance, railway work, and the higher branches of commerce; Spaniards, Italians, and French in the wholesale and retail trade. Uruguayans find an insignificant place in commerce. The foreign trade passes mainly through Montevideo, where the port is being improved. Maldonado is the only deep-water port.

Shipping and communications.

At Montevideo in 1900 there entered from abroad 1206 vessels of 2,318,954 aggregate tonnage, and cleared 1033 of 2,052,723 tons. In the coasting trade 2020 vessels of 507,110 tons entered and 2063 of 508,986 tons cleared at the port. The mercantile shipping of the republic in the same year consisted of 23 steamers aggregating 7036 tons net, and 58 sailing vessels of 15,848 tons. The rivers and streams belonging to or bordering on the republic supply easy means of communication. There are about 2240 miles of national road, besides departmental roads. The railways have a length of 1080 miles open for traffic, and 155 miles were under construction in 1899. At the end of 1898 the capital outlay on the railways amounted to £11,150,857, of which £5,750,000, representing 882 miles, had a Government guarantee of 3½ per cent. There are 100 miles of tramway in operation. In 1900 there were 692 post offices, through which altogether 11,124,500 letters and postcards passed during the year. The telegraph lines had a length of 4598 miles (including 1058 miles of railway telegraph); they were served by 101 offices, through which passed 397,493 messages. In the same year there were two telephone companies, with altogether 9824 miles of wire and 3968 subscribers.

Credit.

The Bank of the Republic was established in 1896 with a nominal capital of $12,000,000, and in 1899 it received the right to issue further shares amounting to $5,000,000. Its note issue, $5,034,426 in 1900, may not exceed the value of half the subscribed capital. There are 3 other banks of issue with an aggregate capital of $8,070,000, and there are 4 foreign banks.

There is no Uruguayan gold coin in circulation, but the theoretical monetary unit is the gold peso nacional, weighing 1·697 grammes, ·917 fine. The silver peso weighs 25 grammes, ·900 fine. The silver in circulation is estimated at 2,000,000 pesos.

The metric system of weights and measures has been officially adopted, but the old Spanish system is still in general use.

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Recent History.—The history of Uruguay between 1875 and 1900 was the history of revolutions and conspiracies, of bloodshed and anarchy, the struggle of one side to obtain possession of the administration and of the other to defend themselves against these aggressive movements. The two great political factors for generations past have been the Colorados and the Blancos. So far as political principles are concerned, there is small difference between them. Men are Colorados or Blancos because their fathers and grandfathers were so before them, and not from any political convictions. The Colorados have held possession of the Government for many years, and it has been on account of the attempts of the Blancos to oust them from office that the country has been plunged into a series of revolutions. It should be stated, however, that the military element has been at the bottom of many of the conspiracies to compel this or that President to resign in order that his place might be filled by somebody more amenable to the demands of the army for additional preferment and a larger share in the official plunder pertaining to the administration.

In 1875 General Latorre headed a conspiracy against

President Ellauri, overthrew the administration, and obtained the resignation of the President. General Latorre then placed Dr Varela in power as dictator, but afterwards became dissatisfied with this arrangement. On 8th March 1876 he deposed Varela and proclaimed himself dictator. In the following year Latorre caused himself to be elected President, but political unrest in all sections of the republic made his position untenable, and he resigned office in March 1880. The president of the senate, Dr Vidal, nominally administered the Government for two years, when General Santos, who practically had held the real power, became President. His administration was so vicious and tyrannical that the Opposition organized a revolutionary movement throughout the country. Their forces, however, were surprised by the Government troops at Quebracho, on the Rio Negro, and totally defeated. Ultimately the Colorados themselves determined that Santos should be deprived of his power, and a decree exiled him from the country. During his administration the national revenues were plundered to supply him with the means of extravagant living, and there was no attempt at government according to the constitution of the republic. The Colorados now placed General Tajes in power as President, the practical direction of the administration being in the hands of Dr Julio Herrera y Obes. In March 1890 General Tajes handed over the Presidency to Dr Herrera y Obes, a clever but unscrupulous man, who filled every official post with his own friends without any regard for their capacity to discharge the duties allotted to them. He also took care that none but supporters of himself should be returned to the Chamber of Representatives, thus stifling all opposition to the official corruption which prevailed. Meanwhile the Blancos were reorganizing in order to be in a position to strike when the opportunity offered. In 1891, in consequence of the corrupt administration, President Herrera y Obes was obliged to suspend the service of the public debt and make arrangements by which the bondholders accepted a very much reduced rate of interest. The country was at this period, to all intents and purposes, conducted as if it were the private estate of the President. No accounts of revenue or expenditure were vouchsafed to the public, and Congress authorized any measures Herrera y Obes thought fit to propose. In 1894 the Colorados nominated Señor Idiarte Borda for the Presidency.

Señor Borda at first gave the impression of being inclined to make a determined attempt to respect civil rights and honestly discharge the duties of his office. Before long, however, it was clear that the evil influences surrounding him had caused a change in his attitude. Corruption was as marked as under the preceding régime. The Blancos, using the fraudulent elections in 1896 as a pretext, now broke out in armed revolt under the leadership of Aparicio Saraiva. The President made no attempt to conciliate them, and in March 1897 a body of Government troops suffered a reverse. All this added greatly to the prestige of the revolt, and discontent began to spread rapidly through the country. On 25th August 1897 President Borda attended a Te Deum at the cathedral in Montevideo. As he was walking through the crowded square in which the cathedral stands a man named Arredondo fired at and killed him. Arredondo was tried at the end of July 1899 and sentenced to two years' imprisonment. The defence was that the murder was a political offence, and therefore not punishable as an ordinary case of assassination for purposes of revenge or other personal motives.

The president of the senate, Señor Juan Cuestas, in accordance with the terms of the constitution, assumed the duties of President of the Republic after the death of Idiarte Borda. No sooner was the new chief magistrate installed in office than he set about making some agreement with the insurgents in order to restore peace. Ultimately it was arranged that hostilities should cease on the conditions that representation of the Blancos was allowed in Congress from certain specified districts where they were known to predominate as regards eligible voters; that a certain number of the *jefes politicos* should be nominated from the Blancos; that free pardon be extended to all who had taken part in the revolt; that a sufficient sum in money be advanced to allow the settlement of the expenses contracted by the insurgents; and that the electoral law be reformed on a basis allowing the people to take part freely in the elections for the Chamber of Representatives. These terms were accepted by Congress, and the insurrection thus came to an end. It must be noted, however, that the Blancos openly stated that they intended to continue organizing in order to accomplish their object of turning the Colorados out of office by force of arms.

The task now before President Cuestas was a difficult one. It was necessary to reduce the chaotic condition of the administration to something approaching order. The military element began to find themselves shorn of many of the privileges they had formerly enjoyed, and civil officials were no longer allowed the freedom in their departments that in former days had permitted corrupt practices with impunity. In February 1898 President Cuestas, finding that the attitude of Congress tended to provoke another revolutionary outbreak on the part of the Blancos, determined upon strong measures to maintain peace. On the 10th of February he assumed dictatorial powers, dissolved the Chambers, and suspended all constitutional guarantees. In normal circumstances the Presidential election should have been held on 1st March 1898, but it was impossible in consequence of the action taken by Señor Cuestas. In the following year Congress was convoked in February, President Cuestas then resigning his office, and being re-elected to the Presidency on 1st March 1899. (W. W. R.; I. P. A. R.; C. E. A.)

Uruguay River. See Plate River.

Uryupina, a Cossack village of Russia, chief town of a district in the province of the Don Cossacks, on the left bank of the river Khoper, 234 miles by rail from Tsaritsyn. It has a great fair for cattle, hides, and sheepskins, which are exported, and all sorts of manufactured goods, which are imported; it is estimated that the turnover at this fair is not less than from £600,000 to £1,000,000. A considerable trade is also carried on in grain and animal products. Population (1897), 9612.

Ushak, a town of Asia Minor, altitude 3160 feet, in the Kutaya sanjak of the Brúsa vilayet, situated in a fertile district, on a tributary of the Mendere, and connected with Smyrna and Konia by rail. It is noted for its heavy pile carpets, *khali*, known as "Turkey carpets." The Oriental character of the carpets has been almost destroyed by the adoption of aniline dyes and the introduction of Western patterns. The town has a trade in valonea, cereals, and opium. The population consists of 9000 Moslems and 2000 Christians.

Usk, Thomas (died 1388), is a name which was first added to the history of English literature in 1897 by Mr Henry Bradley's discovery that *The Testament of Love*, an important prose work hitherto attributed to Chaucer, bore in the initial letters of its chapters a statement of authorship—"Margaret of virtue, have mercy on thine Usk." By the light of this perception, various autobiographical statements became luminous, and there remained no possible doubt that the author was Thomas Usk, who was clerk of the closet to John of Northampton when he was mayor of London from 1381 to 1383. In July 1384 Usk was seized and put in prison, but was released on promise of bringing charges against the mayor. Usk had no wish to be what he called "a stinking martyr," and he freely produced evidence which sent John of Northampton to gaol. For this he was not forgiven by the Duke of Gloucester's party, although he continued to hold confidential posts in London until the close of 1386, when he was appointed sub-sheriff of Middlesex. But he fell with the king, in the triumph of the Duke of Gloucester, and on the 3rd of February 1388, Usk, among others, was tried for treason and condemned. He was sentenced "to be drawn, hung, and beheaded, and that his head should be set up over Newgate." Higden gives a horrid description of his execution, which occurred on the 4th of March 1388, in circumstances of rude barbarity; it took thirty blows of a sword to sever Usk's head from his shoulders. Professor Skeat has shown that the date of his book must be about 1387, for in it he reviews the incidents of his career, including the odd facts that, after his first imprisonment in 1384, he challenged any one who "contraried" his "saws"—that is to say, denied his allegations, to fight, but that no one took up his wager of battle. From 1381 to 1383, while Chaucer was comptroller of customs, Usk was collector, and they were doubtless acquainted. In *The Testament of Love*, the god is made to praise "mine own true servant, the noble philosophical poet in English," who had composed "a treatise of my servant Troilus." Usk had at one time been a Lollard, but in prison he submitted to the Church and thought he was forgiven. His solitary work is remarkable, and the most elaborate production in original English prose which the end of the 14th century has bequeathed to us. It is, however, excessively tedious, and of its obscurity and dulness a very amusing proof is given by the fact that successive editors—and even Mr Bradley and Professor Skeat—did not discover till too late that the leaves of the original MS. had been shuffled and the body of the treatise misarranged. No MS. of *The Testament of Love* has been preserved; it was first printed by Thynne in 1532. In 1897 Professor Skeat, with cancelled sheets to cover the unlucky mistake above referred to, issued a revised and annotated text in his *Chaucerian and other Pieces*. (E. G.)

Uskub, chief town and seat of government of the province (vilayet) of Kossovo, Turkey, comprising all North Albania. It has a population of 40,000, of whom about two-thirds are Albanian Mahommedans. The population has doubled since 1875, owing to the stimulus which trade has derived from the two railways, by one of which Uskub is connected with Mitrovitza, and by the other with Servia on the one hand and Salonica on the other. The imports (valued at £386,200 in 1900) consist principally of metals, woollen and cotton piece-goods, soap, leather, &c. The district produces and exports opium, cereals, fruits, tobacco, skins, and silk. Sericulture, under the encouragement extended to it by the Administration of the Public Debt, is increasing year by year, as it also is in the adjacent vilayets of Monastir and Salonica. Uskub also exports horned cattle and sheep. The butchers of Constantinople take annually over 200,000 head of these sheep. The total export trade was valued at £529,100 in 1900. The vilayet of Kossovo has considerable mineral resources, but the Government does nothing to promote their development. Its pastoral industry is still very far from having attained full growth. It is capable of much further expansion owing to the wide extent of pasture-land in the province, and to a fluvial system which makes water everywhere abundant.

Ust-Byelokalitvenskaya, a Cossack village of Russia, in the province of the Don Cossacks, at the junction of the northern Donets with the Kalitva. Quarries of good sandstone (Chalk), largely used for buildings, are close by, and there is a lively trade in grain and cattle. Population (1897), 18,039.

Ust-Kamenogorsk, a district town of Russian Central Asia, in the province and 135 miles south-east of the town of Semipalatinsk, on the right bank of the Irtysh, at its junction with the Ulba, and on the highway to Bukhtarma. It is a prairie town that has grown rapidly, on account of the development of trade in cattle and various raw products. Population (1897), 8958.

Ust-Khoperskaya, a Cossack village of Russia, in the province of the Don Cossacks, at the junction of the Khoper with the Don. It is an agricultural town, and carries on an active trade in grain and cattle. Population (1897), 12,324.

Ust-Medvyeditsa, a Cossack village of Russia, in the province of the Don Cossacks, of one of the districts of which it is the chief town, on the right bank of the Don, near its confluence with the Medvyeditsa, 63 miles from the Tsaritsyn railway station, Sebryakovo. Its trade in grain, formerly very active, has decreased, but its fairs have still importance for trade in horses and cattle. There is a military technical school. Population (1897), 15,999.

Ustyug Velikiy, a district town of Russia, in the government of Vologda, 303 miles from the capital of the province, on the navigable Sukhora river, near its junction with the Yug. It carries on an active trade in corn, hemp, flax, bristles, and butter, which it exports. Its two yearly fairs are very animated, and the movement of the port is represented by some 350 vessels (about 20,000 tons) and over 200 rafts (3500 tons) entering, and as many vessels leaving. It has a gymnasium for girls, and two middle schools, and is well provided with primary schools. Its artisans are famous for their jewellery, for engraving upon silver, and the fabrication of boxes with secret locks. Population (1897), 11,309.

Utah, a western state of the American Union. The progress of the state during the closing decade of the 19th century was both rapid and substantial. In 1880 the population was 143,963; in 1890 it was 207,905, of whom probably four-fifths were Mormons and nearly one-third of foreign birth. The population in 1900 was 276,749, of whom about two-thirds were Mormon. Of the total population 141,687 (51·2 per cent.) were males and 135,062 (48·8 per cent.) females; 222,972 were native-born and 53,777 (19·4 per cent.) foreign-born; 272,465 were white and 4284 (1·5 per cent.) coloured, of whom 672 were negroes, 572 Chinese, 417 Japanese, and 2623 Indians. The gain in population for the decade 1890–1900 was 33·1 per cent., as compared with 44·4 per cent. for the ten years preceding.

The total land surface of Utah is approximately 82,190 square miles, so that the density of population was, in 1890, 2·5, and in 1900, 3·4 persons to each square mile. There were, in 1900, 66 incorporated cities and towns, of which 18 had more than 2000 inhabitants, 4 had more than 5000, namely, Salt Lake City with 53,531, Ogden with 16,313, Provo City with 6185, and Logan with 5451 inhabitants.

Political History: the Mormon Question.—From the settlement of the Territory to 1890, the People's party, composed of members of the Mormon Church, had entire political control. During this period the Liberal party, composed of Gentiles and apostate Mormons, had been constantly gaining in strength, and in 1889 and 1890 they elected the mayors of Ogden and Salt Lake, and also secured control of the public schools in these cities. On 24th September 1890 President Woodruff of the Mormon Church issued the celebrated Anti-Polygamy Manifesto, in which he said: "We are not teaching polygamy or plural marriage, nor permitting any person to enter into its practice. . . . And I now publicly declare that my advice to the Latter Day Saints is to refrain from contracting any marriage forbidden by the law of the land." This was read to the Mormon Conference, 6th October 1890, and by it unanimously sustained, on the motion of Lorenzo Snow (at that time president of the quorum, and on the death of President Woodruff, 2nd September 1898, elected President of the Mormon Church), in these words: "I move that, recognizing Wilford Woodruff as the president of the Church of Jesus Christ of Latter Day Saints, and the only man on the earth at the present time who holds the keys of the sealing ordinances, we consider him fully authorized by virtue of his position to issue the manifesto which has been read in our hearing, and which is dated September twenty-fourth, 1890, and that as a church in general conference assembled, we accept his declaration concerning plural marriage as authoritative and binding." This was accepted by the Gentile element as having been made in good faith, and as being the beginning of the end of the strife which had existed for years. Accordingly, the Liberal and People's parties were disbanded in 1893, and the two great national political parties organized in place thereof. Following these events, a petition was presented to the President of the United States by the authorities of the Mormon Church, asking amnesty and a removal of the political disabilities which had been put by Congress upon the Mormon people. This petition was endorsed by the Governor of the Territory and by the Chief Justice of the United States Court. On 4th January 1893 President Harrison issued his proclamation granting "full pardon to all persons liable to the penalties of the Tucker-Edmunds Act, who, since 1st November 1890, have abstained from unlawful cohabitation, but upon the express condition that they shall in the future faithfully obey the laws of the United States hereinbefore named, and not otherwise." During the years 1885-95 much personal and real property belonging to the Mormon Church had been escheated to the United States. This action was not instigated by the Gentiles—in fact, it was editorially opposed by the leading Gentile newspaper. It was the result of an Act of Congress designed to check the growing practice of unlawful cohabitation. After the manifesto was issued, this escheated property was returned to the Mormon Church with the hearty approval of the Gentiles.

Admission to Statehood: Recent Events.—Two propositions looking to the future good of the Territory were advocated. Home Rule was suggested by the Democrat and Statehood by the Republican party. In 1895 Congress passed an enabling Act, under which the constitution was prepared and adopted by the people. This constitution, in its third article, provides that polygamy shall be for ever prohibited, and, in addition, that this particular article shall never be repealed, "except by the consent of the United States and the people of the state." It also gives the right of suffrage to women. In the autumn of 1895 the entire Republican state ticket was elected. By proclamation of the President, Utah was admitted to the Union as the forty-fifth state on 4th January 1896. One of the first acts of the Legislature was to declare legitimate all children born of polygamous marriages prior to 4th January 1896, thus enabling them to inherit from their fathers under the law.

About this time it was alleged, as had been frequently the case, that the Mormon Church was dictating to its members in political matters. The ground for the charge was a regulation of the Mormon Church that members holding offices of responsibility in the Church who desired political offices should take counsel of the Church authorities and receive permission before becoming candidates. For failing to do this an apostle, who was a Democratic candidate for the United States Senate in 1897, was deprived of his apostleship and all offices in the Church. This charge of dictation was promptly denied by the first Presidency (consisting of the President and his two counsellors) in a manifesto presented at the Conference in April 1896, which was confirmed by a vote of the Conference, thus committing the Church. With this declaration all public strife between Gentiles and Mormons ceased, mutual good-feeling prevailed, and the state continued to grow and prosper. In 1897 the Jubilee Festival, commemorating the coming of the Pioneers, was observed with the greatest enthusiasm. Gentiles and Mormons vied with each other in making it a success. This harmony continued until 1898, when a Mormon, B. H. Roberts, who had been elected to the National House of Representatives by the Democrats, was publicly charged with living in unlawful cohabitation with three wives, one of whom had been taken since the promulgation of the manifesto. Certain officials of the Mormon Church were also charged with the same offence and were arrested. Some pleaded guilty, and were fined; others pleaded not guilty, and were tried and convicted. The charge against the member of Congress aroused the opposition of the entire country. By an overwhelming majority he was refused a seat in Congress. The vacancy was filled by the election of another Mormon, and the agitations relative to Mormonism ceased. On the return of the excluded member he was indicted for unlawful cohabitation, and on an agreed statement of the facts the case was submitted to the jury. A verdict of guilty was returned and a fine was imposed. On a technicality the case was appealed to the Supreme Court and afterwards dismissed because of a decision in a similar case, which would have meant a reversal of the decision of the lower court in this case.

In the Presidential election of 1896 Mr McKinley (Republican) received 13,484 votes, and Mr Bryan (Democrat) 64,517 votes. In the Presidential election of 1900 the same candidates received respectively 47,139 and 45,006 votes.

Education.

From 1867 onwards parochial schools had been established in a number of towns by the Episcopal Church and by several other Christian denominations. They trained a number of young people in habits of independent thinking, as is evidenced at each election by the Independent vote, and thus prepared the way for the adoption of a more advanced system of public instruction. In 1890 they were superseded by a public school system. The newly elected public school boards entered upon a vigorous policy of administration, excluding all sectarian instruction, and securing the best teachers to be found. New, large, and convenient school buildings were erected throughout the Territory, and the people took a keen interest in public school education. In 1900 there were 659 schools with 1395 teachers, and more than 70,000 children were in attendance. In 1900 the number of persons of school age (five to twenty years inclusive) was 106,513; and out of 67,172 adult males 2470 (3·7 per cent.) were illiterate (unable to write).

The State University, agricultural college, normal school, and school of mines, supported by taxation, and aided by generous legislative grants, have a teaching staff of 60, and an attendance of upwards of 1000 students. The state reform school is situated at Ogden, and the asylum for the care of the insane at Provo City.

Industry.

The year 1890, which brought the anti-polygamy manifesto and the public school system, brought also a very decided industrial revival. Real estate advanced in price, and in the larger towns numerous public and private improvements were made. The chief business of the state, apart from agriculture, is mining. In 1899 the export value of the precious metals was $12,000,000, that of gold being $3,500,000. Coal mining has grown to be a very important industry. The output of 860,000 tons in 1899 was an increase of nearly 50 per cent. over that of 1898. The mining of lead has also increased to such an extent that in 1899 the output was 13 per cent. of the total output of the United States. In 1894 official statistics showed that there were 3½ million acres of irrigable land in the state, and that there were some 500,000 acres under cultivation. These lands are divided into small farms owned largely by contented and prosperous Mormon farmers. Only 11 per cent. of these farms were at that time subject to mortgage indebtedness. There has also been a steady and decided increase in the value of cattle, sheep, and hogs. The chief agricultural products are alfalfa, wheat, oats, and barley. The sugar-beet industry has greatly developed. Two large sugar factories have been erected at Lehi and at Ogden. Canneries for fruits and vegetables (numbering eight in 1900), as well as many small factories of different kinds, have been built. The manufactures of the state are largely an outgrowth of its agricultural development. Under the head of "flouring and grist mill products" 80 establishments were reported in 1900, with a capital of $1,101,885 and products valued at $1,829,840; under "beet sugar and molasses," 3 establishments, with a capital of $1,789,370 and products of $1,037,355; under "cheese, butter, and condensed milk (factory product)," 57 establishments, with a capital of $269,247 and products of $713,889.

Finances, &c.—In 1880 the Territory had no bonded indebtedness; in 1900 the bonded indebtedness was put at $900,000, which was used for state improvements. In 1885 the value of the taxable property of the state was placed at 35 million dollars; in 1900, at a very low valuation, it amounted to 100 million dollars. The tax levy for state purposes in 1900 was five mills on the dollar; that for the maintenance of state educational institutions was three mills. In 1900 there were 29 national and state banks, with a combined capital of $2,066,800 and deposits amounting to $12,403,154. The total clearings of Salt Lake City in 1900 were $120,790,250. The increase in the sale of real estate in Salt Lake City in the same year was 1½ million dollars. In 1890 1090 miles and in 1900 1600 miles of railway were in operation.

(A. Le.)

Utakamand, or Ootacamund, a town of British India, administrative headquarters of the Nilgiris district in Madras, 32 miles by road from the Mettapolliem station on the Madras Railway. Population (1881), 12,335; (1891), 13,991; municipal income (1897–98), Rs.2,40,050. It is the principal sanitarium of southern India, and summer headquarters of the Madras Government, and is placed on a plateau about 7230 feet above the sea, with a fine artificial lake, and mountains rising to above 8000 feet. The mean annual temperature is 58°, with a minimum of 38° in January and a maximum of 76° in May; average annual rainfall, 45 inches. The houses are scattered on the hillsides amid luxuriant gardens, and there are extensive carriage drives. In the neighbourhood are plantations of coffee, tea, and cinchona. It is proposed to extend the rack railway on the metre gauge from Coonoor. There is a brewery, with an output of 200,000 gallons a year, and two dairy farms. The Lawrence asylum for the children of European soldiers, founded in 1858, had 307 boys and 65 girls in 1896–97; the Breeks memorial and Basel mission high schools had 151 pupils in the same year. There are two printing-presses, one of which issues an English newspaper. The library and reading-room has some 300 members and an annual income of Rs.7660.

Utica, a city of New York, U.S.A., capital of Oneida county, on the south bank of the Mohawk river, in the central part of the state, at an altitude of 410 feet. It is divided into fifteen wards, is excellently paved, mainly with asphalt, has a fine water-supply, and is thoroughly sewered. Utica is well provided with transportation facilities; it is on the Erie canal, and has four railways—the Delaware, Lackawanna, and Western; the New York Central and Hudson River; the New York, Ontario and Western; and the West Shore, with lines in all directions. In 1900 there were 733 manufacturing establishments, with a total capital of $19,289,502. They employed 10,759 hands, and the product was valued at $19,550,850. The principal articles of manufacture, with their values, were clothing, $2,585,927; steam fittings, $1,204,693; foundry and machine-shop products, $1,101,826; hosiery and knitted goods and boots and shoes, $2,514,073. The assessed valuation of real and personal property in 1900 was $41,108,660; the net debt was $672,911, and the rate of taxation $24.32 per $1000. The total income, exclusive of loans, was $897,641, and the expenditure for maintenance and operation $690,192. Population (1890), 44,007; (1900), 56,383, of whom 13,470 were foreign-born and 244 negroes.

Utiel, a town of Spain, province of Valencia, to the north-west of Requeña, and to the south of the Sierra of Aledua, near the Rio Magro, with a station on the railway from Valencia to Cuenca. The local brandies have some fame, and the surrounding country chiefly produces good wines, cereals, esparto grass, and sapan. There is a large parish church, and there are good primary schools, a theatre, and bull-ring. Population (1897), 11,465.

Utrecht, a Dutch province between Gelderland on the E., and North and South Holland on the W., the smallest of the eleven provinces in size, but the second in respect of fertility of soil and density of population. The sandy and hilly land in the east of the province is (6 per cent.) uncultivated, yet the edge of this tract near the clay is sprinkled with thriving villages busied with agriculture and the rearing of stock—such as Amerongen, Leersum, Doorn, Driebergen, and Zeist. The flatter and more fertile region west of the Kromme Rijn and Vecht, north of the Oude Rijn, and east of the Vecht in the north-east of the province, supports a population of 100 to 200 per square kilometre, against 50 to 100 in the east sandy district. This population is grouped in villages along the Vecht (Maarssen, Breukelen, Loenen, Vreeland), and small old towns on the Rhine and Hollandsche Yssel (Wyk-by-Duurstede, Ysselstein, Montfoort). The development of these towns is, however, rigorously limited by the rise of the capital, Utrecht, and the decay as waterways of the Rhine, Yssel, and Vecht. Population (1886), 212,454; (1901), 254,867.

Utrecht, the capital of the above province, and the fourth town of Holland. It is an important railway junction, with two railway stations, 22 miles by rail south-south-east of Amsterdam. The town is not, however, a commercial centre, as the Oude and Kromme Rijn, on which it is situated, are, though canalized, available only for small craft. The new waterway, moreover, from Amsterdam to the Lek (the Merwede canal) avoids Utrecht, although by means of the Keulsche Vaart the town has a connexion with the Merwede. Its university (over 50 professors, 824 students, and a library of over 200,000 volumes) was in 1894 enlarged by a building in the Early Renaissance style. Its veterinary school is the only one in the kingdom. A meteorological observatory has been set up near Utrecht in the village of De Bildt. Population (1887), 79,166; (1901), 114,194.

Uttarpara, a town of British India, in the Hooghly district of Bengal, situated on the river Hooghly. Population (1881), 5307; (1891), 6489. It is famous for the public library founded and endowed by Jai Krishna Mukharji, which is specially rich in books on local topography. There is an aided college, and a girls' school supported by a native association.

Uttoxeter, a market town and parish, in the Burton parliamentary division of Staffordshire, England, 15 miles north-east by east of Stafford by rail. Large works for the manufacture of agricultural implements employ over 400 men. It was in the market-place here that Dr Johnson stood hatless in the rain doing voluntary penance for disobedience to his father. A bas-relief commemorates the incident. Population (1901), 5133.

Uxbridge, an ancient borough and market town, in the Uxbridge parliamentary division of Middlesex, England, with a station on a branch of the Great Western Railway. Since 1894 it has been governed by an urban district council. Area, 862 acres. Population (1901), 8585.

Uzés (*Lat.* Ucetia), a town of France in the department of Gard, and capital of an arrondissement of the same name. It is beautifully situated on an eminence above the Alzon, on the Paris, Lyons, and Mediterranean Railway, 12 miles north-east of Nimes. It was an Episcopal see from the 10th to the 17th century, when (in 1611) its cathedral, remains of which are still to be seen, was destroyed. Uzés has some fine mediæval buildings, notably the palace (Lé Duché), and a clock-tower (Fénestrelle); also a statue of Admiral Brueys, who fell at the battle of the Nile. There are extensive manufactures of silk, and a lively trade in wine and olive-oil. Population (1901), 4060.

Vaalpens. See Bushmen.

History.

Vaccination is the term originally devised for a method of protective inoculation against small-pox, consisting in the intentional transference to the human being of a disease of cattle called cow pox. The discovery of vaccination is due to Dr Edward Jenner, at the time a country medical practitioner of Berkeley, in the vale of Gloucester, whose investigations were first published in 1798 in the form of a pamphlet entitled *An Inquiry into the Causes and Effects of the Variolæ Vaccinæ, &c.* Many years previously, while he was an apprentice to a medical man at Sodbury, near Bristol, his attention was directed to a belief, widely prevalent in Gloucestershire during the latter half of the 18th century, that those persons who in the course of their employment on dairy farms happened to contract cow-pox were thereby protected from a subsequent attack of small-pox. In particular, his interest was aroused by a casual remark made by a young countrywoman who happened to come to the surgery one day for advice, and who, on hearing mention made of small-pox, immediately volunteered the statement that she could not take the disease, as she had had cow-pox. On coming up to London in 1770, to finish his medical education, Jenner became a pupil of John Hunter, with whom he frequently discussed the question of the possibility of obtaining protection against small-pox. On his return to his native village of Berkeley in 1773, to practise as a medical man, he took every opportunity of talking over and investigating the matter, but it was not until May 1796 that he actually began to make experiments. His first case of vaccination was that of a boy eight years of age, whom he inoculated in the arm with cow-pox matter taken from a sore on the hand of a dairymaid, who had become infected with the disease by milking cows suffering from cow-pox. It was apparently not until 1798 that he made his first attempt to carry on a strain of lymph from arm to arm. In the spring of that year he inoculated a child with matter taken directly from the nipple of a cow, and from the resulting vesicle on the arm of the child first operated upon, he inoculated, or, as it may now be more correctly termed, "vaccinated," another. From this child several others were vaccinated. From one of these a fourth remove was successfully carried out, and finally a fifth. Four of these children were subsequently inoculated with small-pox—the "variolous test"—without result. The success of many such experiments, in his own hands and in those of his contemporaries, led Jenner to express his belief—a mistaken one, as events have proved—that the protective influence of vaccination would be found to last throughout the lifetime of the person operated on. Obviously he did not realize the fact that the data at his disposal were insufficient for the formation of an accurate judgment on this point, since time alone could prove the exact duration of the protection originally obtained. Subsequent experience has demonstrated that, as has been well said by a writer in the *Edinburgh Review*, "even after efficient vaccination a slow progress away from safety and towards danger is inevitable, and re-vaccination at least once after childhood is necessary if protection is to be maintained."

Relationship of variola and vaccinia.

In applying to cow-pox the term "variolæ vaccinæ," Jenner gave expression to his belief that this disease was in reality nothing more nor less than small-pox of the cow. But soon it was discovered that if there were such a malady as "small-pox of the cow," there was also, as Dr Loy first satisfactorily demonstrated, a small-pox of the horse, which, under the name of "grease," was resorted to from time to time as a source of vaccine lymph. Jenner had, indeed, put forward the suggestion that "grease" was a necessary antecedent to cow-pox; but even taking this term to have been used by him in the sense of horse-pox, he was, in all probability, mistaken in his assumption. At the same time, however, there can be little doubt that these two diseases are very closely allied, if indeed they be not identical. As evidence of a definite relationship between human small-pox and cow-pox, it may be mentioned that whereas, prior to the introduction of vaccination, epidemics of these disorders frequently arose concurrently, the so-called "natural" cow-pox has now in great measure disappeared. There is, moreover, no appreciable difference in the minute anatomical appearances characteristic of the eruption following on inoculation of one or other of these two affections in the human subject. But of far greater importance in this connexion are the results obtained by numerous observers who, in various parts of the world, and almost from the time of Jenner onwards, have set themselves the task of attempting, by experimental methods, to solve the problem of the true relationship of variola to vaccinia. As the outcome of this work it may now be definitely stated that small-pox lymph, more especially, as the writer has shown, if obtained from the primary vesicle of a case of the inoculated form of the disease, by passage through the system of the calf can be so altered in character as to become deprived of its power of causing a generalized eruption, while inducing at the site of inoculation a vesicle indistinguishable from a typical vaccine vesicle; and, more important still, that when transferred again to man, it has by such treatment completely lost its former infectious character. Such being the case, it may fairly be asserted that cow-pox, or rather that artificially-inoculated form of the disease which we term vaccinia, is nothing more nor less than variola modified by transmission through the bovine animal. An outbreak of small-pox, indeed, may be turned to account for raising, by appropriate experimental methods, a fresh stock of vaccine lymph.

Bacteriology.

There is much evidence to prove that the results following on vaccination are due to a specific contagium, and, moreover, that the particular micro-organism concerned is capable of existing, during one period of its life-cycle, in a resting or spore form, in which condition it is more resistant to the germicidal effects of glycerine than is the case with non-sporing microbes. Advantage is taken of this fact, in the method devised by the writer, and now employed officially in England, as also on the Continent and in America, for ensuring the bacteriological purity of vaccine lymph. Up to the present, unfortunately, no satisfactory method has been discovered by which the micro-organism of vaccinia can be unfailingly cultivated on artificial media while still retaining its specific properties.

Vaccination Commission, 1889-96.

The publication in 1896 of the final report of the Royal Commission on Vaccination, in which the various phases of the vaccination question are discussed on the basis of evidence obtained from witnesses of all shades of opinion during a period extending over no less than six years, considerably simplifies the task of dealing with this subject. The Royal Commission, originally numbering fifteen members,[1] with the late Lord Herschell as president, was appointed in May 1889, the terms of reference being as follows: "To inquire and report as to—(1) The effect of vaccination in

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[1] The original Commissioners were—Lord Herschell, C. Bradlaugh, Dr Bristowe, Dr Collins, Sir C. Dalrymple, J. S. Dugdale, Q.C., Prof. M. Foster, Sir E. H. Galsworthy, Sir Guyer Hunter, J. Hutchinson, Sir James Paget, J. A. Picton, Sir William Savory, S. Whitbread, F. Meadows White, Q.C. Mr Bradlaugh, Dr Bristowe, and Sir William Savory died during the progress of the inquiry. Only one of the vacancies thus caused was filled up, Mr J. A. Bright having been appointed on the death of Mr Bradlaugh.

> reducing the prevalence of, and mortality from, small-pox. (2) What means, other than vaccination, can be used for diminishing the prevalence of small-pox; and how far such means could be relied on in place of vaccination. (3) The objections made to vaccination on the ground of injurious effects alleged to result therefrom; and the nature and extent of any injurious effects which do, in fact, so result. (4) Whether any, and, if so, what means should be adopted for preventing or lessening the ill effects, if any, resulting from vaccination; and whether, and, if so, by what means, vaccination with animal vaccine should be further facilitated as a part of public vaccination. (5) Whether any alterations should be made in the arrangements and proceedings for securing the performance of vaccination, and, in particular, in the provisions of the Vaccination Acts with respect to prosecutions for non-compliance with the law."

The evidence given before the Royal Commission was published at intervals in a series of Blue-books, but, as stated, it was not until August 1896 that the final report made its appearance. As regards the effect of vaccination in reducing the prevalence of, and mortality from, small-pox, the following conclusions were arrived at, Dr Collins and Mr Picton alone dissenting: "(1) That it diminishes the liability to be attacked by the disease. (2) That it modifies the character of the disease and renders it (*a*) less fatal, and (*b*) of a milder or less severe type. (3) That the protection it affords against attacks of the disease is greatest during the years immediately succeeding the operation of vaccination. It is impossible to fix with precision the length of this period of highest protection. Though not in all cases the same, if a period is to be fixed, it might, we think, fairly be said to cover in general a period of nine or ten years. (4) That after the lapse of the period of highest protective potency, the efficacy of vaccination to protect against attack rapidly diminishes, but that it is still considerable in the next quinquennium, and possibly never altogether ceases. (5) That its power to modify the character of the disease is also greatest in the period in which its power to protect from attack is greatest, but that its power thus to modify the disease does not diminish as rapidly as its protective influence against attacks, and its efficacy, during the later periods of life, to modify the disease is still very considerable. (6) That re-vaccination restores the protection which lapse of time has diminished, but the evidence shows that this protection again diminishes, and that, to ensure the highest degree of protection which vaccination can give, the operation should be at intervals repeated. (7) That the beneficial effects of vaccination are most experienced by those in whose case it has been most thorough. We think it may fairly be concluded that where the vaccine matter is inserted in three or four places, it is more effectual than when introduced into one or two places only, and that if the vaccination marks are of an area of half a square inch, they indicate a better state of protection than if their area be at all considerably below this."

Limitations of space render it impossible here to reproduce the evidence, statistical or otherwise, on which these conclusions are based. For such further information the Reports of the Royal Commission should be consulted. But reference may here be made to two facts of which proof is overwhelming. (1) Small-pox, in pre-vaccination days a disease of infancy and childhood—like measles at the present day—has in the United Kingdom become a disease mainly of adults. The shifting of age-incidence can only be accounted for by the custom of vaccination in infancy. To this day, when small-pox attacks young unvaccinated children, it is found to be as virulent as, or even more virulent than, small-pox in the unvaccinated at higher ages. On the other hand, small-pox is practically unknown among well-vaccinated children. When, quite exceptionally, such children have been attacked, the disease has been so trivial in character as to be liable to escape recognition altogether. (2) Medical men, nurses, and other persons exposed to the disease habitually protect themselves by efficient re-vaccination, and when this precaution has been taken, never contract small-pox.

Efficient vaccination.

The clinical activity and bacteriological purity of the lymph employed for vaccination; the skilful performance of the operation itself; the making an adequate number of insertions of lymph over a sufficient area; the observance of precautions needful for ensuring strict asepsis, both at the time of vaccination and subsequently until the vaccination wounds are soundly healed—all these are matters to be regarded as essential to "efficient vaccination." Certain principles in respect of them are generally recognized, and in the case of public vaccinators, whose work comes under Government inspection, a series of instructions on these several points are prescribed by the Local Government Board. First in regard to lymph. That which is now almost universally employed in Great Britain is glycerinated calf lymph, the use of which has entirely superseded, in public vaccinations, the arm-to-arm method which for many years previously had been employed as the best means then attainable of ensuring the activity and comparative purity of the lymph. Glycerinated lymph, under proper conditions, usually retains its potency for many weeks or months; but nevertheless, in certain circumstances at present imperfectly understood, is liable to become gradually weakened, and even eventually to become altogether inert. Possibly the condition of the calves from which the lymph is obtained, especially as regards their general health and the suppleness or the reverse of their skins, or exposure of the lymph to the action of light or to a high temperature, are of special importance. Consequently, in order to ensure the best results from its use, it is not only necessary that great care should be exercised in its manufacture, but it is also advisable that the lymph should be employed for vaccination as soon as possible after bacteriological examination has demonstrated its freedom from suppurative and other extraneous micro-organisms. As regards the carrying out of the operation itself, it is somewhat unfortunate that there exists no official definition of what constitutes a "successful vaccination," and in consequence it is open to any practitioner to give a certificate of successful vaccination in cases where but one minute vesicle may have been produced. It is to be feared that such certificates are too frequently given, and it cannot be too strongly urged that vaccination of this sort involves incomplete protection. The standard laid down by the Local Government Board—the production, namely, of a total area of vesiculation of not less than half a square inch, divided among four separate vesicles or groups of vesicles, not less than half an inch from one another—has for the most part proved easily attainable in practice, and it is much to be desired that in private as in public work the attainment of this standard should be aimed at in every instance.

The protection afforded by a primary vaccination tends gradually to diminish, and eventually to disappear more or less completely, with the lapse of time. In consequence, it is desirable that the operation should be repeated at the age of from seven to ten years, and thereafter, if it be possible, at intervals during later life. The final report of the Royal Commission thus summarizes the evidence as to the value of such additional procedure:—

> "Where re-vaccinated persons were attacked by, or died from, small-pox, the re-vaccination had for the most part been performed a considerable number of years before the attack. There were very few cases where a short period only had elapsed between the re-vaccination and the attack of small-pox. This seems to show that it is of importance, in the case of any persons specially exposed to the risk of contagion, that they should be re-vaccinated, and that in the case even of those who have been twice re-vaccinated with success, if a long interval since the last operation has elapsed, the operation should be repeated for a third, and even a fourth time."

It not unfrequently happens that in the case of a re-vaccination the process runs a somewhat different course from that witnessed in a typical primary vaccination. In a successful re-vaccination, the site of operation may be distinctly reddened and somewhat irritable by the second day, while papules will probably make their appearance about the third to the fifth day. The papules may or may not develop further into vesicles and pustules. Occasionally a re-vaccination appears to fail altogether;

but, as pointed out by the Royal Commission, it is advisable, as in the case of a primary vaccination, to make further attempts with lymph of known potency before concluding that the individual is really insusceptible.

Alleged injurious effects.

In a certain small proportion of cases the operation of vaccination has been followed, after a longer or shorter interval, by various complications, of which by far the most important are those of an inflammatory nature, such as erysipelas, which are not peculiar to vaccination, but which constitute the danger of any local lesion of the skin, however caused. During the many decades in which vaccination from arm to arm was practised, in many millions of children, a few authenticated cases were recorded in which there was reason to believe that syphilis could have been invaccinated. Such an occurrence could at no time have happened if proper care had been taken by the vaccinator; and now that the use of calf lymph has become practically universal, the possibility of such occurrence in the future may be disregarded, since the calf is not capable of contracting this disease. Tubercle in its various forms and leprosy have also been included in the list of possible complications of vaccination, though without any sufficient proof. The employment of calf lymph, treated with glycerine after the manner first advocated by the present writer, will obviate any such danger, for even if tubercle bacilli or the streptococcus of erysipelas were by chance present in the lymph material when collected, it has been found experimentally that they are quite unable to survive prolonged exposure to the action of a 50 per cent. solution of glycerine in water. Leprosy is not communicable to the calf. In view of the frequency of various skin eruptions in infancy, it is to be expected that in a proportion of cases they will appear during the weeks following vaccination. Eczema and impetigo in particular have, *post hoc*, been attributed to vaccination, but no direct connexion has been proved to exist between the operation and the occurrence of these disorders. In section 434 of the final report of the Royal Commission on Vaccination the extent to which other inoculable diseases are liable to complicate vaccination is thus summed up:—

> "A careful examination of the facts which have been brought under our notice has enabled us to arrive at the conclusion that although some of the dangers said to attend vaccination are undoubtedly real, and not inconsiderable in gross amount, yet when considered in relation to the extent of vaccination work done, they are insignificant. There is reason, further, to believe that they are diminishing under the better precautions of the present day, and with the additions of the future precautions which experience suggests, will do so still more in the future."

Recent legislation.

Under the provisions of the Vaccination Act, 1898, which came into force in January 1899 for a period of five years, and of the Vaccination Order (1898) of the Local Government Board, numerous changes in connexion with vaccination administration and with the performance of the operation were introduced, in addition to the supersession of arm-to-arm vaccination by the use of glycerinated calf lymph. Thus, whereas by the Vaccination Acts of 1867 and 1871 the parent or person having the custody of any child was required to procure its vaccination within three months of birth, this period by the Act of 1898 has been extended to six months. Again, no parent is now liable to a penalty under the compulsory clauses of the Vaccination Acts who affords proof that he has, within four months of the birth of a child, satisfied a stipendiary magistrate, or two justices in petty sessions, that he conscientiously believes that vaccination would be prejudicial to the health of the child. Moreover, in no case can proceedings now be taken more than twice against a defaulting parent, namely, once under section 29 of the Act of 1867, and once under section 31 of the same Act, provided that the child has reached the age of four years. Finally, the public vaccinator is now required to visit the homes of children for the purpose of offering vaccination with glycerinated calf lymph, "or such other lymph as may be issued by the Local Government Board." The operative procedure in public vaccinations was formerly based on the necessity of carrying on a weekly series of transferences of vaccine lymph from arm to arm; and for the purposes of such arm-to-arm vaccination the provision of stations, to which children were brought first for the performance of the operation, and again, after a week's interval, for inspection of the results, was an essential. The occasional hardships to the mothers, and a somewhat remote possibility of danger to the children, involved in being taken long journeys to a vaccination station in bad weather, or arising from the collecting together in one room of a number of children and adults, one or more of whom might happen to be suffering at the time from some infectious disorder, are a few of the reasons which appeared to render a change in this regulation desirable; as a matter of fact, it would appear that nothing but good has arisen from the substitution of domiciliary for stational vaccination. The working of the so-called "conscience clause" also has by no means justified the somewhat gloomy forebodings expressed, both in Parliament and elsewhere, at the time of its incorporation in the Act of 1898. On the contrary, its operation has undoubtedly tended to the more harmonious working of the Vaccination Acts, by affording a legal method of relief to such parents and guardians as are prepared to affirm their conscientious belief that the performance of the operation might, in any particular instance, be prejudicial to the health of the child. The period of five years during which the Act of 1898 was to remain operative would expire on 31st December 1903. Consequently, at some period antecedent to that date the whole question of vaccination, and presumably of re-vaccination also, must again occupy the attention of the British Legislature.

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Vacherot, Étienne (1809–1897), French philosophical writer, was born of peasant parentage at Torcenay, near Langres, 29th July 1809. He was educated at the École Normale, and returned thither as director of studies in 1838, after some years spent in provincial schoolmasterships. His *Histoire critique de l'École d'Alexandrie* (3 vols., 1846–51), his first and best-known work, drew on him attacks from the Clerical party which led to his suspension from office in 1851. Shortly afterwards he refused to swear allegiance to the new imperial Government, and was dismissed the service. His work *Démocratie* (1859) led to a political prosecution and imprisonment. In 1868 he was elected to the French Academy. On the fall of the Empire he took an active part in politics, was *maire* of a district of Paris during the siege, and in 1871 was in the National Assembly, voting as a Moderate Liberal. In 1873 he drew nearer the Conservatives, and, though never again successful as a parliamentary candidate, maintained his principles vigorously in the press. His other works are entitled *La Métaphysique et la Science* (1858), *Essais de philosophie critique* (1864), *La Religion* (1869), *La Science et la Conscience* (1870), *Le nouveau spiritualisme* (1884), *La Démocratie libérale* (1892). He died 28th July 1897. Vacherot was a man of high character and strict adherence to his principles, which were generally opposed to those of the party in power. His chief philosophical importance consists in the fact that he was a leader in the attempt to revivify French philosophy by the new thought of Germany, to which he had been introduced by Cousin, but of which he never had more than a second-hand knowledge. Metaphysics he held to be based on psychology. He maintains the unity and freedom of the soul, and the absolute obligation of the moral law. In religion, which was his main interest, he was much influenced by Hegel, and appears somewhat in the ambiguous position of a sceptic anxious to believe. He sees insoluble contradictions in every mode of conceiving God as real, yet he advocates religious belief, though the object of that belief have but an abstract or imaginary existence. (H. ST.)

Valais, one of the Swiss cantons. Its total area is 2025·3 square miles. The population was 100,190 in 1880, and in 1900, 114,158. In 1900 there were 56 inhabitants to each square mile, the lowest rate of density in Switzerland save in the Grisons and Uri. Two-thirds of the people are French-speaking, and one-third German-speaking, and the canton is almost wholly Roman Catholic. As the highest summit of Monte Rosa rises on a promontory, it (and not the Dom as often stated) is the loftiest peak situated entirely within Switzerland. There is a funicular railway from Visp up to Zermatt, and thence an electric line up to the Gornergrat. The political capital is Sion. In 1890 the state revenue was 1,425,833 francs, a rise of 18¾ per cent. since 1885 (estimate for 1900, 1,518,229 francs), and the state expenditure 1,387,477 francs, a rise of 21¼ per cent. since 1885 (estimate for 1900, 1,714,515 francs), while in 1898 there was a surplus of 44,626 francs. In 1897 the public debt was 6,913,460 francs. The cantonal constitution of 1875 is still in force, but the legislative assembly now numbers 104 members, owing to the increase of population. The boring of the Simplon tunnel was commenced in 1899, and has brought about a great increase in population at Naters, close to Brieg, the labourers being all Italians.

See *Blätter aus d. Wallisergeschichte* (published by the Cant. Hist. Soc.). Sion. From 1889.—GAY. *Hist. du Vallais*, 2 vols. Geneva, 1888.—GREMAUD. *Documents relatifs à l'hist. du V.*, 8 vols. (to 1457). Lausanne, 1875–1898.—HEUSLER. *Die Rechtsquellen d. Cant. Wallis.* Basel, 1890.—HOPPELER. *Beiträge z. Geschichte d. Wallis im Mittelalter.* Zürich, 1897. RAMEAU. *Le Vallais Historique.* Sion, 1886. (W. A. B. C.)

Valdivia, a city of Chile, capital of a province and department of the same name. It is one of the most prosperous towns of southern Chile. One of the principal industries is beer brewing, one brewery producing over eight million litres a year. Tanning is also an important industry. In 1900, 439 ships of 450,912 tons entered the port (Corral, 12 miles distant), about the same number clearing. In the same year the imports were valued at 2,497,083, and the exports at 2,200,620 pesos. The coastwise trade was represented in the same year by 598 steamers and 30 sailing vessels, which carried goods valued at 8,367,983 pesos. A railway runs from Valdivia to Osorno, and another connecting it with the north is being constructed. Population (1895), 8062; (1900), 9819.

Valdosta, a city of Georgia, U.S.A., capital of Lowndes county, at the intersection of four railways, in the southern part of the state, near the Florida boundary. Population (1890), 2854; (1900), 5613, of whom 50 were foreign-born and 2958 negroes.

Valence, chief town of the department of Drôme, France, 384 miles south-south-east of Paris, an important junction on the railway from Lyons to Marseilles. A fine bronze monument to Émile Augier (1820–1889), the dramatist, has been added to the public statues. Metal founding has declined, but the making of hosiery and the printing of linen and cotton handkerchiefs are amongst the leading industries. The annual value of the industrial products is about £800,000, of which more than one-third is supplied by flour and tinned foods. The surrounding vineyards, at one time nearly destroyed by the phylloxera, have been replanted and extended. Population (1891), 19,970; (1901), 24,199.

Valencia, a Mediterranean province of Spain, with an area of 4352 miles. Population (1887), 733,978; (1897), 775,995. The birth-rate is 3·80 per cent., the death-rate 3 per cent. It is divided into nineteen districts and 265 parishes. There are 335 miles of railways. The industries are still important, although the silk manufactures have declined after three decades of prosperity (from 1850 to 1880). Silk rose in importance when local causes brought about the decay of that industry in France. The manufactures of carpets and tapestry, woollen goods, hemp and linen stuffs, are considerable.

Rice grown in the lowlands provides splendid crops that give work to 140 mills. Both figs and oranges constitute important products and the staple articles of the export trade. The orange exports ranged from £42,000 to £100,000 between 1877 and 1895, and the average crop of figs has been 1,360,000 ℔ a year. This province also produces sugar-cane, and has thriving sugar factories. About 120,000 acres are well irrigated, and over 1,500,000 cultivated. Half a million acres are still covered with woods and commons. In 1897 wheat was grown on 94,784 acres, other cereals on 150,680 acres, pod fruit on 25,000 acres, vines on 275,582, olives on 73,120. The live stock in the same year included 28,733 horses, 30,765 mules, 30,112 asses, 6246 cattle, 178,658 sheep, 66,961 goats, and 66,989 pigs.

Valencia, capital of the above province, 3 miles from the Mediterranean, on the Guadalaviar. It is an archbishopric, the seat of an army corps and captain-general, and of a court of appeal. The city is connected with its port, El Grao, by two railways and two tramways. The older part still preserves its quaint and original character, but in the new town there are broader streets and avenues, with many industries, splendid provincial and municipal buildings, and good drainage. Valencia is a populous, thriving, progressive town, divided into ten districts and sixty-four quarters, with a population which rose from 170,763 in 1887 to 204,768 in 1897. There is a rich provincial museum, with paintings by Velazquez, Ribera, Dürer, Joannes, Bosco, Goya, and many modern artists. The industries include silks, cloths, linen, leather, ceramics, fans, and esparto grass rugs. Agricultural produce, especially oranges, rice, maize, and fruit of all sorts, is exported. El Grao is one of the largest, safest, and most important ports in Spain. The harbour works, begun in 1792 at local expense, have been improved down to 1897, and now provide many facilities for trade on the moles and wharves. In 1898, 877 foreign vessels of 624,481 tons entered the port and 362 foreign vessels of 621,688 tons cleared. The total value of exports in 1898 was £354,000, and of imports £124,100. The coasting trade is also important, and 260 vessels were engaged in it in 1898. The fishing fleet of El Grao comprises about 600 boats with 2800 hands.

Valencia de Alcantara, a town of Spain on the Portuguese frontier, in the province of Caceres, on the left bank of the river Avid, with a station on the railway from Madrid to Lisbon. It is the most important custom-house for direct traffic between the Peninsular kingdoms, and has a garrison, old-fashioned loopholed walls, and a dismantled castle on a hill. The town is clean, with regular streets, and some houses that still reveal Moorish traits in the interior yards and architecture. The town hall is of the 16th century, as are also the churches of Encarnacion and Roqueamador, and a fine convent. In the neighbourhood there are Roman ruins and an aqueduct that still brings water to the Alameda of Alcantara. The surrounding country yields agricultural produce of every kind, and also contains mines of phosphorite and antimony. Alcantara was taken twice by the Portuguese in the wars of 1664 and 1698 with Spain. Population (1887), 8230; (1897), 9276.

Valenciennes, chief town of arrondissement, department of Nord, France, 32 miles south-east of Lille, on the railway from Paris to Mons. The fortifications, dismantled in 1892, have been replaced by boulevards. Metallurgical industries are very active, employing more than 2000 persons. Among secondary industrial features large glass-works and factories for the manufacture of starch, chemicals, and soap have become noteworthy. Imports in 1899 were valued at £1,168,000, exports at £1,184,000. The port traffic in the same year amounted to 150,442 tons. Population (1891), 21,698; (1901), 28,786.

Valera y Alcalá Galiano, Juan (1824——), Spanish novelist, son of a retired commodore, José Valera, who married Doña Dolores Alcalá Galiano, Marquesa de la Paniega, widow of a Swiss general named Freuller, was born on 18th October 1824 at Cabra, in the province of Cordoba. Valera was educated at Malaga and at the University of Granada, where he took a degree in law. Entering diplomacy in 1847, he was named unpaid attaché to the Spanish embassy at Naples under the famous Duke de Rivas, the leader of the romantic movement in Spain. Valera witnessed the events of the revolution, was promoted second secretary to the embassy at Lisbon in 1850, and in 1851 was transferred as first secretary to Rio de Janeiro, where he remained for two years. After a short period passed at Dresden, he was appointed to the permanent staff of the Foreign Office at Madrid, and in 1857 was attached to the special embassy to St Petersburg under the Duke de Osuna. In 1858 he resigned his post, was elected deputy for Archidona, in the province of Malaga, took his seat with the advanced Liberal Opposition, and joined with Albareda and Fabié in founding *El Contemporaneo*, a very influential journal. An expert in the art of covering an opponent with polite ridicule, he at once caught the ear of the Cortes, and his writings in the press attracted general attention. He was elected a member of the Spanish Academy in 1861, and remained in Opposition till 1865, when O'Donnell appointed him minister to Frankfort: on the flight of Isabella II. in 1868 he returned to Spain, was elected deputy for Montilla in the province of Cordoba, became under-secretary of state for foreign affairs, and was one of the deputation who offered the crown to Amadeus of Savoy in the Pitti Palace at Florence. Valera has always called himself a Moderate Liberal, but he has invariably voted for what are considered Radical measures in Spain, and a speech delivered by him in February 1863 against the temporal power of the Pope created a profound sensation. However, though a member of the revolutionary party, he has steadily opposed organic constitutional changes, and therefore he retired from public life during the period of republican government. Since the Bourbon restoration he has acted as ambassador at Lisbon (1881–83), at Washington (1885), at Brussels (1886), and at Vienna (1893–95). He is a life senator, and has ceased to take an active part in politics. Valera's first publication, *Canciones, Romances y Poemas*, was published in 1856 (2nd edition 1885). His verses are melodious, finished, and various in subject; but they are rather the imitative exercises of a scholarly man of the world than the inspirations of an original poet. That they failed to attract notice is not altogether to be regretted, for, as Valera himself confesses, in his half-ironical, half-ingenuous preface, "In spite of my idleness, I should have shown a most deplorable fecundity had I been received with favour and applause." As it is, though he has published little more in the shape of verse, he has written incessantly in prose. More than two-thirds of his work he has left uncollected, buried in reviews and newspapers; but we may safely take it that in the eighteen volumes which bear his name he has rescued all that he thought most valuable. His criticism may be read in the *Estudios críticos sobre literatura* (1864), in the *Disertaciones y juicios literarios* (1878), and in the *Nuevos estudios críticos* (1888); yet, with all his penetration and taste, Valera labours under one disadvantage not frequent in critics. He suffers from an excessive amiability. He will say a hundred incisive, wise, witty, subtle, and suggestive things concerning the mysticism of St Theresa, the art of novel-writing, *Faust*, the Inquisition, *Don Quixote*, Shakespeare, the psychology of love in literature; but, if he is to do himself justice, it is an almost indispensable condition that he should deal with the past. In the presence of a living author Valera is disarmed. Unless the writer be an incurable pessimist, Valera will find something in his work to praise, exhausting the vocabulary of compliment and graceful tribute; but, except in the *Cartas americanas* (1889), where the laudation is manifestly so exaggerated that no harm can come of it, this trick of eulogy is both perplexing and misleading. Valera, in effect, refuses to criticize contemporary literature; as a rival author, it seems to him an indelicacy to censure others, and he is either laudatory or silent. It is regrettable, for criticism is greatly needed in Spain. Valera, then, excels neither as a poet nor as an impartial critic; he has the vocation of the novelist, though he was slow in discovering it, since he was in his fiftieth year before he published the novel which was to make him famous. *Pepita Jiménez* (1874) is a recital of the fall of Luis de Vargas, a seminarist who conceived himself to be a mystic and a potential saint, and whose aspirations dissolve at the first contact with reality. It is easy to point out blemishes: as a piece of mechanics, the story is not well constructed, and it has pauses during which the writer's fantasy plays at pleasure over a hundred subjects not very germane to the matter; but its characters are as real as any in fiction, the love story is told with the most refined subtlety and malicious truth, while page upon page is written in such Spanish as would not misbecome the best writers of the 16th and 17th centuries. Unquestionably *Pepita Jiménez* is a very remarkable achievement—so remarkable, that readers are reluctant to admit the superiority of its successors. It is certain that Valera's second novel, *Las ilusiones del Doctor Faustino* (1875), was received with marked disfavour, and that it has the faults of over-refinement and of cruelty; yet in keen analysis and in humour it surpasses *Pepita Jiménez.* The *Comendador Mendoza* (1877) is surely more pathetic and of a profounder significance; and if *Doña Luz* (1879) repeats the situation and the general idea already used in *Pepita Jiménez*, it strikes a deeper and more tragic note, which came as a surprise to those most familiar with the lighter side of Valera's genius. Besides these elaborate psychological studies, Valera has published a volume of *Cuentos* (1887), some of these short tales and dialogues being marvels of art and of insight. Thenceforward he was silent for eight years, but since his retirement from politics he has given us several good books—*El hechicero* (1895), *Juanita la larga* (1896), *Genio y figura* (1897), *De varios colores* (1898), and *Morsamor* (1899). These are not all of equal excellence, but they are characteristic of their author, and abound in understanding, humorous comment, and sympathetic creation. Valera is certainly the most eminent man of letters in Spain. He has not Pereda's force, nor his energetic realism; he has not the copious invention nor the reforming purpose of Pérez Galdós; yet he is as real as the former and as innovating as the latter. And, for all his cosmopolitan spirit, he has fortunately remained intensely and incorrigibly Spanish. His aristocratic scepticism, his strange elusiveness, his incomparable charm are his own: his humour, his flashing irony, his urbanity are eminently the gifts of his land and people. He is by no means an impersonal artist; in almost every story there is at least one character who talks and thinks, and subtilizes and refines as Valera himself does in his most brilliant essays. This may be a fault in art; but, if so, it is a fault which most great artists have committed, from Cervantes to Thackeray. It is dangerous to attempt a forecast of Valera's place in literary history, yet it seems safe to say that *Pepita Jiménez* and *Doña Luz* will survive all changes of fashion and of taste, and that their author's name will be inseparably connected with the renascence of the modern Spanish novel.

Valladolid, a province of Spain, almost in the centre of the Peninsula. Area, 3043 square miles. Population (1887), 267,148; (1897), 276,366. The birth-rate is 4·31 per cent., the death-rate 3·85 per cent., and the proportion of illegitimate births 5·07 per cent. of the total births. The province is divided into 11 districts and 237 parishes. It has about 200 miles of railway. The industries are unimportant, excepting those connected with agriculture, flour and saw mills. There are some iron foundries, and linen and woollen factories. The principal exports are flour, cereals, wool, wine, and live stock.

The soil is excellent for all sort of cereals and fruit and vegetables, whilst the vineyards yield good red and white wines. Forests and brushwood occur only in the south-east, covering barely 250,000 acres. Much land is devoted to pasture, and over 1,800,000 acres are well cultivated, of which 374,400 acres were in 1897 covered with wheat crops, 188,565 with other cereals, 85,940 with pod fruit, 197,125 with vines. The live stock in the same year included 3401 horses, 21,633 mules, 14,118 asses, 7585 cattle, 285,746 sheep, 3181 goats, and 5346 pigs.

Valladolid, capital of the above province, on the Pisuerga, a station on the railway from Madrid to the French frontier. Population (1887), 62,012; (1897), 68,746. It is the seat of an army corps, a court of appeal, and an archbishopric. The surrounding country is fertile and yields much wine, cereals, fruit, and vegetables; the industries include flour, beer, paper, soap, leather, chocolate, woollen and linen stuffs, iron, porcelain, and pottery. The university has been well attended since the decline of Salamanca. There are an institute, normal and primary school, the royal academy for cavalry cadets, an artillery park, a provincial lunatic asylum, several hospitals, a seminary (raised in 1897 by Pope Leo XIII. to the rank of a pontifical university), an archæological museum, a picture gallery, and a public library with 36,000 volumes. The greater part of the city has a modern aspect, with broad, regular streets, squares, and good houses several storeys high. The Pisuerga is spanned by an old bridge and more modern ones connecting the city with the suburbs.

Vallecas, a town of Spain, province of Madrid, to the south-east of Madrid, with which it is connected by the Madrid–Saragossa railway and by a steam tramway. Its population was 5611 in 1887, and 9027 in 1897. It is situated in a flat, fertile country, through which flows the Manzanares, which produces much wine, pod fruit, vegetables, and cereals of every kind. It is mostly frequented by the lower and middle classes of Madrid on Sundays and fête days, owing to its very popular bull-ring. The parish church of San Pedro ad Vincula has two good paintings by Jordaens, and about 3 miles off, on the Argande road, there is a hermitage of Our Lady of the Towers with six fine plateresque altars. Vallecas was founded by the Christians after the expulsion of the Moors, and took its name from an Arab chief Kas—the vale of Kas.

Vallejo, a city of Solano county, California, U.S.A., on San Pablo Bay and a branch of the Southern Pacific Railroad. It has a good harbour, and ships large quantities of wheat. It is the outlet of the beautiful Napa Valley, one of the finest fruit-growing regions of the State. Population (1890), 6343; (1900), 7965, of whom 2033 were foreign-born and 223 coloured, including 39 negroes.

Valletta. See MALTA.

Valleyfield, or SALAHERRY DE VALLEYFIELD, town and port of entry, Beauharnois county, Quebec, 30 miles south-west of Montreal, at the foot of Lake St Francis—an expansion of the river St Lawrence—and at the head of the Beauharnois canal. It is a station on the Canada Atlantic and New York Central railways, and a port of call of all steamers plying between Montreal and Lake Ontario ports. It is the see of a Roman Catholic bishop, and contains a college and convent. It has extensive cotton and paper mills. Population (1891), 5515; (1901), 11,055.

Valparaiso, city and port of Chile, capital of a province and department of the same name. Population (1895), 122,447; (1900), 135,674. The bay and city are defended by twelve forts armed with modern guns of heavy calibre. In 1896, 1214 ships of 1,416,031 tons entered and 1224 ships of 1,427,413 tons cleared; in 1898, 1054 ships of 1,337,018 tons visited the port; and in 1900, 1027 ships of 1,386,884 tons entered and 1024 of 1,394,119 tons cleared. The value of the trade in 1900 was, in pesos (paper), imports, 79,109,629; exports, 12,792,527. In 1898 Valparaiso had 63·41 per cent. of the total import trade of the republic, and 16·19 per cent. of the export trade. The customs receipts in 1900 were 19,598,112 pesos (paper). There were at the end of 1898 tramways of a total length of nearly 8 miles. Among the monuments are statues of Wheelwright, the builder of the first South American railway, Columbus, and Thomas Cochrane (tenth Earl of Dundonald), the organizer of the Chilian navy. The finest monument in Chile is probably that inaugurated in Valparaiso in 1886 and dedicated to the national navy, on the summit of which is the statue of Admiral Prat.

Valparaiso, a borough of Indiana, U.S.A., capital of Porter county, in the north-western part of the state, at the intersection of the Grand Trunk, the New York, Chicago and St Louis, and the Pennsylvania railways, at an altitude of 736 feet. It contains foundries, machine-shops, and clock factories. Population (1880), 4461; (1890), 5090; (1900), 6280, of whom 660 were foreign-born.

Valtellina (German, *Veltlin*), properly the name of the upper valley of the Adda, in North Italy. Historically and officially, it also comprises the Liro valley, which extends from the Splügen Pass past Chiavenna to the Lake of Como, the Liro entering this lake slightly to the north of the Adda. These two valleys (but not Colico, which is in the province of Como) form together the province of Sondrio. Population (1881), 120,534; (1901), 126,425.

Vámbéry, Ármin (1832- ——), Hungarian Orientalist and traveller, was born of humble parentage at Duna-Szerdahely, a village on the island of Shütt, in the Danube, on the 19th of March 1832. He was educated at the village school until the age of twelve, and owing to congenital lameness had to walk with crutches. At an early age he showed remarkable aptitude for acquiring languages, but straitened circumstances compelled him to earn his own living. After being for a short time apprentice to a ladies' tailor, he became tutor to an innkeeper's son. He next entered the untergymnasium of St Georgen, and proceeded thence to Pressburg. Meanwhile he supported himself by teaching on a very small scale, but his progress was such, that at sixteen he had a good knowledge of Hungarian, Latin, French, and German, and was rapidly acquiring English and the Scandinavian languages, and also Russian, Servian, and other Slavonic tongues. At the age of twenty he had obtained sufficient knowledge of Turkish to lead him to go to Constantinople, where he set up as teacher of European languages, and shortly afterwards became a tutor in the house of Pasha Hussein Daim. Under the influence of his friend and instructor, the Mollah Ahmed Effendi, he became, nominally at least, a full Osmanli, and entering the Turkish service, was afterwards secretary to Fuad Pasha. After spending six years in Constantinople, where he published a *Turkish–German Dictionary* and various linguistic works, and where he acquired some twenty Oriental languages and dialects, he visited Tehran; and then, disguised as a dervish, joined a band of pilgrims from Mecca, and spent several months with them in rough and squalid travel through the deserts of Asia. He succeeded in maintaining his disguise, and on arriving at Khiva went safely through two audiences of the khan. Passing Bokhara, they reached Samarkand, where the emir, whose suspicions were aroused, kept him in audience for a full half-hour; but he stood the test so well that the emir was not only pleased with "Resid Effendi" (Vámbéry's assumed name), but gave him handsome presents. He then reluctantly turned back by way of Herat, where he took leave of the dervishes, and returned with a caravan to Tehran, and subsequently, in March 1864, through Trebizond and Erzerúm to Constantinople. By the advice of Prokesch-Osten and Eötvös, he paid a visit in the following June to London; there his daring adventures and linguistic triumphs made him the lion of the day. In the same year he published his *Travels in Central Asia.* In connexion with this work it must be remembered that Vámbéry could write down but a few furtive notes while with the dervishes, and dared not take a single sketch; but the weird scenes, with their misery and suffering, were so strongly impressed on his memory, that his book is convincing by its simplicity, directness, and evidence of heroic endurance. Vámbéry also called the attention of politicians to the movements of Russia in central Asia, and aroused much general interest in that question. From London he went to Paris, and he notes in his autobiography that the Parisians were much more interested in his strange manner of travelling than in the travels themselves. He had an interview with Napoleon III., who failed to impress him "as the great man which the world in general considers him." Returning to Hungary, he was appointed professor of Oriental languages in the University of Budapest: there he settled down, contributing largely to periodicals, and publishing a number of books, chiefly in German and Hungarian. His travels have been translated into many languages, and his *Autobiography* was written in English. Amongst the best known of his works, besides those alluded to, are *Wanderings and Adventures in Persia* (1867); *Sketches of Central Asia* (1868); *History of Bokhara* (1873); *Manners in Oriental Countries* (1876); *Primitive Civilization of the Turko-Tatar People* (1879); *Origin of the Magyars* (1882); and *The Turkish People* (1885).

Van.—(1) A vilayet of Asiatic Turkey, situated on the Persian frontier, between the vilayets of Erzerúm and Mosul. It is divided into two sanjaks, Van and Hakkiari, has an area of about 18,000 square miles, and a population, according to Cuinet, of 430,000 (Moslems, chiefly Kúrds, 241,000; Christians, 178,000, including 92,000 Nestorians; Jews, 5000; Yezidis, &c., 6000). The mountains have been disforested, and in summer are covered with pasture. The winter is long and severe. The mineral wealth of the vilayet has never been fully explored, but is believed to be great. There are petroleum springs at Kordzot, a coal-field at Sivan, and hot sulphur springs at Zilan Deresi and Julamerk. The exports—sheep, wool, mohair, hides, and furs—amounted in 1898 to £52,000, and the imports to £160,000.

(2) The chief town of the vilayet and of the Van sanják, and a military station, altitude 5200 feet, situated about 1½ mile from the east shore of Lake Van, on the south side of an isolated ridge of rock which runs nearly east and west and rises to a height of 300 feet above the surrounding plain. The ridge is about 1400 yards long, and on its precipitous southern face is the trilingual inscription of Xerxes. On its north side and in other places are Vannic inscriptions, and on its summit is the old citadel. The town has flat-roofed mud houses and narrow, winding streets. On gently sloping ground towards the east are gardens covering an area of about 15 square miles, in which the European consuls, the missionaries, and wealthy inhabitants live. They are irrigated by the Shemiram Rúd, an artificial canal 19 miles long, of very ancient date. The climate is very cold in winter, hot in summer, and unhealthy in autumn. Earthquakes are frequent; the last severe one was in 1891. There are a flourishing American mission and a Dominican mission. The population of 30,000 consists of 16,000 Moslems and 14,000 Christians, chiefly Armenians. Van occupies the site of Dhuspas, the capital of a kingdom of which the native name was Biainas (Assyrian, *Urardhu;* see Ararat), the Byana of Ptolemy and Ivan of Cedrenus, whence the modern Van. Dhuspas, the Thospia of Ptolemy, gave its name to the district Thospitis, the present Tosp. The Biainian dynasty, of which Sarduris I. *circ.* 833 B.C., was the first king, died out with Sarduris II., who in 645 B.C. entered into an alliance with Assur-bani-pal. Inscriptions of nearly all the kings exist, and excavations near Van have brought to light the foundations of a temple and various works of art, statuettes, vases, &c., which show an advanced state of civilization and great technical skill (see illustrations in Maspero's *Hist. Ancienne*, vol. iii. *Les Empires*). In the 6th century B.C. Van passed into the hands of the Persians, and, shortly before it fell to Alexander it was, according to Armenian historians, rebuilt by a native prince called Van. In 149 B.C. Valarsaces, or Vagharshag, rebuilt the town, and a colony of Jews was settled in it by Tigranes (94–56 B.C.). In the middle of the 4th century of our era it was taken by Sapor II. and became the capital

of an autonomous province of the Sassanian empire until it fell into the hands of the Arabs, *circ.* 640, under whom it retained its autonomy. About 908 the governor of Van, or Vaspuragan, was crowned king by the Khalíf Muktadir, and in 1021 his descendant Senekherim was persuaded by Basil II. to exchange his kingdom for the viceroyalty of the Sebasteian Theme. After having formed part of the possessions of Seljúks, Mongols, Tatars, and Persians, Van passed to the Osmanlis in 1514 after the defeat of Shah Ismail by Selim I. In 1845 the town was held for a time by the Kúrd chief Khán Mahmúd, who eventually surrendered and was exiled. In November 1895 and June 1896 massacres of Armenians occurred in the town.

Lake Van.—The water is too salt to drink, and a deposit of alkaline salts, consisting chiefly of carbonate of soda and chloride of sodium, is obtained by evaporation and used in washing. There is, however, good water along the coast from springs and streams. There are eighty-four native sailing boats, carrying about twenty tons. Severe storms make navigation dangerous in winter, and no voyages are made between December and March.

See SAYCE, "Cuneiform Inscriptions of Lake Van," in *Journal of Royal Asiatic Society*, vols. xiv., xx., and xxvi.—LYNCH, *Armenia*, vol. ii., 1901.—BELCK and LEHMANN, papers in *Verhand. d. Berliner Ges. für Anthropologie*, 1892–99 ; *Zeit. für Ethnologie*, 1892, 1899 ; *Mitt. d. Geog. Ges.* (Hamburg), 1898, 1899.—*Consular Reports.*—MURRAY'S *Handbook to Asia Minor.* (C. W. W.)

Van Beers, Jan (1821–1888), Belgian poet, usually called the elder to distinguish him from his son, the well-known painter, was born at Antwerp, 22nd February 1821. He was essentially a Netherlander, though politically a Belgian, expressing his thoughts in the same language as any North Netherland writer. In fact, the poems of Jan Van Beers are perhaps more popular in Holland than in Belgium, and of many of them there exist more editions printed in Holland than in his political fatherland. Van Beers started life as a teacher of Dutch language and literature, first at Malines, then at Lierre, and in 1860 was appointed a professor of both at the Athenæum (high school) in Antwerp, where he had also been a sub-librarian in the communal library. Van Beers as a teacher was early in the field, with Hendrik Conscience, Willems, and others, when the Flemish movement began. He composed a Dutch grammar (1852), which, in enlarged editions, still holds the field, and a volume of selections from Dutch authors, both books being so much appreciated that the Belgian Government made them text-books in the public schools. Van Beers's historical poems, the principal of which is, perhaps, *Jakob Van Maerlant* (Amsterdam, 1860), helped the Flemish revival in Belgium as powerfully as his school-books. He is best known, however, as the writer of ballads and songs. *Jongelingsdroomen* ("A Young Man's Dreams") first appeared at Antwerp and Amsterdam in 1853. These poems were followed by *Levensbeelden* ("Life Figures or Pictures," Amsterdam, 1858), and by *Gevoel en Leven* ("Feeling–Living," Amsterdam, 1861). His *Rijzende Bladen* ("Rising Leaves") first made its appearance at Ghent and Rotterdam in 1883. In the following year an *édition de luxe* of his poetry was published, adorned with pen-and-ink sketches by Jan Van Beers the younger, and a popular edition of his collected poems was published at Ghent and Rotterdam in 1873 and 1884. Among the best known are *De Blinde* ("Blind"), *De Zieke Jongeling* ("Young and Doomed"), *Bij 't Kerkportaal* ("At the Church Porch"). Van Beers's poetry, full of glow and pathos, simple yet forcible, is somewhat akin to that of Longfellow. Van Beers died at Antwerp on the 14th of November 1888. (H. Ti.)

Vancouver, a city of Washington, U.S.A., capital of Clarke county, on the north bank of the Columbia river, six miles north of Portland, in the southern part of the state. Its interests are connected with lumbering, and it is the terminus of a lumber railway running north-east into the heavy forests of the eastern part of the county. Large quantities of lumber are sawn and shipped here. Fort Vancouver, a United States military post, is situated here, also St James College, a Roman Catholic institution opened in 1856. Vancouver was a trading post of the Hudson Bay Company, built as such in 1828, and is therefore one of the oldest settlements in the north-west. Population (1880), 1722; (1890), 3545; (1900), 4006, of whom 47 were foreign-born.

Vancouver, a town and port in the province of British Columbia, Canada, on the southern side of Burrard Inlet, the western terminus of the Canadian Pacific Railway. It is the chief Canadian shipping port for Japan, China, Australia, and the islands at which the C.P.R. mail steamers call. There are regular lines of steamers between Vancouver, calling at Victoria on Vancouver Island, and Alaska and the points of connexion with the Yukon Territory; and lines also to Puget Sound and San Francisco in the United States. In 1886, soon after its establishment, fire swept the whole town out of existence, but the inferior wooden buildings at first erected have been largely replaced by stone and brick structures, giving a handsome appearance to the principal streets. Vancouver is well supplied with water, lighting, electric cars, a fine park, sea-bathing, and all improvements of modern cities. Though there is little agricultural land in the immediate neighbourhood, a large wholesale trade is carried on with the many scattered settlements of the province. It is, besides, the centre of the important timber industry of British Columbia. Population estimated at about 25,000.

Vancouver Island. See BRITISH COLUMBIA.

Vanderbilt, Cornelius (1794–1877), American capitalist and railway organizer, was born on Staten Island, New York, 27th May 1794. He was of Dutch ancestry, and received but little schooling. At the age of sixteen he worked a vessel regularly between Staten and Manhattan islands; later he engaged in the coasting trade, and after 1817 was manager of steamboat lines from New York to New Brunswick and Elizabethport, N.J. After 1830 he built and worked on his own account steamboats on the Hudson river, Long Island Sound, and the Delaware river. In 1851 he established a steamship line from New York to California by the Nicaragua route, and from 1855 to 1861 conducted a transatlantic line. From his extensive relations with navigation, Vanderbilt became popularly known as the "Commodore." As early as 1845 he had become financially interested in railways, and in 1864, abandoning water transportation, he secured control of the New York and Harlem Railroad. He next reorganized the Hudson River Railroad, which in 1869 he consolidated with the New York Central Railroad, forming a through trunk line from New York to Buffalo. On this route was begun the movement of grain and other bulk freights to the seaboard. After 1873 the Lake Shore and Michigan Southern Railway was worked in conjunction with the New York Central and Hudson River as a continuous line from New York to Chicago, controlled by Vanderbilt, who was undoubtedly the foremost railway manager of his time. Mr Vanderbilt's wealth at the time of his death, which took place in New York City on the 4th of January 1877, was variously estimated at from $60,000,000 to $100,000,000. He had in 1873 founded Vanderbilt University at Nashville, Tennessee, and made other notable gifts for philanthropic purposes.

Vannes, chief town of the department of Morbihan, France, and a bishop's see, 3 miles north of the Bay of Quiberon, 84 miles north-west of Nantes by the railway to Brest. The present hôtel de ville was built in 1884, and the Jules Simon College rebuilt in 1886. A monument was erected to Lesage, author of *Gil Blas*, in 1892. There are various industries, amongst them shipbuilding, iron-works, tanneries, breweries, linen and cotton mills. Port du Conteau serves as the port of Vannes. Population (1886), 20,036; (1901), 23,375.

Van 't Hoff, Jacobus Hendricus (1852–——), Dutch chemist, was born in Rotterdam on 30th August 1852. He studied from 1869 to 1871 at the polytechnic at Delft, in 1871 at the University of Leyden, in 1872 with Kekulé at Bonn, in 1873 with Wurtz at Paris, and in 1874, when he took his doctor's degree, with Mulder at Utrecht. In 1876 he became lecturer of physics at the veterinary school at Utrecht. Two years later he was chosen professor of chemistry, mineralogy, and geology in Amsterdam University. In 1896 he was appointed ordinary honorary professor of chemistry in Berlin University. Van 't Hoff's name is especially associated with two important developments of chemical theory. In the first place, he may be regarded as the founder of the doctrine of stereo-isomerism, for he was the first, in 1874, to introduce a definite mechanical theory of valency, and to connect the optical activity exhibited by many carbon compounds with their chemical constitution. In respect of this doctrine of the "asymmetric carbon atom," van 't Hoff's name is generally linked with that of Le Bel (born on 21st January 1847, at Pechelbronn, Lower Alsace), who, only two months later, independently enunciated the theory of asymmetric combinations with carbon; though it must be noted that J. Wislicenus, to whom van 't Hoff, in fact, acknowledges his indebtedness, had several years earlier definitely suggested that in order to explain the constitution of certain organic bodies, the tridimensional arrangement of atoms in space must be taken into account. For this work van 't Hoff and Le Bel received the Davy medal jointly from the Royal Society in 1893. Van 't Hoff is also identified with the development of the view that a close analogy must be recognized between the state of substances in solution and the same in the state of gas, and in a memoir on *Les lois de l'équilibre chimique* (1886), he showed that for dilute solutions the osmotic pressure follows the same laws as for gases. Van 't Hoff is a prolific worker and writer in the domain of physical chemistry, and since 1885 has published the *Zeitschrift für physikalische Chemie*, in collaboration with Professor Ostwald of Leipzig (born on 2nd September 1853 at Riga), another prominent investigator in the same field.

Van Wert, a city of Ohio, U.S.A., capital of Van Wert county, in the north-western part of the state, at the crossing of the Pennsylvania and the Cincinnati Northern railways, at an altitude of 782 feet. It is in an agricultural region, for which it serves as a market and supply point. Population (1880), 4079; (1890), 5512; (1900), 6422, of whom 221 were foreign-born and 183 negroes.

Vaporization.—§ 1. In common language, a *vapour* is a gaseous or elastic fluid, which emanates or evaporates from the surface of a solid or liquid at temperatures below its boiling-point. A *volatile* liquid or solid is one which evaporates rapidly at ordinary temperatures. It is a matter of common experience that evaporation is accelerated by currents of air, or by the use of an exhaust pump, or by any process which removes the vapour as rapidly as it is formed. On the other hand, it is retarded, and finally ceases, if the vapour is allowed to accumulate in a closed space. When this equilibrium state is reached, the space is said to be *saturated* with the vapour; the density of the vapour is then the maximum which can exist in the presence of the liquid at the temperature of the experiment, and its pressure is called the *saturation-pressure.* The term vapour-pressure, when used without qualification, is also generally employed to denote the saturation or maximum pressure. Dalton showed that the saturation-pressure of a vapour depends only on the temperature, and is unaffected by the presence of any neutral gas or vapour. This relation has been more accurately verified by many subsequent observers, and the exceptions to it have been minutely studied and elucidated. The saturation-pressure invariably increases rapidly with rise of temperature, according to a regular law which has been the subject of many elaborate investigations. When the vapour-pressure of a liquid becomes equal to the external pressure, bubbles of vapour are freely formed in the interior of the liquid by the familiar process of boiling or ebullition. The temperature at which this occurs under the normal atmospheric pressure of 760 mm. of mercury (reduced to 0° C. and sea-level in latitude 45°) is termed the *boiling-point* (B.P.) of the liquid, and is usually determined by taking the temperature of the saturated vapour under normal pressure, to avoid error from superheating or impurities in the liquid. If the external pressure remains constant, the temperature will also remain constant, provided that the liquid is pure and that its composition remains unaltered, until the whole is vaporized. If, on the other hand, the liquid is contained in a closed space, it may be made to boil at much lower temperatures by diminishing the pressure; or the temperature of the liquid may be raised considerably above the normal boiling-point, as in the boiler of a steam engine, if the pressure is raised by preventing the free escape of the vapour. In all cases, if the temperature is given, there is a corresponding equilibrium or saturation-pressure of the vapour, and *vice versâ*, in accordance with Dalton's law. It was shown, however, by Cagniard de la Tour (*Ann. Chim. Phys.*, 1822, 1823) that the temperature and pressure of the liquid could not be raised indefinitely in this manner. By heating liquids in strong glass bulbs with manometers attached, he found that at a certain temperature the meniscus or curved surface separating the liquid from the vapour disappeared, and the bulb became filled with an apparently uniform substance. The temperature at which this mixing of liquid and vapour occurs is definite for each liquid, and is called the *critical temperature.* La Tour found the critical temperature in the case of water to be 362° C., a result which has been remarkably confirmed by later researches (Cailletet, *Ann. Chim. Phys.*, 25, p. 519, 1892). In many books of recent years, it has been the custom, following a suggestion of Andrews, to restrict the term "gas" to temperatures above the critical temperature, and the term "vapour" to temperatures below. But this is often inconvenient in practice, as there is no sudden change in the gaseous phase at ordinary pressures on passing the critical temperature. It is more convenient to employ the term "vapour" only when discussing the properties of the gaseous phase in relation to the liquid or solid, and to follow the common usage in describing substances like CO_2, or even SO_2 and NH_3, as gases at ordinary temperatures and pressures.

§ 2. *Continuity of State.*—The form of the isothermal curve, representing the compression of a vapour at constant temperature, consists, as shown in Fig. 1A, of three discontinuous branches. The relation between pressure and volume for an unsaturated vapour is represented by the branch DE, which is similar to the isothermal of a gas obeying Boyle's law. When the saturation-pressure is reached at D the vapour begins to condense, and the volume diminishes without further increase of pressure, giving the isopiestic branch DCB. At B, when the vapour is completely liquefied, further compression produces a rapid rise of pressure, as shown by the branch BA, representing the behaviour of the liquid. It is possible, however, to trace the branch DN for the supersaturated vapour continuously beyond D without liquefaction in the absence of nuclei. It is similarly possible to trace the liquid branch ABM beyond B to lower pressures in the absence of dissolved gases. As the temperature is raised, the length of the branch BD, representing the increase of volume in passing from the liquid to the gas, diminishes, as shown in Fig. 1B, which represents the isothermals of CO_2,[1] according to Andrews (*Phil. Trans.*, 1869). Above the critical temperature, the discontinuities at B and D disappear from the isothermal curve, and it is impossible to obtain separation of the two states, liquid and gas, however great the pressure applied. The critical pressure is the vapour-pressure of the liquid at the critical temperature. It is possible to obtain a perfectly continuous passage from the gaseous to the liquid state by keeping the vapour at a pressure greater than the critical pressure while it is cooled from a temperature above the critical point, at which it would expand indefinitely (if the pressure were reduced) without separation into two phases, to a temperature below the critical point, at which expansion would produce separation into liquid and vapour as soon as the pressure was reduced to the saturation value. It was maintained by Andrews, on the basis of these and similar observations, that the gaseous and liquid states were merely widely separated forms of the same condition of matter, since one could be converted into the other without any breach of continuity or sudden evolution of heat or change of volume; just as an amorphous solid in the process of fusion becomes gradually more and more plastic as the temperature is raised, and passes into the state of a viscous liquid with continually diminishing viscosity. The same idea was further developed by James Thomson (*Proc. R.S.*, 1871), who suggested that the discontinuity of the isothermal at temperatures below the critical point was only apparent. He supposed that the extensions of the liquid and vapour curves BM, DN, in Fig. 1A, representing the states of superheated liquid and supersaturated vapour, might theoretically be joined by a continuous curve MN, representing a homogeneous transformation, which, however, could not be realized in practice, as the state of the substance corresponding to this part of the curve would be unstable. Maxwell (*Nature*, 1875) showed that the straight line BCD representing the saturation-pressure must cut off loops BMC, CND, of equal area from this imaginary isothermal; otherwise it would be theoretically possible to obtain a balance of work without any difference of temperature by taking the substance through the isothermal cycle BCDNCMB. The theoretical isothermal of James Thomson is qualitatively represented by an equation of the type devised by Van der Waals, in which the mutual attraction of the molecules of a gas is regarded as equivalent to an internal pressure of the form a/v^2, which he supposes identical with the capillary pressure of the liquid. It has been found, however, that this simple expression is not sufficiently exact. It is probable that it is not merely a question of varying attraction between similar molecules. A vapour should rather be regarded as containing a certain proportion of compound or co-aggregated molecules, which partially dissociate when the pressure is diminished or the temperature raised. A liquid similarly contains dissolved molecules of vapour, and the state of equilibrium is more nearly analogous to that between conjugate saturated solutions (*e.g.*, water and phenol).

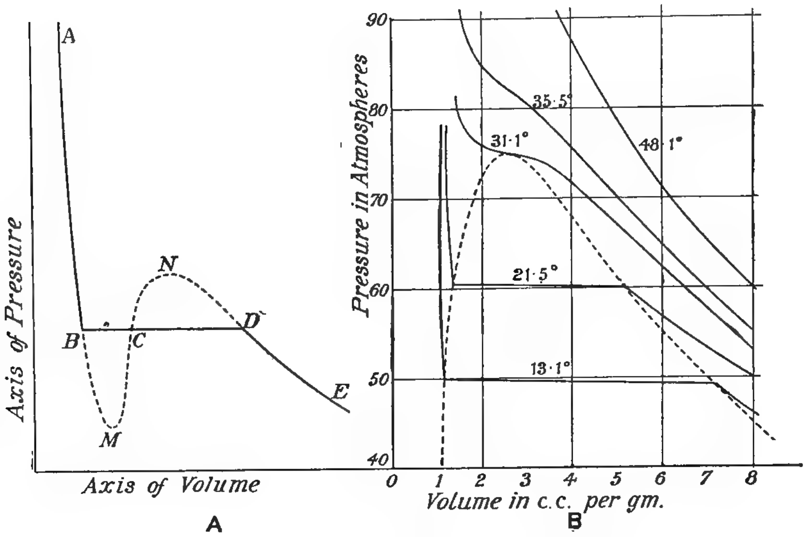

Fig. 1.

A, James Thomson Isothermal; B, Isothermals of CO_2 (Andrews).

§ 3. *Effect of Capillary Pressure.*—It was observed by Sir William Thomson (Lord Kelvin) (*Phil. Mag.*, iv. 42, p. 448, 1871) that if a capillary tube is partially immersed in a liquid which rises in the tube to a height h above the plane surface, and the whole apparatus is contained in an isothermal enclosure, the vapour must be in equilibrium with the liquid both at the plane surface and at the curved surface in the capillary tube. The equilibrium vapour-pressures of the liquid at the two surfaces must therefore differ by an amount equal to the pressure due to a column of vapour of height h. If r is the radius of curvature of the meniscus in the capillary tube (supposed circular in section) at the point where the tangent is horizontal at a height h, and if T is the surface tension, g the acceleration of gravity, D the density of the liquid, and d that of the vapour, the difference of pressure P between the liquid and vapour due to curvature of the meniscus is given by Laplace's formula

$$-P=2T/r=gh(D-d) \quad . \quad . \quad . \quad (1)$$

If p_o is the normal vapour-pressure at the plane surface, and p that at the curved surface, we have $(p_o-p)=ghd$, which when combined with (1) gives the relation

$$(p-p_o)/P=d/(D-d) \quad . \quad . \quad . \quad (2)$$

If we substitute for d its value $mp_o/R\theta$, where m is the molecular weight of the vapour and $R=8{\cdot}31\times10^7$ C.G.S., and if we put $D=1/V$, where V is the volume of unit mass of the liquid, neglecting the ratio d/D in comparison with unity, we have approximately

$$(p-p_o)/p_o=mPV/R\theta \quad . \quad . \quad . \quad (3)$$

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[1] The slight increase of pressure observed during condensation was attributed by Andrews to the presence of a trace of air in the CO_2.

Instead of regarding the effect as being due to the curvature of the surface, we may regard it as being directly due to the change of stress $P=ghD$ in the liquid, in which case d should be omitted in the denominator of (2), and relation (3) is accurate. In the case of water we may deduce from formula (3) that the relative increase of the vapour-pressure per atmosphere (megadyne) of increase of pressure P is $18/83 \times 273$ at 0° C., or only 8 parts in 10,000; and that it varies inversely as θ, if we neglect the expansion of V. The corresponding compression of the liquid is about 1 in 20,000, which is a quantity of a similar order of magnitude, if we remember that the molecules of the liquid are already nearly in contact.

Although we cannot suppose the formula of Laplace to hold accurately for drops of molecular dimensions, this increase of vapour-pressure with curvature in the case of small drops affords a natural explanation of the phenomenon of supersaturated vapour already alluded to. A minute drop of liquid of radius r in a fog or cloud will evaporate unless the vapour-pressure in the surrounding gas exceeds the normal saturation-pressure by $2Td/rD$. Similarly, in order that a fog may form in a moist atmosphere containing dust or ionic nuclei, it is necessary that the temperature should be lowered until the vapour-pressure exceeds that corresponding to the temperature by $2Td/rD$, where r is the equivalent radius of a nucleus. If there are no dust nuclei present, Wilson (*Phil. Trans.*, 1898) has found that a very fine fog of a distinct character is formed when the density of the vapour is about four times the saturation value. Assuming Laplace's formula, this would imply the normal presence of nuclei of a radius 4×10^{-7} cms. This value of r approaches molecular dimensions, and the experiment may be regarded as a corroboration of the view that a vapour contains coaggregated or liquid molecules in solution.

The very considerable superheating of a liquid above its normal boiling-point, which occurs in the absence of dissolved gases, is readily explained as the direct effect of the capillary pressure. The pressure inside a small bubble of radius r must exceed that in the surrounding liquid by $2T/r$, which may be very large for bubbles of molecular dimensions. Moreover, the vapour-pressure inside such a bubble is less than the normal saturation-pressure by $2Td/rD$. A liquid free from gas or other suitable nuclei can only evaporate at the surface, and may be considerably superheated, especially if its surface is covered with oil or some liquid of a higher boiling-point which does not mix with it.

We may suppose that a relation similar to (3) holds between the vapour-pressure of a *solid* and the pressure to which it is exposed, although in this case the theoretical or experimental proof would be more difficult, and possibly unsatisfactory. It is easy, however, to see that some such relation is required to correspond with the effect of pressure on the melting-point of a solid. (See FUSION.) The vapour-pressure of the solid at its melting-point, at which it is in equilibrium with the liquid, must be equal to that of the liquid; otherwise the phase possessing the higher vapour-pressure would evaporate, and the vapour would condense on the phase possessing the lower vapour-pressure, until the whole were transformed. Above the melting-point the vapour-pressure of the liquid must be less than that of the solid, as the liquid is the stable phase; below the melting-point the solid has the lower vapour-pressure. The curves of vapour-pressure of the solid and liquid phases intersect at an angle, and are not continuous as Regnault supposed. The difference of slope of the curves at the melting-point θ_o was shown by Kirchhoff (see (24) below) to be $L/v\theta_o$, where L is the latent heat of fusion and v the specific volume of the vapour. This may also be written $Lmp_o/R\theta^2_o$, since $p_o v=R\theta_o/m$. Hence if p', p'' are the normal vapour-pressures of the solid and liquid respectively at a temperature θ near the melting-point, the difference $(p'-p'')$ due to change of temperature $(\theta-\theta_o)$ is given by the formula

$$(p'-p'')/p_o=Lm(\theta-\theta_o)/R\theta^2_o \quad . \quad . \quad . \quad (4)$$

Assuming formula (3) to apply to both liquid and solid, if V' is the specific volume of the solid and V'' that of the liquid, for the same increase of pressure P the vapour-pressure of the solid is increased by $mPV'p_o/R\theta$, and that of the liquid by $mPV''p_o/R\theta$. The difference of vapour-pressure due to P is given by the formula

$$(p'-p'')/p_o=(V'-V'')mP/R\theta \,. \quad . \quad . \quad . \quad (5)$$

If we suppose the pressure P applied by some neutral fluid such as air, the melting-point must change in such a manner that the vapour-pressure of the liquid may be the same as that of the solid at the new melting-point. The difference of vapour-pressures due to change of pressure P must be equal and opposite to that due to change of temperature. Equating the values of $(p'-p'')$ in (4) and (5) with a change of sign, we obtain the well-known relation

$$(\theta-\theta_o)/\theta_o=(V''-V')P/L \quad . \quad . \quad . \quad . \quad (6)$$

Since this may be directly deduced from the second law of thermodynamics, we conclude that relation (3) correctly represents the change of vapour-pressure of a solid due to pressure P.

The same condition of equality of vapour-pressure evidently applies to other cases of "transition-points," or temperatures at which two different phases or modifications of a substance are capable of coexisting in equilibrium with each other in presence of the vapour. For instance, the rhombic and monosymmetric forms of sulphur must have the same vapour-pressure at their transition point, 95·6° C., the difference of slope of the vapour-pressure curves at this point being related to the latent heat of transition in the same manner as in the case of ice and water. Similarly at the transition point of two hydrates—*e.g.*, the hydrates of zinc sulphate with 6 and 7 molecules of water respectively, which can exist in equilibrium with the same saturated solution at 39° C. (see FUSION)—the solubilities must be equal, and the pressure of aqueous vapour in equilibrium with each solid hydrate must be the same as the vapour-pressure of the saturated solution at the transition point.

§ 4. *Mixtures and Solutions.*—The vapour-pressure of a liquid is not appreciably affected by the presence of another gas or vapour (neglecting the small effect of pressure already discussed), except in so far as the latter is soluble in the liquid. If two liquids which are mutually insoluble evaporate into the same space, the vapour-pressure of each attains its normal saturation value independently of the presence of the other. If each is partially soluble in the other, the mixture separates into two conjugate solutions, which must have the same vapour-pressure. The vapour-pressure of the mixture in this case is less than the sum of the separate vapour-pressures of the components. A solid dissolved in a liquid produces a similar lowering of vapour-pressure, which has been the subject of many important investigations.

The rise of boiling-point produced by substances in solution was demonstrated by Faraday in 1820. Babo, 1847, found that the "relative lowering" of the vapour-pressure of a solution $(p-p_o)/p_o$, where p is the vapour-pressure of the solution and p_o that of the pure solvent, at any temperature t, was independent of the temperature for the same solution. Wüllner (*Pogg. Ann.*, 103, p. 529, 1858) found the lowering of vapour-pressure to be nearly proportional to the strength of solution for the same salt. Ostwald, employing Wüllner's results, found the lowering produced by different salts to be approximately the same for solutions of the same concentration C measured in gramme-molecules per c.c. A most important experimental contribution was that of Raoult (*Comptes Rendus*, 1886, 1887), who employed other solvents than water. He verified the laws of Babo, Wüllner, and Ostwald, except for strong solutions, and showed that the lowering in different solvents was the same for solutions of the same "molecular concentration," for which the ratio of the number of molecules of the dissolved substance or solute to the number of molecules of the solvent in a given volume of solution was the same. These experimental results have been theoretically explained in terms of the osmotic pressure of the solution by Arrhenius, van 't Hoff, and others. The relation of the lowering of vapour pressure to the osmotic pressure may be obtained by reasoning similar to that employed by Lord Kelvin for capillary pressure, and is identical in form with (2) if we regard the osmotic pressure as a *diminution* of the pressure of the molecules of the solvent, due to partial displacement by molecules of the solute. The osmotic pressure P may be measured by the height of a column of the solution maintained by osmosis when a vessel permeable to the solvent but not to the solute is filled with solution and immersed in the pure solvent. If we imagine the whole apparatus to be kept in an isothermal enclosure containing only the vapour of the solvent, the vapour must be in equilibrium with both solution and solvent at different levels, and the vapour-pressure of the solution p must be less than that of the pure solvent p_o, by the pressure due to a column of vapour (density d), equal in height to the column of solution (density D) maintained by the osmotic pressure. This leads immediately to the relation

$$(p_o-p)/P=d/(D-d) \quad . \quad . \quad . \quad . \quad (7)$$

which is identical with (2), except that the sign of P is changed, because the osmotic pressure P of the solute is equivalent to a diminution of the concentration pressure of the solvent. The relation in this form is generally true, and includes all cases of abnormal vapour-densities and abnormal osmotic pressures; but for a considerable lowering of the vapour-pressure, it would be necessary to take account of the variation of density of the vapour, and to a less extent of that of the solution, in the height of the column corresponding to the osmotic pressure. The relation in this form is of little use, as the osmotic pressure cannot readily be measured. But in the case of dilute solutions we may make the usual assumption $P=R\theta C$. Since we have also $p_o=R\theta d/m$, the relation takes the simple form

$$(p_o-p)/p_o=mC/D \quad . \quad . \quad . \quad . \quad (8)$$

This corresponds approximately with Raoult's experimental law for dilute solutions, since D/m is the number of gramme-molecules of the solvent per c.c. of the solution. It involves the assumption that the molecules of the solute and the vapour are both normal. The most important exceptions are: (1) electrolytes, the molecules of which in dilute solutions are more or less split up into separate ions, which act as independent molecules as regards osmotic pressure; and (2) substances, like acetic acid, with abnormal vapour-densities.

The rise of boiling-point produced by any substance in solution is readily calculated from the lowering of vapour-pressure by dividing it by the increase of pressure per degree of temperature ($dp/d\theta$) for the solvent at its boiling-point. As a simple example, if 342 grammes of sugar (one gramme-molecule) are dissolved in 18 litres (1000 gramme-molecules) of water, the lowering of vapour-pressure at 100° C. is nearly one-thousandth part of the whole pressure, *i.e.*, of 760 mm. The rate of increase of steam-pressure at 100° C. is 27·2 mm. per 1° C. Hence the B.P. of the solution is raised by $760/27{\cdot}2 \times 1000 = {\cdot}028°$ C.

§ 5. *Total Heat and Latent Heat.*—To effect the conversion of a solid or liquid into a vapour without change of temperature, it is necessary to supply a certain quantity of heat. The quantity required per unit mass of the substance is termed the *latent heat of vaporization.* The *total heat* of the saturated vapour at any temperature is usually defined as the quantity of heat required to raise unit mass of the liquid from any convenient zero up to the temperature considered, and then to evaporate it at that temperature under the constant pressure of saturation. The total heat of steam, for instance, is generally reckoned from the state of water at the freezing-point, 0° C. If h denote the heat required to raise the temperature of the liquid from the selected zero to the temperature $t°$ C., and if H denote the total heat and L the latent heat of the vapour, also at $t°$ C., we have evidently the simple relation

$$H = L + h. \quad . \quad . \quad . \quad . \quad (9)$$

The pressure under which the liquid is heated makes very little difference to the quantity h, but, in order to make the statement definite, it is desirable to add that the liquid should be heated under a constant pressure equal to the final saturation-pressure of the vapour. The usual definition of total heat applies only to a saturated vapour. For greater simplicity and generality it is desirable to define the total heat of a substance as the function $(E+pv)$, where E is the intrinsic energy and v the volume of unit mass. (See THERMODYNAMICS.) This agrees with the usual definition in the special case of a saturated vapour, if the liquid is heated under the final pressure p, as is generally the case in heat engines and in experimental measurements of H.

The method commonly adopted in measuring the latent heat of a vapour is to condense the vapour at saturation-pressure in a calorimeter. The quantity of heat so measured is the total heat of the vapour reckoned from the final temperature of the calorimeter, and the heat of the liquid h must be subtracted from the total heat measured to find the latent heat of the vapour at the given temperature. It is necessary to take special precautions to ensure that the vapour is dry or free from drops of liquid. Another method, which is suitable for volatile liquids or low temperatures, is to allow the liquid to evaporate in a calorimeter, and to measure the quantity of heat required for the evaporation of the liquid at the temperature of the calorimeter and at saturation-pressure. The first method may be called the method of condensation. It was applied in the most perfect manner by Regnault to determine the latent heats of steam and several other vapours at high pressures. The second method may be called the method of evaporation. It is more difficult of application than the first, but has given some good results in the hands of Griffiths[1] and Dieterici, although the experiments of Regnault by this method were not very successful.

It was believed for many years, in consequence of some rough experiments made by Watt, that the total heat of steam was constant. This was known as Watt's law, and was sometimes extended to other vapours. An alternative supposition, due to Southern, was that the latent heat was constant. The very careful experiments of Regnault, published in 1847, showed that the truth lay somewhere between the two. The formula which he gave for the total heat H of steam at any temperature $t°$ C., which has since been universally accepted and has formed the basis of all tables of the properties of steam, was as follows:—

$$H = 606{\cdot}5 + 0{\cdot}305t. \quad . \quad . \quad . \quad . \quad (10)$$

He obtained similar formulæ for other vapours, but the experiments were not so complete or satisfactory as in the case of steam, which may conveniently be taken as a typical vapour in comparing theory and experiment.

§ 6. *Total Heat of Ideal Vapour.*—It was proved theoretically by Rankine (*Proc. R.S.E.*, vol. xx. p. 173, read February 1850, published 1853) that the increase of the total heat of a saturated vapour between any two temperatures should be equal to the specific heat S of the vapour at constant pressure multiplied by the difference of temperature, provided that the saturated vapour behaved as an ideal gas, and that its specific heat was independent of the pressure and temperature. Expressed in symbols, the relation may be written

$$H' - H'' = S(\theta' - \theta'') \quad . \quad . \quad (11)$$

This relation gives a linear formula for the variation of the total heat, a result which agrees in form with that found by Regnault for steam, and implies that the coefficient of t in his formula should be equal to the specific heat S of steam. Rankine's equation follows directly from the first law of thermodynamics, and may be proved as follows: The heat absorbed in any transformation is the change of intrinsic energy *plus* the external work done. To find the total heat H of a vapour, we have $H = E + p(v - b)$, where the intrinsic energy E is measured from the selected zero θ_o of total heat. The external work done is $p(v-b)$, where p is the constant pressure, v the volume of the vapour at θ, and b the volume of the liquid at θ_o. If the saturated vapour behaves as a perfect gas, the change of intrinsic energy E depends only on the temperature limits, and is equal to $s(\theta - \theta_o)$, where s is the specific heat at constant volume. Taking the difference between the values of H for any two temperatures θ' and θ'', we see that Rankine's result follows immediately, provided that $p(v-b)$ is equal to $(S-s)\theta$ or $R\theta/m$, which is approximately true for gases and vapours when v is very large compared with b. We may observe that the equation (11) is accurately true for an ideal vapour, for which $pv = (S-s)\theta$, provided that the total heat is defined as equal to the change of the function $(E+pv)$ between the given limits. Adopting this definition, without restriction to the case of an ideal vapour or to saturation-pressure, the rate of variation of the total heat with temperature ($dH/d\theta$) at constant pressure is equal to S under all conditions, whether S is constant, or varies both with p and θ. (See THERMODYNAMICS, § 7.)

§ 7. *Specific Heat of Vapours.*—The question of the measurement of the specific heat of a vapour possesses special interest on account of this simple theoretical relation between the specific heat and the variation of the latent and total heats. The first accurate calculations of the specific heats of air and gases were made by Rankine in a continuation of the paper already quoted. Employing Joule's value of the mechanical equivalent of heat, then recently published, in connexion with the value of the ratio of the specific heats of air $S/s = 1{\cdot}40$ deduced from the velocity of sound, Rankine found for air $S = {\cdot}240$, which was much smaller than the best previous determinations (*e.g.*, Delaroche and Berard, $S = {·267}$), but agreed very closely with the value $S = {·238}$, found by Regnault at a later date. Adopting for steam the same value of the ratio of the specific heats, namely, 1·40, Rankine found $S = {·385}$, a value which he used, in default of a better, in calculating some of the properties of steam, although he observed that it was much larger than the coefficient ·305 in Regnault's formula for the variation of the total heat. The specific heat of steam was determined shortly afterwards by Regnault (*Comptes Rendus*, 36, p. 676) by condensing superheated steam at two different temperatures (about 125° and 225° C.) successively in the same calorimeter at atmospheric pressure, and taking the difference of the total heats observed. The result found in this manner, namely, $S = {·475}$, greatly increased the apparent discrepancy between Regnault's and Rankine's formulæ for the total heat. The discrepancy was also noticed by Kirchhoff, who rediscovered Rankine's formula (*Pogg. Ann.*, 103, p. 185, 1858). He suggested that the high value for S found by Regnault might be due to the presence of damp in his superheated steam, or, on the other hand, that the assumption that steam at low temperatures followed the law $pv = R\theta$ might be erroneous. These suggestions have been frequently repeated, but it is probable that neither is correct. Zeuner, at a later date (*La Chaleur*, p. 441), employing the empirical formula $pv = B\theta + Cp^{·25}$ for saturated steam, found the value $S = {·568}$, which further increased the discrepancy. Hirn and Cazin (*Ann. Chim. Phys.*, iv. 10, p. 349, 1867) investigated the form of the adiabatic for steam passing through the state $p = 760$ mm., $\theta = 373°$ Abs., by observing the pressure of superheated steam at any temperature which just failed to produce a cloud on sudden expansion to atmospheric pressure. Assuming an equation of the form $\log (p/760) = a \log (\theta/373)$, their results give $a = S/R = 4{·}305$, or $S = 0{·}474$, which agrees very perfectly with Regnault's value. It must be observed, however, that the agreement is rather more perfect than the comparative roughness of the method would appear to warrant. More recently, Macfarlane Gray (*Proc. Inst. Mech. Eng.*, 1889), who has devoted minute attention to the reduction of Regnault's observations, assuming $S/s = 1{·}400$ as the theoretical ratio of specific heats of all vapours on his "ether-pressure theory," has calculated the properties of steam on the assumption $S = 0{·}384$. He endeavours to support this value by reference to sixteen of Regnault's observations on the total heat of steam at atmospheric pressure with only 19° to 28° of superheat. These observations give values for S ranging from 0·30 to 0·46, with a mean value 0·3778. But it must be remarked that the superheat of the steam in these experiments is only 1 or 2 per cent. of the total heat measured. A similar objection applies, though with less force, to Regnault's main experiments between 125° and 225° C., giving the value $S = 0{·}475$, in which the superheat (on which the value of S depends) is only one-sixteenth of the total heat measured. Gray explains the higher value found by Regnault over the higher range as due to the presence of particles of moisture in the steam, which he thinks "would not be evaporated up to 124° C., but would be more likely to be evaporated in the higher range of temperature." Perry (*Steam Engine*, p. 580), assuming a characteristic equation similar to Zeuner's (which makes v a linear function of the temperature at constant pressure, and S independent of the pressure), calculates S as a function of the temperature to satisfy Regnault's formula (10) for the total heat. This method is logically consistent, and gives values ranging from 0·305 at 0° to 0·341 at 100° C. and 0·464 at 210° C., but the difference from Regnault's $S = 0{·}475$ cannot easily be explained.

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[1] "Latent Heat of Steam," *Phil. Trans.*, A. 1895; of "Benzene," *Phil. Mag.*, 1896.

§ 8. *Throttling Calorimeter Method.*—The ideal method of determining by direct experiment the relation between the total heat and the specific heat of a vapour is that of Joule and Thomson, which is more commonly known in connexion with steam as the method of the throttling calorimeter. It was first employed in the case of steam by Peabody as a means of estimating the wetness of saturated steam, which is an important factor in testing the performance of an engine. If steam or vapour is "wire-drawn" or expanded through a porous plug or throttling aperture without external loss or gain of heat, the total heat $(E + pv)$ remains constant (THERMODYNAMICS, § 11), provided that the experiment is arranged so that the kinetic energy of flow is the same on either side of the throttle. Thus, starting with saturated steam at a temperature θ' and pressure p', as represented by the point A on the $p\theta$ diagram (Fig. 2), if the point B represent the state $p''\theta''$ after passing the throttle, the total heat at A is the same as that at B, and exceeds that at any other point D (at the same pressure p'' as at B, but at a lower temperature θ) by the amount $S(\theta'' - \theta)$, which would be required to raise the temperature from D to B at constant pressure. We have therefore the simple relation between the total heats at A and D—

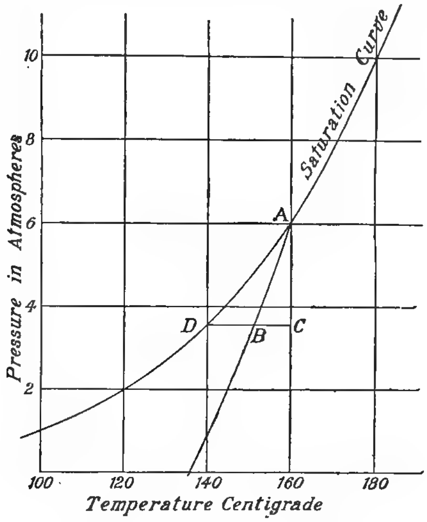

FIG. 2.—Throttling Calorimeter Method.

$$H_A - H_D = S(\theta'' - \theta). \quad . \quad . \quad . \quad (12)$$

If the steam at A contains a fraction z of suspended moisture, the total heat H_A is less than the value for dry saturated steam at A by the amount zL. If the steam at A were dry and saturated, we should have, assuming Regnault's formula (10), $H_A - H_D = {·305}\ (\theta' - \theta)$, whence, if $S = {·475}$, we have $zL = {·305}\ (\theta' - \theta) - {·475}\ (\theta'' - \theta)$. It is evident that this is a very delicate method of determining the wetness z, but, since with dry saturated steam at low pressures this formula always gives *negative* values of the wetness, it is clear that Regnault's numerical co-efficients must be wrong.

From a different point of view, equation (12) may be applied to determine the specific heat of steam in terms of the rate of variation of the total heat. If we assume Regnault's formula (10) for the total heat, we have evidently the simple relation $S = 0{·}305\ (\theta' - \theta)/(\theta'' - \theta)$, supposing the initial steam to be dry, or at least of the same quality as that employed by Regnault. This method was applied by Ewing (*B.A. Rep.*, 1897) to steam near 100° C. He found the specific heat smaller than 0·475, but no numerical results were given. A very complete investigation on the same lines was carried out by Grindley (*Phil. Trans.*, 1900) at Owens College under the direction of Osborne Reynolds. Assuming $dH/d\theta = 0{\cdot}305$ for saturated steam, he found that S was nearly independent of the pressure at constant temperature, but that it varied with the temperature from 0·387 at 100° C. to 0·665 at 160° C. Writing Q for the Joule–Thomson "cooling effect," $d\theta/dp$, or the slope BC/AC of the line of constant total heat, he found that Q was nearly independent of the pressure at constant temperature, a result which agrees with that of Joule and Thomson for air and CO_2; but that it varied with the temperature as $(1/\theta)^{3{\cdot}8}$ instead of $(1/\theta)^2$. These results for the variation of Q are independent of any assumption with regard to the variation of H. Employing the values of S calculated from $dH/d\theta = 0{\cdot}305$, he found that the product SQ was independent of both pressure and temperature for the range of his experiments. Assuming this result to hold generally, we should have $S = 0{\cdot}306$ at 0° C., which agrees with Rankine's view; but increasing very rapidly at higher temperatures to $S = 1{\cdot}043$ at 200° C., and 1·315 at 220° C. The characteristic equation, if SQ = constant, would be of the form $(v + SQ) = R\theta/p$, which does not agree with the well-known behaviour of other gases and vapours. Whatever may be the objections to Regnault's method of measuring the specific heat of a vapour, it seems impossible to reconcile so wide a range of variation of S with his value $S = 0{\cdot}475$ between 125° and 225° C. It is also extremely unlikely that a vapour which is so stable a chemical compound as steam should show so wide a range of variation of specific heat. The *experimental* results of Grindley with regard to the mode of variation of Q have been independently confirmed by Callendar (*Proc. R.S.*, 1900), who quotes the results of similar experiments made at McGill College in 1897, but gives an entirely different interpretation, based on a direct measurement of the specific heat at 100° C. by an electrical method.

The method of deducing the specific heat from Regnault's formula for the variation of the total heat is evidently liable in a greater degree to the objections which have been urged against his method of determining the specific heat, since it makes the value of the specific heat depend on small differences of total heat observed under conditions of greater difficulty at various pressures. The more logical method of procedure is to determine the specific heat independently of the total heat, and then to deduce the variations of total heat by equation (12). The simplest method of measuring the specific heat appears to be that of supplying heat electrically to a steady current of vapour in a vacuum-jacket calorimeter, and observing the rise of temperature produced. Employing this method, Callendar finds $S = 0{\cdot}497$ for steam at one atmosphere between 103° C. and 113° C. This is about 4 per cent. larger than Regnault's value, but is not really inconsistent with it, if we suppose that the specific heat at any given pressure diminishes slightly with rise of temperature, as indicated in formula (16) below.

§ 9. *Corrected Equation of Total Heat.*—Admitting the value $S = 0{\cdot}497$ for the specific heat at 108° C., it is clear that the form of Regnault's equation (10) must be wrong, although the numerical value of the coefficient 0·305 may approximately represent the average rate of variation over the range (100° to 190° C.) of the experiments on which it chiefly depends. Regnault's experiments at lower temperatures were extremely discordant, and have been shown by the work of Griffiths (*Proc. R.S.*, 1894) and Dieterici (*Wied. Ann.*, 37, p. 504, 1889) to give values of the total heat 10 to 6 calories too large between 0° and 40° C. At low pressures and temperatures it is probable that saturated steam behaves very nearly as an ideal gas, and that the variation of the total heat is closely represented by Rankine's equation with the ideal value of S. In order to correct this equation for the deviations of the vapour from the ideal state at higher temperatures and pressures, the simplest method is to assume a modified equation of the Joule–Thomson type (THERMODYNAMICS, equation (17)), which has been shown to represent satisfactorily the behaviour of other gases and vapours at moderate pressures. Employing this type of equation, all the thermodynamical properties of the substance may conveniently be expressed in terms of the diminution of volume c due to the formation of compound or coaggregated molecules

$$(v - b) = R\theta/p - c_o(\theta_o/\theta)^n = V - c \quad . \quad . \quad (13)$$

The index n in the above formula, representing the rate of variation of c with temperature, is approximately the same as that expressing the rate of variation of the cooling effect Q, which is nearly proportional to c, and is given by the formula

$$SQ = (n+1)c - b \quad . \quad . \quad . \quad (14)$$

The corresponding formula for the total heat is

$$H - H_o = S_o(\theta - \theta_o) - (n+1)\ (cp - c_op_o) + b(p - p_o) \quad . \quad (15)$$

and for the variation of the specific heat with pressure

$$S = S_o + n(n+1)pc/\theta \quad . \quad . \quad . \quad (16)$$

where S_o is the value of S when $p = o$, and is assumed to be independent of θ, as in the case of an ideal gas.

Callendar's experiments on the cooling effect for steam by the throttling calorimeter method gave $n = 3{\cdot}33$ and $c = 26{\cdot}3$ c.c. at 100° C. Grindley's experiments gave nearly the same average value of Q over his experimental range, but a rather larger value for n, namely, 3·8. For purposes of calculation, Callendar (*Proc. R.S.*, 1900) adopted the mean value $n = 3{\cdot}5$, and also assumed the specific heat at constant volume $s = 3{\cdot}5\ R$ (which gives $S_o = 4{\cdot}5\ R$) on the basis of a hypothesis, doubtfully attributed to Maxwell, that the number of degrees of freedom of a molecule with m atoms is $2m + 1$. The assumption $n = s/R$ simplifies the adiabatic equation, but the value $n = 3{\cdot}5$ gives $S_o = 0{\cdot}497$ at zero pressure, which was the value found by Callendar experimentally at 108° C. and 1 atmosphere pressure. Later and more accurate experiments have confirmed the experimental value, and have shown that the limiting value of the specific heat should consequently be somewhat smaller than that given by Maxwell's hypothesis. The introduction of this correction into the calculations would slightly improve the agreement with Regnault's values of the specific heat and total heat between 100° and 200° C., where they are most trustworthy, but would not materially affect the general nature of the results.

Values calculated from these formulæ are given in the table below. The values of H at 0° and 40° agree fairly with those found by Dieterici (596·7) and Griffiths (613·2) respectively, but differ considerably from Regnault's values 606·5 and 618·7. The rate of increase of the total heat, instead of being constant for saturated steam as in Regnault's formula, is given by the equation

$$dH/d\theta = S(1 - Q dp/d\theta) \quad . \quad . \quad . \quad (17)$$

and diminishes from 0·478 at 0° C. to about 0·40 at 100° and 0·20 at 200° C., decreasing more rapidly at higher temperatures. The mean value, 0·313 of $dH/d\theta$, between 100° and 200° agrees fairly well with Regnault's coefficient 0·305, but it is clear that considerable errors in calculating the wetness of steam or the amount of cylinder condensation would result from assuming this important coefficient to be constant. The rate of change of the latent heat is easily deduced from that of the total heat by subtracting the specific heat of the liquid. Since the specific heat of the liquid increases rapidly at high temperatures, while $dH/d\theta$ diminishes, it is clear that the latent heat must diminish more and more rapidly as the critical point is approached. Regnault's formula for the total heat is here again seen to be inadmissible, as it would make the latent heat of steam vanish at about 870° C. instead of at 365° C. It should be observed, however, that the assumptions made in deducing the above formulæ apply only for moderate pressures, and that the formulæ cannot be employed up to the critical point owing to the uncertainty of the variation of the specific heats and the cooling effect Q at high pressures beyond the experimental range. Many attempts have been made to construct formulæ representing the deviations of vapours from the ideal state up to the critical point. One of the most complete is that proposed by Clausius, which may be written

$$R\theta/p - v = R\theta(v - b)\ (A - B\theta^n)/p(v + a)^2\theta^n \quad . \quad (18),$$

but such formulæ are much too complicated to be of any practical use, and are too empirical in their nature to permit of the direct physical interpretation of the constants they contain.

§ 10. *Empirical Formulæ for the Saturation-Pressure.*—The values of the saturation-pressure have been very accurately determined for the majority of stable substances, and a large number of empirical formulæ have been proposed to represent the relation between pressure and temperature. These formulæ are important on account of the labour and ingenuity expended in devising the most suitable types, and also as a convenient means of recording the experimental data. In the following list, which contains a few typical examples, the different formulæ are arranged to give the logarithm of the saturation-pressure p in terms of the absolute temperature θ. As originally proposed, many of these formulæ were cast in exponential form, but the adoption of the logarithmic method of expression throughout the list serves to show more clearly the relationship between the various types.

$\log p = A + B\theta$ . . . (Dalton, 1800) . . (19)
$\log p = C \log (A + B\theta)$ . . (Young, 1820)
$\log p = A\theta/(B + C\theta)$ . . (Roche, 1830)
$\log p = A + Bb^\theta + Cc^\theta$ . . (Biot, 1844 ; Regnault)
$\log p = A + B/\theta + C/\theta^2$ . . (Rankine, 1849)
$\log p = A + B/\theta + C \log \theta$. (Kirchhoff, 1858 ; Rankine, 1866)
$\log p = A + B/\theta^b$ . . . (Unwin, 1887)
$\log p = A + B \log \theta + C \log (\theta + c)$. (Bertrand, 1887)
$\log p = A + B/(\theta + C)$ . . (Antoine, 1888)

The formula of Dalton would make the pressure increase in geometrical progression for equal increments of temperature. In other words, the increase of pressure per degree $(dp/d\theta)$ divided by p should be constant and equal to B, but observation shows that this ratio decreases, *e.g.*, from 0·0722 at 0° C. to 0·0357 at 100° C. in the case of steam. Observing that this rate of diminution is approximately as the square of the reciprocal of the absolute temperature, we see that the almost equally simple formula $\log p = A + B/\theta$ represents a much closer approximation to experiment. As a matter of fact, the two terms $A + B/\theta$ are the most important in the theoretical expression for the vapour-pressure given below. They are not sufficient alone, but give good results when modified, as in the simple and accurate formulæ of Rankine, Kirchhoff, Antoine, and Unwin. If we assume formulæ of the simple type $A + B/\theta$ for *two different substances*, which have the same vapour-pressure p at the absolute temperatures θ' and θ'' respectively, we may write

$$\log p = A' + B'/\theta' = A'' + B''/\theta'' \quad . \quad . \quad (20)$$

from which we deduce that the ratio θ'/θ'' of the temperatures, at which the vapour-pressures are the same, is a linear function of the temperature θ' of one of the substances. This approximate relation has been employed by Ramsay and Young (*Phil. Mag.*, 1887) to deduce the vapour-pressures of any substance from those of a standard substance, by means of two observations. More recently the same method has been applied by Findlay (*Proc. R.S.*, 1902), under Ramsay's direction, for comparing solubilities which are in many respects analogous to vapour-pressures. The formulæ of Young and Roche are purely empirical, but give very fair results over a wide range. That of Biot is far more complicated and troublesome, but admits greater accuracy of adaptation, as it contains five constants (or six, if θ is measured from an arbitrary zero). It is important as having been adopted by Regnault (and also by many subsequent calculators) for the expression of his observations on the vapour-pressures of steam and various other substances. The formulæ of Rankine and Unwin, though probably less accurate over the whole range, are much simpler and more convenient in practice than that of Biot, and give results which suffice in accuracy for the majority of purposes.

§ 11. *Theoretical Equation for the Saturation-Pressure.*—The empirical formulæ above quoted must be compared and tested in the light of the theoretical relation between the latent heat and the rate of increase of the vapour-pressure $(dp/d\theta)$, which is given by the second law of thermodynamics, namely,

$$\theta(dp/d\theta) = L/(v - w), \quad . \quad . \quad . \quad (21)$$

in which v and w are the volumes of unit mass of the vapour and liquid respectively at the saturation-point (THERMODYNAMICS, § 4). This relation cannot be directly integrated, so as to obtain the equation for the saturation-pressure, unless L and $v - w$ are known as functions of θ. Since it is much easier to measure p than either L or v, the relation has generally been employed for deducing either L or v from observations of p. For instance, it is usual to calculate the specific volumes of saturated steam by assuming Regnault's formulæ for p and L. The values so found are necessarily erroneous if formula (10) for the total heat is wrong. The reason for adopting this method is that the specific volume of a saturated vapour cannot be directly measured with sufficient accuracy on account of the readiness with which it condenses on the surface of the containing vessel. The specific volumes of superheated vapours may, however, be measured with a satisfactory degree of approximation. The deviations from the ideal volume may also be deduced by the method of Joule and Thomson. It is found by these methods that the behaviour of superheated vapours closely resembles that of non-condensible gases, and it is a fair inference that similar behaviour would be observed up to the saturation-point if surface condensation could be avoided. By assuming suitable forms of the characteristic equation to represent the variations of the specific volume within certain limits of pressure and temperature, we may therefore with propriety deduce equations to represent the saturation-pressure, which will certainly be thermodynamically consistent, and will probably give correct numerical results within the assigned limits.

The simplest assumptions to make are that the vapour behaves as a perfect gas (or that $p(v - w) = R\theta$), and that L is constant. This leads immediately to the simple formula,

$$\log_e (p/p_o) = (1/\theta_o - 1/\theta)\, L/R, \quad . \quad . \quad (22)$$

which is of the same type as $\log p = A + B/\theta$, and shows that the coefficient B should be equal to L/R. A formula of this type has been widely employed by van 't Hoff and others to calculate heats of reaction and solution from observations of solubility and *vice versâ*. It is obvious, however, that the assumption $L =$ constant is not sufficiently accurate in many cases. The rate of variation of the latent heat at low pressures is equal to $S - s_l$, where s_l is the specific heat of the liquid. Under these conditions both S and s_l may be regarded as approximately constant, so that L is a linear function of the temperature. Substituting $L = L_o + (S - s_l)\,(\theta - \theta_o)$, and integrating between limits, we obtain the result

$$\log_e p = A + B/\theta + C \log_e \theta, \quad . \quad . \quad (23)$$

where

$$C = (S - s_l)/R,\ B = -[L_o + (s_l - S)\theta_o]/R, \text{ and}$$
$$A = \log_e p_o - B/\theta_o - C \log_e \theta_o.$$

A formula of this type was first obtained by Kirchhoff (*Pogg. Ann.*, 103, p. 185, 1858) to represent the vapour-pressure of a solution, and was verified by Regnault's experiments on solutions of H_2SO_4 in water, in which case a constant, the heat of dilution, is added to the latent heat. The formula evidently applies to the vapour-pressure of the pure solvent as a special case, but Kirchhoff himself does not appear to have made this particular application of the formula. In the paper which immediately follows, he gives the oft-quoted expression for the difference of slope $(dp/d\theta)_s - (dp/d\theta)_l$ of the vapour-pressure curves of a solid and liquid at the triple point, which is immediately deducible from (21), namely,

$$\theta(dp/d\theta)_s - \theta(dp/d\theta)_l = (L_s - L_l)/(v-w) = L_f/(v-w) \quad . \quad (24),$$

in which L_s and L_l are the latent heats of vaporization of the solid and liquid respectively, the difference of which is equal to the latent heat of fusion L_f. He proceeds to calculate from this expression the difference of vapour-pressures of ice and water in the immediate neighbourhood of the melting-point, but does not observe that the vapour-pressures themselves may be more accurately calculated for a considerable interval of temperature by means of formula (23), by substituting the appropriate values of the latent heats and specific heats. Taking for ice and water the following numerical data, $L_s = 674\cdot7$, $L_l = 595\cdot2$, $L_f = 79\cdot5$, $R = 0\cdot1103$ cal/deg., $p_o = 4\cdot61$ mm., $s_l - S = \cdot519$ cal/deg., and assuming the specific heat of ice to be equal to that of steam at constant pressure (which is sufficiently approximate since the term involving the difference of the specific heats is very small), we obtain the following numerical formulæ, by substitution in (23),

Ice . . . $\log_{10} p = 0\cdot6640 + 9\cdot73\ t/\theta$,
Water . $\log_{10} p = 0\cdot6640 + 8\cdot585\ t/\theta - 4\cdot70\ (\log_{10} \theta/\theta_o - Mt/\theta)$,

where $t = \theta - 273$, and $M = \cdot4343$, the modulus of common logarithms. These formulæ are practically accurate for a range of 20° or 30° C. on either side of the melting-point, as the pressure is so small that the vapour may be treated as an ideal gas. They give the following numerical values :—

Temperature, C.	−20°	−10°	0°	+10°	+20°
V.P. of ice, mms.	0·79	1·97	4·61	10·20	21·27
V.P. of water, mms.	0·96	2·17	4·61	9·27	17·58

The error of the formula for water is less than 1 mm. (or a tenth of a degree C.), at a temperature so high as 60° C.

Formula (23) for the vapour-pressure was subsequently deduced by Rankine (*Phil. Mag.*, 1866), by combining his equation (11) for the total heat of gasefication with (21), and assuming an ideal vapour. A formula of the same type was given by Dupré (*Théorie de Chaleur*, p. 96, Paris, 1869), on the assumption that the latent heat was a linear function of the temperature, taking the instance of Regnault's formula (10) for steam. It is generally called Dupré's formula in Continental text-books, but he did not give the values of the coefficients in terms of the difference of specific heats of the liquid and vapour. It was employed as a purely empirical formula by Bertrand and Barus, who calculated the values of the coefficients for several substances, so as to obtain the best general agreement with the results of observation over a wide range, at high as well as low pressures. Applied in this manner, the formula is not appropriate or satisfactory. The values of the coefficients given by Bertrand, for instance, in the formula for steam, correspond to the values $S = \cdot576$ and $L = \cdot573$ at 0° C., which are impossible, and the values of p given by his formula (*e.g.*, 763 mm. at 100° C.) do not agree sufficiently with experiment to be of much practical value. The true application of the formula is to low pressures, at which it is very accurate. The close agreement found under these conditions is a very strong confirmation of the correctness of the assumption that a vapour at low pressures does really behave as an ideal gas of constant specific heat. The formula was independently rediscovered by Hertz (*Wied. Ann.*, 17, p. 177, 1882) in a slightly different form, and appropriately applied to the calculation of the vapour-pressures of mercury at ordinary temperatures, where they are much too small to be accurately measured.

§ 12. *Corrected Equation of Saturation-Pressure.*—The approximate equation of Rankine (23) begins to be 1 or 2 per cent. in error at the boiling-point under atmospheric pressure, owing to the coaggregation of the molecules of the vapour and the variation of the specific heat of the liquid. The errors from both causes increase more rapidly at higher temperatures. It is easy, however, to correct the formula for these deviations, and to make it thermodynamically consistent with the characteristic equation (13) by substituting the appropriate values of $(v-w)$ and $L = H - h$ from equations (13) and (15) in formula (21) before integrating. Omitting w and neglecting the small variation of the specific heat of the liquid, the result is simply the addition of the term $(c-b)/V$ to formula (23)

$$\log p = A + B/\theta + C \log \theta + (c-b)/V \quad . \quad . \quad (25)$$

The values of the coefficients B and C remain practically as before. The value of c is determined by the throttling experiments, so that all the coefficients in the formula with the exception of A are determined independently of any observations of the saturation-pressure itself. The value of A for steam is determined by the consideration that $p = 760$ mm. by definition at 100° C. or 373° Abs. The most uncertain data are the variation of the specific heat of the liquid and the value of the small quantity b in the formula (13). The term b, however, is only 4 per cent. of c at 100° C., and the error involved in taking b equal to the volume of the liquid is probably small. The effect of variation of the specific heat is more important, but is nearly eliminated by the form of the equation. If we write $h = s_o t + dh$, where s_o is a selected constant value of the specific heat of the liquid, and dh represents the difference of the actual value of h at t from the ideal value $s_o t$, and if we similarly write $\phi = s_o \log_e (\theta/\theta_o) + d\phi$ for the entropy of the liquid at t, where $d\phi$ represents the corresponding difference in the entropy (which is easily calculated from a table of values of h), it is shown by Callendar (*Proc. R.S.*, 1900, *loc. cit.*) that the effect of the variation of the specific heat of the liquid is represented in the equation for the vapour-pressure by adding to the right-hand side of (23) the term $-(d\phi - dh/\theta)/R$. If we proceed instead by the method of integrating the equation $H - h = \theta(v-w)dp/d\theta$, we observe that the expression above given results from the integration of the terms $-dh/R\theta^2 + w(dp/d\theta)/R\theta$, which were omitted in (25). Adopting the formula of Regnault as corrected by Callendar (*Phil. Trans. R.S.*, 1902) for the specific heat of water between 100° and 200° C., we find the values of the difference $(d\phi - dh/\theta)$ to be less than one-tenth of $d\phi$ at 200° C. The whole correction is therefore probably of the same order as the uncertainty of the variation of the specific heat itself at these temperatures. It may be observed that the correction would vanish if we could write $dh = w\theta dp/d\theta = wL/(v-w)$. This assumption is made by Gray (*Proc. Inst. C.E.*, 1902). It is equivalent, as Callendar (*loc. cit.*) points out, to supposing that the variation of the specific heat is due to the formation and solution of a mass $w/(v-w)$ of vapour molecules per unit mass of the liquid. But this neglects the latent heat of solution, unless we may suppose it included by writing the internal latent heat L_i in place of L in Callendar's formula. In any case the correction may probably be neglected for practical purposes below 200° C.

It is interesting to remark that the simple result found in equation (25) (according to which the effect of the deviation of the vapour from the ideal state is represented by the addition of the term $(c-b)/V$ to the expression for log p) is independent of the assumption that c varies inversely as the n^{th} power of θ, and is true generally provided that $c-b$ is a function of the temperature only and is independent of the pressure. But in order to deduce the values of c by the Joule–Thomson method, it is necessary to assume an empirical formula, and the type $c = c_o(\theta_o/\theta)^n$ is chosen as being the simplest. The justification of this assumption lies in the fact that the values of c found in this manner, when substituted in equation (25) for the saturation-pressure, give correct results for p within the probable limits of error of Regnault's experiments.

§ 13. *Numerical Application to Steam.*—As an instance of the application of the method above described, the results in the table below are calculated for steam, starting from the following fundamental data :—$p = 760$ mm. at $t = 100°$ C. or $373\cdot0°$ Abs. $pV/\theta = 0\cdot11030$ calories per degree for ideal steam. $S_o = 0\cdot478$ calories per degree at zero pressure, $L = 540\cdot2$ calories at 100° C. (Joly-Callendar), $n = 3\cdot33$, $c_{100} = 26\cdot30$ c.c., $b = 1$ c.c., $h = 0\cdot9970t + wL/(v-w)$. 750 mm. *Hg.* = 1 megadyne per sq. cm.

TABLE OF PROPERTIES OF SATURATED STEAM.

Temp. Cent.	Coaggregation, c cub. cms.	Total Heat, H calories.	Latent Heat, L calories.	Specific Heat, S cals/deg.	Saturation-Pressure, p mm. of Hg.
0°	74·43	595·2	595·2	·4786	4·6
20°	58·81	604·7	584·7	·4796	17·6
40°	47·19	614·0	574·0	·4818	55·4
60°	38·68	623·1	563·1	·4860	149·4
80°	31·60	631·9	551·9	·4926	355·0
100°	26·30	640·3	540·2	·5027	760·0
120°	21·93	648·1	527·8	·5163	1490·4
140°	18·73	655·1	514·5	·5347	2715·8
160°	16·00	661·4	500·3	·5571	4647
180°	13·76	666·9	485·3	·5834	7534
200°	11·92	671·6	469·3	·6134	11660

The values of the coaggregation-volume c, which form the starting-point of the calculation, are found by taking $n=10/3$ for convenience of division in formula (13). The unit of heat assumed in the table is the calorie at 20° C., which is taken as equal to 4·180 joules, as explained in the article CALORIMETRY. The latent heat L (formula 9) is found by subtracting from H (equation 15) the values of the heat of the liquid h given in the same article. The values of the specific heat in the next column are calculated for a constant pressure equal to that of saturation by formula (16) to illustrate the increase of the specific heat with rise of pressure. The specific heat at any given pressure diminishes with rise of temperature. The values of the saturation-pressure given in the last column are calculated by formula (25), which agrees with Regnault's observations better than his own empirical formulæ. The agreement of the values of H with those of Griffiths and Dieterici at low temperatures, and of the values of p with those of Regnault over the whole range, are a confirmation of the accuracy of the foregoing theory, and show that the behaviour of a vapour like steam may be represented by a series of thermodynamically consistent formulæ, on the assumption that the limiting value of the specific heat is constant, and that the isothermals are generally similar in form to those of other gases and vapours at moderate pressures. Although it is not possible to represent the properties of steam in this manner up to the critical temperature, the above method appears more satisfactory than the adoption of the inconsistent and purely empirical formulæ which form the basis of most tables at the present time.

A similar method of calculation might be applied to deduce the thermodynamical properties of other vapours, but the required experimental data are in most cases very imperfect or even entirely wanting. The calorimetric data are generally the most deficient and difficult to secure. An immense mass of material has been collected on the subject of vapour-pressures and densities, the greater part of which will be found in Winkelmann's *Handbook*, vol. ii., and in similar compendiums. The results vary greatly in accuracy, and are frequently vitiated by errors of temperature measurement, by chemical impurities and surface condensation, or by peculiarities of the empirical formulæ employed in smoothing the observations; but it would not be within the scope of the present article to discuss these details. Even at the boiling-points the discrepancies between different observers are frequently considerable. The following table contains the most probable values for a few of these points which have been determined with the greatest care or frequency:—

Table of Boiling-Points at Atmospheric Pressure on Centigrade Scale.

Hydrogen	−252°·6	Benzophenone	+305°·8
Oxygen	−182°·8	Mercury	+356°·7
CO_2	−78°·3	Sulphur	+444°·5
SO_2	−10°·0	Cadmium	+756°
Aniline	+184°·1	Zinc	+916°
Naphthalene	+218°·0		

Alphabetical Index of Symbols.

A, B, C,	Empirical constants in formulæ; section (10).
b,	Minimum volume or co-volume of vapour, equation (13).
C,	Concentration of solution, gm. mols. per c.c.
c,	Coaggregation-volume of vapour, equation (13).
D, d,	Density of liquid and vapour.
E,	Intrinsic energy of vapour.
g,	Acceleration of gravity.
H,	Total heat of vapour.
h,	Heat of the liquid; height of capillary ascent.
L,	Latent heat of vaporization.
M,	Modulus of logarithms.
m,	Molecular weight.
n,	Index of θ in expression for c, equation (13).
P,	Osmotic or capillary pressure.
p,	Pressure of vapour.
Q,	Cooling effect in adiathermal expansion.
R,	Constant in gas equation, $pv=R\theta$.
r,	Radius of curvature, formula (1).
S,	Specific heat of vapour at constant pressure.
s,	Specific heat of liquid, equation (23); Specific heat of vapour at constant volume, § 8.
T,	Surface tension of liquid.
t,	Temperature Centigrade.
V,	Ideal volume of vapour, equation (13). Specific volume of solid or liquid, equation (5).
v,	Specific volume of vapour or steam.
w,	Specific volume of water or liquid.
θ,	Temperature on thermodynamic scale.
ϕ,	Entropy of vapour or liquid.

(H. L. C.)

Var, a department of the south-east of France, bordering on the Mediterranean, and crossed by the offshoots of the Alps.

Area, 2334 square miles. Owing to Italian immigration, the population increased from 283,689 in 1886 to 325,490 in 1901. But the births in 1899, numbering 6074, of which 435 were illegitimate, were fewer than the deaths, which amounted to 7044; marriages numbered 2252. The primary schools in 1896 numbered 474, with 34,000 pupils, 4 per cent. of the population being illiterate. There were 1,170,780 acres under cultivation in 1896, but only 350,740 acres were arable and 106,210 acres under vines, most of the remainder being covered with wood. In 1901 the vineyards yielded 29½ million gallons of wine. The wheat grown in 1899 was valued at only £252,000; oats, £24,000; potatoes, £65,000; vines, £1,016,000; chestnuts, £24,200; plums, £2120; mulberry leaves, £14,500. Sericulture produced (1899) 8520 cwt. of cocoons. The live-stock numbered 10,100 horses, 8810 mules, 3450 asses, 2480 cattle, 193,400 sheep, 20,450 pigs, and 14,550 goats. There was mined in 1898, 3300 metric tons of lignite, 5865 tons of iron, which, with sea-salt and other substances, yielded a revenue of £63,000. There are, however, no important furnaces. The industries of consequence are in paper, silk, and soap. Draguignan, the capital, had in 1901, 9671 inhabitants, and Toulon 101,172.

Varese, a town of the province of Como, Lombardy, Italy, 18 miles by rail west of Como and 37 north-west of Milan. It is a well-to-do place, planted in a beautiful situation near the Lake of Varese, and for this reason a favourite autumn resort of the Milanese, who have numerous country houses in the vicinity. The principal church is the basilica of St Victor (originally 7th century; rebuilt 1580–1615 and 1795), to which is attached an ancient baptistery (9th and 13th centuries). There are other churches, an archæological museum, a school of the industrial arts, and a theatre. Varese is the seat of active silk-spinning, tanning, paper-making, and the manufacture of organs and vehicles. Excellent wine is made. Large weekly markets are held. Population (1881), 8877; (1900), about 10,000.

Variation and Selection.—(1) The term *Variation*, as used in biology, means the occurrence of individual animals or plants which differ from the "type" proper to their race or species. The diagnosis of a species given by most systematic zoologists is either an enumeration of characters which distinguish a certain individual called the "type" from members of other known species, or a statement, gained from a study of numerous individuals, of the characters by which all these individuals differ from members of other species. In either case individuals which do not present exactly those characters described in the diagnosis of their species are said to vary. The conception of a specific or racial type, when it is not based upon a single specimen, is seldom clearly defined by zoologists; several possible definitions will be discussed in the next paragraph.

For the purposes of comparative morphology, which endeavours to present the main facts of animal structure in an intelligible form, it is necessary to consider species as if every individual were "typical," since the general facts can only be realized after some such process of simplification. For other purposes, such a treatment of species is altogether inadequate. The production of a regular series of variations, under given environmental conditions, is a property of species as constant as the production of typical individuals, and if we wish to study the relation between a race or species and its environment, or to test any theory of organic evolution, we must know the extent and frequency of such variations, as well as the frequency of the type.

(2) The characters of individual animals or plants depend upon so many complex conditions, most of which are generally unknown to us, that the statements we can make concerning them are of a peculiar kind. We cannot predict with any exactness the characters of a single unborn individual; but if we consider a large number of unborn individuals, we can predict with considerable accuracy the percentage of individuals which will have the mean character proper to their generation, or will differ from that mean character within any assigned limits. So long as we confine our attention to one or two individuals, we fail to detect any order in the occurrence of variations; but when we examine large numbers we find that it is possible to arrange them in an orderly series, which can be easily and simply described. The series, into which we can arrange the results of observing phenomena of complex causation, whether exhibited by living organisms or not, have certain properties in common, which are dealt with by the theory of chance. Many of the properties of such series, and the methods of describing them, are dealt with in the article ERROR, LAW OF (vol. xxiii.); and the frequency with which the mean value or any deviation from the mean value of a character occurs in a race of animals or of plants may probably always be expressed in terms of one or other of the series there described. The theory of chance was applied to the study of human variation by Quetelet; but the most important applications of this theory to biological problems are due in the first instance to Mr Francis Galton, who first used the theory of *correlation* (cf. article ERROR, LAW OF, §§ 7, 8, and 18, 19) in describing the relation between the deviation of one character in an animal body from the mean proper to its race and that of a second character in the same body (correlation as commonly understood), or between deviation of a parent from the mean of its generation and deviation of offspring from the mean of the following generation (inheritance). The conceptions indicated by Mr Galton have been extended and added to by Professor Karl Pearson, who has also developed the theory of chance so as to provide a means of describing many series of complex results in a simpler and more accurate way than was hitherto possible. The great majority of organic variations require for their description the formulæ developed by him and described in the article ERROR, LAW OF, §§ 52–54.

(3) The conception of a race of animals or of plants as a group of individuals capable of being arranged in an orderly series with respect to the condition of a particular character enables us to define the "type" of that character proper to the race. Table I. shows the number of female swine which had a given number of "Müller's glands" on the right fore leg, in a sample of 2000 swine observed by Davenport in Chicago. If we take the whole number of glands in the series, and divide this by the whole number of swine, we obtain the *mean* number of glands per swine. For many purposes this is the most convenient "type" of the series.

TABLE I.

Number of Glands.	Number of Swine.	Number of Glands.	Number of Swine.
0	15	6	134
1	209	7	72
2	365	8	22
3	482	9	8
4	414	10	2
5	277		

Two other ways of determining a "type" will be obvious by reference to the diagram, Fig. 1, in which the observed results are recorded by the thick continuous line, and the form of Pearson's "generalized probability curve" best fitted to represent them by a dotted line. The ordinate of the dotted curve which contains its "centre of gravity" has, of course, for its abscissa the "mean" number of glands; the maximum ordinate of the curve is, however, at 2·98, or sensibly at 3 glands, showing what Pearson has called the "modal" number of glands, or the number occurring most frequently. The ordinate which divides the area of the dotted curve into two equal areas is the *median* of Galton: it lies in this case nearly at 3·38 glands. The best simple measure of the frequency of deviations from the mean character is the "standard deviation" or "error of mean square" of the system (see article PROBABILITY), in this case equal to 1·68 glands.

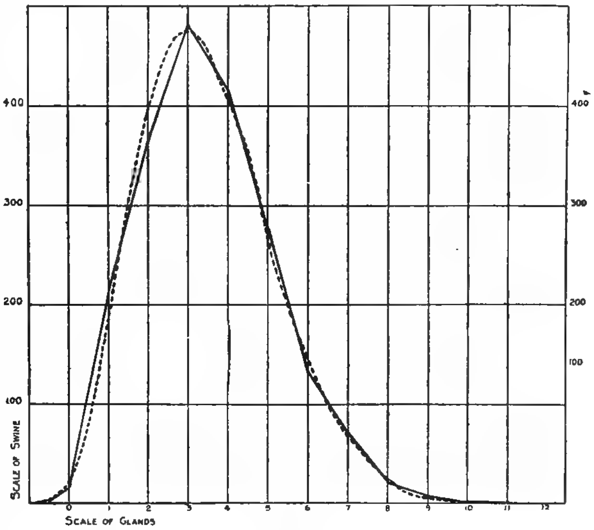

Fig. 1

In cases of nearly symmetrical distribution about the mean, the three "types," the mean, the median, and the mode, may sensibly coincide. For example, in Powis's table of the frequency of statures in male Australian criminals between 40 and 50 years of age (*Biometrika*, vol. i., part 1, p. 41), the mean stature is 66·91 inches, the modal 66·96 inches, the median lying between the two. In other cases the difference between the three may be considerable. As an example of extreme asymmetry we may take De Vries's record of the frequency with which given numbers of petals occur in a certain race of buttercups. Pearson has shown (*Phil. Trans.*, A., 1893) that this frequency may be closely represented by the curve whose equation is

$$y = 0{\cdot}211225x^{-0{\cdot}332}(7{\cdot}3253 - x)^{3{\cdot}142}.$$

The curve, and the observations it represents, are drawn in Fig. 2. The two are compared numerically in Table II. Here the mode is at 4·5 petals, the mean at 5·6 petals, the median lying of course between the two.

TABLE II.

Numbers of petals .	5	6	7	8	9	10	11
Frequency observed	133	55	23	7	2	2	0
Frequency given by Pearson's curve .	136·9	48·5	22·6	9·6	3·4	0·8	0·2

The distributions represented in Figs. 1, 2, and 3 may be taken as examples of three common forms of series into which the individuals of a race may be arranged with respect to a single character; a comparison of the three will show how little can be learnt from a mere statement of racial type, without some knowledge of the way in which deviations from the type are distributed.

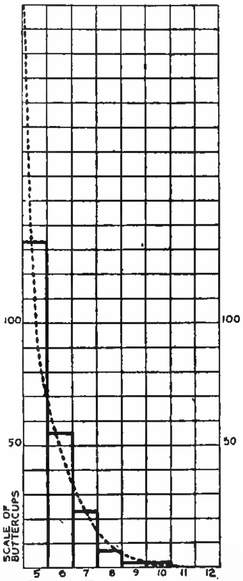

Fig. 2.

(4) The variability of structures which are repeated in the body of the same individual (serial homologues) has been studied by Pearson and his pupils with important results. The simplest of such repeated elements are the cells of the tissues, more complex are cell-aggregates, from hairs, scales, teeth, and the like, up to limbs or metameres in animals, or the leaves and their homologues in plants. Serially homologous structures, borne on the same body, are commonly differentiated into sets, the mean character of a set produced in one part of the body, or during one period of life, differing from the mean character of a set produced in a different region or at a different time. Such differentiation may be measured by determining the correlation between the position or the time of production and the character of the organs produced, the methods by which the correlation is measured being those described in the article ERROR, LAW OF. An excellent example of structures differentiated according to position is given by the appendages borne on the stem of an ordinary flowering plant—the one or two seed leaves; the stem leaves, which may or may not be differentiated into secondary sets; and the various floral organs borne at the apex of the stem or its lateral branches. The change which often occurs in the mean character and variability of the flowers produced at different periods of the flowering season by the same plant is an example of differentiation associated with time of production; as this kind of differentiation is less familiar than differentiation according to the region of production, it may be well to give an example. In a group of plants of *Aster prenanthoides*, examined by Shull (*American Naturalist*, xxxvi., 1902), the mean number of bracts, ray-florets, and disc-florets, and the standard deviation of each, was determined on four different days, with the following result:—

TABLE III.

	Sept. 27.	Sept. 30.	Oct. 4.	Oct. 8.
Mean No. of bracts .	47·41	44·34	43·83	41·92
Standard deviation .	5·52	5·15	5·28	4·89
Mean No. of ray-florets .	30·77	28·71	28·25	26·34
Standard deviation .	3·99	3·57	3·50	3·01
Mean No. disc-florets .	56·43	51·71	49·16	45·78
Standard deviation .	3·99	4·99	4·88	4·78

Notwithstanding this differentiation, the mean character of a series of repeated organs is often constant through a considerable region of the body or a considerable period of time; and the standard deviation of an "array" of repeated parts, chosen from such an area, or within such limits of time, may be taken as a measure of the individual variability of the organism which produces them. If such an array of repeated organs be chosen from the proper region of the body, within proper limits of time, in each of a large series of individuals belonging to a race, and if all the arrays so chosen be added together, a series will be formed from which the *racial variability* can be determined. Thus a series of arrays of beech leaves, gathered, subject to the precautions indicated, from each of 100 beech trees in Buckinghamshire by Professor Pearson, gave 16·1 as the mean number of veins per leaf, the standard deviation of the veins in the series being 1·735. The number of leaves gathered from each tree was 26, and the frequency of leaves with any observed number of veins in the whole series of 2600 leaves was as follows:—

TABLE IV.

No. of veins .	10	11	12	13	14	15	16	17	18	19	20	21	22
No. of leaves .	1	7	34	110	318	479	595	516	307	181	36	15	1

The whole series contains 2600 leaves. If a leaf from this series be chosen at random, it is clearly more likely to have sixteen veins than to have any other assigned number; but if a first leaf chosen at random should prove to have some number of veins other than sixteen, a second leaf, chosen at random from the same series, is still more likely to have sixteen veins than to have any other assigned number. If, however, a series of leaves *from the same tree* be examined in pairs, the fact that one leaf from the tree is known to possess an abnormal number of veins makes it probable that the next leaf chosen from the same tree will also be abnormal, or in other words, the fact that leaves are borne by the same tree establishes a correlation between them. Professor Pearson has measured this correlation. Taking each leaf of his series, with an assigned number of veins, he has determined the array of pairs of leaves which can be formed by pairing the chosen leaf with all others from its own tree in succession. The pairs so formed were collected in a table, from which the correlation between the first leaf and the second leaf of a pair, chosen from one tree, could be determined by the methods indicated in the article ERROR, LAW OF. The mean and standard deviation of all first leaves or of all second leaves will clearly be the same as those already determined for the series of leaves; since every leaf in the series is used once as a first member and once as a second member of a pair. The coefficient of correlation is 0·5699, which indicates that the standard deviation of an array is equal to that of the leaves in general multiplied by $\sqrt{1-(0{\cdot}5699)^2}$; and performing this multiplication, we find 1·426 as the standard deviation of an array. The variability of an array of such a table—that is, of any line or column of it—is the mean variability of pairs of leaves, each pair chosen from one tree, and having one leaf of a particular character; it may therefore be taken as a fair measure of the variability of such a tree. We see therefore that while leaves, gathered in equal numbers from each of 100 trees, are distributed about their mean with a standard deviation of 1·735 veins, the leaves gathered from a single tree are distributed about their mean with a standard deviation of 1·426 veins, the ratio between variability of the race and variability of the individual tree being $\sqrt{1-(0{\cdot}5699)^2}=0{\cdot}822$.

The correlation between undifferentiated sets of serial homologues, produced by a single individual, is the measure of what Pearson has called homotyposis. In an elaborate memoir on the homotyposis in plants (*Phil. Trans.*, vol. 197 A., 1901), from which the foregoing statements about beech leaves are taken, Pearson has given the correlation between such sets of organs in a large number of plants: he and his pupils have subsequently determined the correlation between structures repeated in the bodies of individual animals. The results obtained are sometimes puzzling, because it is sometimes difficult to choose the whole series of structures observed from a region of the body which is not affected by differentiation. In spite of this difficulty, however, the values of the correlation coefficients so far obtained cluster fairly well round the mean value of all of them, which is almost exactly $\frac{1}{2}$. From this result it follows (see ERROR, LAW OF) that the standard deviation of the array, which we have taken as a measure of individual variability, is equal to the standard deviation of the race multiplied by $\sqrt{1-\left(\frac{1}{2}\right)^2}$ or by $\frac{\sqrt{3}}{2}$. These results cannot be accepted as final, but they are based on so many investigations of animals and plants, of such widely different kinds, that they may confidently be expected to hold for large classes of organic characters. We may therefore conclude that for large classes of characters, both animal and vegetable, the variability of an individual, as measured by the standard deviation of its undifferentiated but repeated organs, is a constant fraction of the variability of its race, as measured by the standard deviation of the corresponding series of organs produced by all the individuals of its race.

(5) Among the most important structures produced in repeated series are the reproductive cells; and Pearson points out that if the variability of animals or of plants be supposed to depend upon that of the germ-cells from which they arise, then the correlation between brothers in the array produced by the same parents will give a measure of the correlation between the parental germ-cells, the determination requiring, of course, the same precautions to avoid the effects of differentiation as are necessary in the study of other repeated organs. After a large series of measurements, involving the most varied characters of human brothers, Pearson has shown that the correlation has a value very nearly equal to $\frac{1}{2}$; so that the variability of human children obeys the same law as that of other repeated structures, the standard deviation of an array, produced by the same parents, having an average value equal to the standard deviation of the whole filial generation multiplied by $\sqrt{1-\left(\frac{1}{2}\right)^2}$ or by $\frac{\sqrt{3}}{2}$. Such measurements of fraternal correlation in the lower animal as Pearson and his pupils have at present made give values very close to $\frac{1}{2}$. The evidence that the correlation between sexually produced brethren is the same as that existing between the asexually repeated organs on an individual body renders it impossible to accept Weismann's view that one of the results produced by the differentiation of animals and plants into two sexes is an increase in the variability of their offspring. Warren has lately shown by direct observation that the correlation between brothers among the broods produced parthenogenetically by one of the *Aphides* has a value not far from the $\frac{1}{2}$ observed in sexually-produced brethren (*Biometrika*, vol. i. 1902); he has obtained a fairly concordant result for the broods of parthenogenetic *Daphnia* (*Proc. Roy. Soc.*, vol. lxv. 1899). Finally, Simpson has measured the correlation between the pairs of young produced by the simple asexual division of *Paramœcium* (*Biometrika*, vol. i. part 4, 1902), and after some necessary corrections the value he obtains is 0·56, a value which probably does not, if we remember the difficulties of the inquiry, differ very significantly from $\frac{1}{2}$. There is therefore in a large class of cases an indication that the variability of an array of brethren, produced either sexually or asexually, is a constant fraction of the variability of the race to which the brethren belong.

(6) The subject of *inheritance* is beyond the scope of the present article. It must, however, be pointed out that the constancy in the variability of arrays of brethren, indicated in the last paragraph, determines a limit below which the variability of a race cannot be reduced by any process of selecting parents. In the large number of cases investigated by Pearson and his pupils, in which the Galton-Pearson law of inheritance holds, it is possible to produce a permanent change in the mean character of the race by selecting parents through only a very small number of generations; but such a process of selection, indefinitely continued, will not reduce the variability of any generation below a fixed limit, given by the measure of fraternal variability. In many of the domestic races of plants and animals, produced by selection, the mean character of any large number of individuals is constant, but the characters of small numbers of individuals cannot be predicted with accuracy. These "unfixed varieties" are examples of races in which the fraternal variability is high. Among wild races of animals the existence of a high fraternal variability may lead to what Pearson has called "periodic selection." Thus in some races of the genus *Clausilia* the characters of the shell are subject to selection so stringent that only individuals with shells which closely approach the mean character of their race can become mature and breed. The mean character of the shell, in the young produced by these individuals, is identical with the mean character of the parental shells; but the fraternal variability is so high that each successive generation contains a number of abnormal forms which are destroyed during growth by a selective process which reduces the variability of the race without changing its mean character (cf. *Biometrika*, No. i., 1901).

(7) *Selection* and its results can only be adequately studied in those cases which admit of statistical tabulation. In any race of animals, the number of young produced in a season is almost always greater than the number which survives to attain maturity; it is not certain that every one of those which become mature will breed, and not all of those which breed contribute an equal number of offspring to the next generation. At every stage some individuals are prevented from contributing to the next generation, and if the continual process of elimination affects individuals possessing any one character more strongly than it affects others, so that a relation is established between individual character and the chance of producing a certain number of young, selection is said to occur.

We may distinguish broadly two ways by which such selective elimination of individuals from the number of those who contribute to the next generation may occur, namely, a *differential destruction*, which prevents certain classes of individuals from breeding by killing them, and a series of processes leading to *differential fertility* among the survivors, without necessarily involving any differential death-rate. A third form of selection, which may affect the composition of the next generation without of necessity involving a differential death-rate or a differential fertility, is *assortative mating*, or the tendency of those members of one sex which exhibit a particular character to mate only with members of the other sex which exhibit the same or some other definite character.

Differential fertility may be induced in either of two ways. Individuals may not be able to pair, unless they possess a character which is absent, or insufficiently developed, in some members of the race. The kind of selection involved may then be measured by comparing those animals which pair with the general body of adults. This is what Darwin especially intended to denote by the term "sexual selection." Or, again, individuals of certain character may be able to pair, but the fertility of their union may not be the same as that of unions between individuals with other characters. This kind of selection, called by Pearson "reproductive" or "genetic" selection, may be measured by finding the correlation between the characters of the individuals which pair and the number of young produced. [For an attempt to treat the whole problem of differential fertility and assortative mating numerically see Pearson, *The Grammar of Science*, 2nd edition, London, 1900.]

Assortative mating exists when individuals which mate are not paired at random, but a definite correlation is established between the characters of one mate and those of the other. This kind of selection is measured by the correlation between deviation of either mate from the type, and deviation of the other. Pearson has shown that Galton's function has a value of 0·28 for stature of middle-class Englishmen and their wives.

(8) The problems which arise when we attempt to discover whether any existing species is being maintained or modified by a process of natural selection can only be solved by methods, such as those indicated in the preceding paragraphs, capable of giving numerical results. For this reason those cases in which the facts of variation, correlation, and inheritance can be numerically expressed have been treated at some length. It must not, however, be forgotten that many classes of variation exist which cannot at present be numerically described by any known formula. Among variations which have not yet been properly formulated are numerous cases of dimorphism, in which the variations in the same sex vary about two modes. Such cases are especially common in variations of secondary sexual characters. Many of these can probably be formulated as cases of "alternative" inheritance, and treated by the methods which express the facts of dimorphism in the colour of human eyes (*cf.* Galton, *Natural Inheritance*, and Pearson, *Proc. Roy. Soc.*, lxvi.).

Numerous cases of variation are on record, especially among domestic animals and plants, which are said to have appeared suddenly, and in such a way that they cannot be shown to form parts of orderly series, of the kind described in previous paragraphs. The origin of many domestic races is ascribed to such "sports." The evidence concerning these is seldom sufficient, in the judgment of the present writer, to make discussion of them profitable. They are, no doubt, sometimes the extreme terms of orderly series, in which the other terms have not attracted the attention of breeders; their alleged frequency among animals and plants of mixed ancestry suggests that they are often due to "alternative" or to "particulate" inheritance; and a proper study of such cases involves a knowledge of the circumstances which determine whether inheritance is "particulate," or "alternative," or "blended." Many cases of bud variation in plants are doubtless cases of alternative inheritance. It would be impossible to describe these variations without discussing a great body of unsatisfactory evidence in each case separately. They are mentioned here to show that the process of formulating variations, in such a way that our knowledge can be applied to the problem of organic evolution, or to other problems of binomics, has not yet gone so far as to include, even approximately, all the phenomena observed.

(9) The theory of natural selection as the great factor in organic evolution, enunciated by Darwin, is essentially a statistical theory, resting upon three main conceptions: (1) the regular occurrence among all animals and plants of an orderly series of variations, capable of being formulated in the manner already alluded to; (2) the existence of a correlation between structure and fertility, or between structure and death-rate; (3) the existence of a correlation between structure in parents and structure in their offspring. These three factors—Variation, Selection, and Inheritance—must be studied statistically in a large number of cases before the true value of Darwin's theory can be ascertained. A fertile source of misconception has hitherto been the habit of testing the theory of natural selection by our power of imagining an obvious use for the characters of animals which undoubtedly survive; and the validity of the theory has been largely made a question of our power to recognize the "adaptive" or "useful" nature of specific characters. In our present condition of ignorance concerning the function of any organ in the great majority of animals, it is evident that our theories of their utility must often be erroneous or imperfect: the only really adequate test of such theories is the statistical test whether individuals which deviate from the type we consider useful or adaptive do in fact die more rapidly, or leave fewer descendants, than others which conform more nearly to our idea of what is useful; but if we know that such a correlation between structure and death-rate, or between structure and fertility, actually exists, we know that a form of natural selection is at work; and although the question of the physiological process by which this is brought about is one of the highest interest, it is of no importance as proof that the observed selection exists. A branch of biology is slowly but surely growing up which attempts to deal with Darwin's theory from a purely numerical standpoint. For the purposes of this new science, organisms may be considered simply as series of parts of variable magnitude, the functions of these parts, as ordinarily understood, being neglected. The variability of each organ, the correlation between change in the magnitude of any one or more organs and change in the others, may be formulated by the methods indicated in the article ERROR, LAW OF, and the statements so made, for any species, embody that knowledge of variation which is the first necessity of the theory. Such knowledge being obtained, the next step is to formulate in the same way the correlation between change of structural character and change in death-rate or in fertility, thereby expressing the facts of selection. Finally, the numerical statement of correlation between organic structure in ancestors and in offspring constitutes the necessary and sufficient statement of inheritance. All these statements are purely numerical, and involve no physiological or morphological theory whatever. They are in themselves a sufficient statement of the facts of evolution; but they are also, on the one hand, the only means by which any physiological theory of selection or of inheritance can be judged, while, on the other, the knowledge that a particular character of unknown function is in fact associated with an increase or decrease in death-rate or fertility, affords a powerful stimulus to physiological inquiry. The hope of an ultimate answer to the questions which arise when we attempt to formulate a theory of organic evolution lies in the co-operation of workers pursuing two lines of inquiry, one purely statistical, one purely physiological, each in turn testing the hypotheses of the other, and suggesting new and wider fields of work. (W. F. R. W.)

Variation of an Integral.—It was inevitable that the ideas and methods of the Calculus of Variations should be subjected to the same kind of criticism as has been applied during the last half-century to other branches of mathematical analysis. In the foundations of analysis, and in many of its developments, the outcome of this critical process has been, on the one hand, a gain in logical precision, and, on the other hand, the achievement of new points of view and new results. A critical examination of the Calculus of Variations was made by P. du Bois Reymond, and the reformulation of the subject was undertaken by Weierstrass. The methods used by the latter and the results obtained by him were communicated to students in his lectures; from this source the new theory has spread over Europe and America, and its advance has been facilitated by the appearance of a small number of monographs dealing in accordance with Weierstrassian ideas with particular problems of a general character. To this category belong the memoirs of Kobb and Zermelo. Other analysts—Mayer, Scheefer, Kneser—working on independent lines, have sought to make the methods of the calculus more rigorous. It is the purpose of this article to give some account of the methods and results of modern investigations in the simpler parts of the subject.

1. *Nature of the Problems.*—All the problems of the Calculus of Variations are of geometrical or mechanical origin: thus we may inquire concerning the shortest line between two points in a plane or on a given surface, the surface of maximum area with given volume, the course of a system for which the action is a minimum, and so on. In all cases the answer to the question will lie in the determination of one or more functions to satisfy certain conditions, of which one is that an integral involving these functions and one or more of their differential coefficients is to be a maximum or minimum. The nature of the problem itself imposes a restriction on the character of the function, if there is one, that can be the answer to the question; for the question is one concerning a curve, or a course of motion, or some other geometrical or mechanical object, and the function that yields the answer to the question must accordingly be suitable for the representation of objects of the kind sought. We have thus to find a function for the purpose of finding something that is not a function. It is, accordingly, necessary at the outset to recall, or, it may be, to reformulate, the analytical restrictions to be imposed on functions in order that they may be suitable for the purpose in hand. Another consideration of great importance is that there is a distinction between a "greatest value," a "maximum," and a "superior limit," and between a "least value," a "minimum," and an "inferior limit"; and it is necessary to state with precision what is meant by a maximum or minimum of a quantity which is expressed as the integral of an unknown function through an imperfectly known domain.

2. *Limitation of the Problems. The First Problem.*—We shall restrict ourselves for the present to questions relating to curves joining fixed points; and then, regarding x and y as the co-ordinates of a point of a curve, and writing y' for dy/dx, we shall deal with questions in which the variable magnitude to be made a maximum or minimum is of the kind that can be represented by the line-integral

$$\int F(x, y, y')dx \quad . \quad . \quad . \quad (1)$$

taken along a curve joining the two fixed points. The function F must be such that this integral has a definite meaning. The only differential coefficient involved in F is of the first order. The form (1) is free from ambiguity when the curve is such that y is a one-valued function of x; but we can have no guarantee beforehand that this will be the case for the curve sought. To avoid this difficulty we define a curve, not by a functional relation between its co-ordinates, but by relations between the two co-ordinates and a variable parameter θ. We write

$$x=\phi(\theta),\ y=\psi(\theta),$$

and then the integral to be considered takes the form

$$\int f(x, y, \dot{x}, \dot{y})d\theta, \quad . \quad . \quad (2)$$

where $\dot{x}$ and $\dot{y}$ are the differential coefficients of x and y with respect to θ, and the function f is homogeneous of the first degree (but not necessarily rational) in $\dot{x}$ and $\dot{y}$. The function f is assumed to be an analytic function of its four arguments.

The restrictions imposed on θ, $\phi(\theta)$, $\psi(\theta)$ are, then, as follows:—

(i.) Two fixed values, θ_0 and θ_1, of the parameter θ are chosen to correspond to the two fixed points. The integral takes the form

$$\int_{\theta_0}^{\theta_1} f(x, y, \dot{x}, \dot{y})d\theta,$$

and we shall suppose $\theta_1 > \theta_0$. The fixed point corresponding to θ_0 will be regarded as the "initial point" of the curve.

(ii.) The functions $\phi(\theta)$ and $\psi(\theta)$ take given values when θ takes the values corresponding to the fixed points.

(iii.) The functions $\phi(\theta)$ and $\psi(\theta)$ are one-valued and continuous throughout the interval between θ_0 and θ_1.

(iv.) The interval can be divided into a finite number of partial intervals within each of which the functions $\phi(\theta)$ and $\psi(\theta)$ are monotonous (cf. FUNCTIONS OF REAL VARIABLES, § 8).

(v.) The interval can be divided into a finite number of partial intervals within each of which the functions $\phi(\theta)$ and $\psi(\theta)$ have finite and continuous differential coefficients of the first order with respect to θ, and at a junction of two such partial intervals these functions have finite progressive and regressive differential coefficients.

The conditions (iii.), (iv.), and (v.) define analytically what is meant by a plane "curve," but an additional restriction is necessary if the curve is to be determined by differential equations, as in the methods that have been devised for the solution of questions of the kind proposed. The functions of a parameter, by means of which the co-ordinates of a point on a curve can be expressed, when the curve is determined by a differential equation, are *analytic* functions, or are such as can be expanded by Taylor's series in the neighbourhood of all but certain "singular" values of the parameter. We accordingly assume—

(vi.) The interval between the end-values of θ can be divided into a finite number of partial intervals, within each of which the functions $\phi(\theta)$ and $\psi(\theta)$ are analytic and without singularities.

Corresponding to each such partial interval we have an arc of an "analytic curve," and the conditions (iii.), (iv.), (v.), and (vi.) may be expressed in the form that the curve sought is either an analytic curve or consists of a finite number of arcs of analytic curves. In what follows we shall restrict the sense of the word "curve" in this way. In accordance with (v.) such a curve may present points of discontinuity of direction.

We suppose that one curve has been drawn between the fixed points A and B, and consider any point P of this curve to be displaced to a new position P′, in such a way that the locus of the point P′ is a curve joining A and B. For this it is necessary that the co-ordinates of

P′ should be expressible in terms of the parameter θ by functions subject to the same restrictions as those which express the co-ordinates of P, or the locus of P′ must be made up of a finite number of arcs of analytic curves. The locus of P′ is described as a *variation* of the locus of P, or as a *varied curve.* We may form the integral such as (2) for the locus of P′ instead of the locus of P, and then the excess of the value of the integral along the varied curve above its value along the original curve is a *variation of the integral.* The displacement is said to be small if the distance between any point P and the corresponding point P′ is everywhere less than some given small distance ϵ. If the curve locus of P has been so chosen that it is possible to find a value of h, which has the property that the variation of the integral is positive (negative) for all values of ϵ which are less than h, then the integral along the locus of P is a minimum (maximum). Thus a *maximum* is a greatest value for all curves derived from the one in question by *sufficiently small displacements.* Similarly for a minimum. The point for point correspondence of the original curve and the varied curve is not essential. When the integral taken along the original curve is, as above, a maximum (minimum) then it is possible to mark off a simply connected region of the plane, containing this curve, and such that the integral is greater (less) for this curve than for any other curve joining the same two points and lying entirely within the region.

The variation of the integral is now formed as follows:—We replace x and y by $x+\xi$ and $y+\eta$, where ξ and η are functions of the parameter θ, which vanish at the end-values of θ, and obey the restrictions previously laid down; then the variation is

$$\int_{\theta_0}^{\theta_1} f(x+\xi,\ y+\eta,\ \dot{x}+\dot{\xi},\ \dot{y}+\dot{\eta})d\theta - \int_{\theta_0}^{\theta_1} f(x,\ y,\ \dot{x},\ \dot{y})d\theta,$$

and we seek to determine x and y as functions of θ, so that this expression may be one-signed for all functions ξ, η, which obey the stated restrictions and are less than some fixed sufficiently small number.

3. In attempting the solution of the question thus proposed, which may be called the *First Problem of the Calculus of Variations*, there are two matters to which attention must be directed. The first is that if any curve can be found which possesses the required property, then every part of the curve possesses the same property. Suppose that a particular curve has been found joining two points A and B, and having the property that a certain geometrical magnitude expressed by an integral of the form in question is a minimum for that curve, and let P and Q be any two points on the curve between A and B; then the part of the curve between P and Q is a curve joining P and Q which has the property that the corresponding geometrical magnitude is a minimum for that curve.

The other preliminary remark to be made is that, if any (admissible) functions are chosen to represent the displacements ξ, η from the original curve to the varied curve, and a condition that the variation of the integral may be one-signed for that particular kind of displacement is deduced, this condition is a necessary condition which must be satisfied if the magnitude represented by the integral is a maximum or minimum. It may happen that a curve can be found for which the variation of the integral is one-signed for some kinds of displacement, but not for others, however small they may be; when this is the case the magnitude represented by the integral is a maximum or minimum for some displacements, but not for all admissible ones. The only restriction to which the functions that can represent admissible displacements are subject are (α) those necessary to secure that the locus of the displaced points is a curve, and (β) that the integral has a meaning for the varied curve.

4. *Stationary Curves.*—We choose in the first place displacements ξ, η, which can be expressed in the forms

$$\xi=\kappa u, \quad \eta=\kappa v,$$

where κ is a positive number which can be taken as small as may be wished, and u and v are independent of κ, and, besides satisfying the conditions previously laid down, have their first differential coefficients continuous throughout the interval of integration. This additional restriction of the displacements may be stated in the form that no discontinuity of direction is introduced by the displacement; when the original curve presents no such discontinuity the varied curve has the same property; when the displacement is small the tangents to the original curve and the varied curve at corresponding points are nearly parallel.

With these displacements the variation of the integral takes the form

$$\kappa\int_{\theta_0}^{\theta_1}\left(\frac{\partial f}{\partial x}u+\frac{\partial f}{\partial y}v+\frac{\partial f}{\partial \dot{x}}\dot{u}+\frac{\partial f}{\partial \dot{y}}\dot{v}\right)d\theta+\kappa(\kappa)_2, \quad . \quad (1)$$

where $(\kappa)_2$ denotes an expression which has zero for its limit when κ is indefinitely diminished. The term in κ is called the *first variation* of the integral, and, in consequence of the conditions restricting u and v, it may be transformed by integration by parts into

$$\kappa\int_{\theta_0}^{\theta_1}\left\{\left(\frac{\partial f}{\partial x}-\frac{d}{d\theta}\frac{\partial f}{\partial \dot{x}}\right)u+\left(\frac{\partial f}{\partial y}-\frac{d}{d\theta}\frac{\partial f}{\partial \dot{y}}\right)v\right\}d\theta.$$

It then appears that the variation of the integral cannot be one-signed unless x and y satisfy the differential equations

$$\left.\begin{aligned}\frac{d}{d\theta}\frac{\partial f}{\partial \dot{x}}-\frac{\partial f}{\partial x}=0,\\ \frac{d}{d\theta}\frac{\partial f}{\partial \dot{y}}-\frac{\partial f}{\partial y}=0.\end{aligned}\right\}, \qquad (2)$$

Further, these equations are not independent, but we have

$$\begin{aligned}\frac{1}{\dot{y}}\left(\frac{d}{d\theta}\frac{\partial f}{\partial \dot{x}}-\frac{\partial f}{\partial x}\right)&=\frac{1}{\dot{x}}\left(\frac{d}{d\theta}\frac{\partial f}{\partial \dot{y}}-\frac{\partial f}{\partial y}\right)\\ &=\frac{\partial^2 f}{\partial x\partial \dot{y}}-\frac{\partial^2 f}{\partial y\partial \dot{x}}+f_1(\dot{x}\ddot{y}-\dot{y}\ddot{x}),\end{aligned}$$

where

$$f_1=\frac{1}{\dot{y}^2}\frac{\partial^2 f}{\partial \dot{x}^2}=\frac{1}{\dot{x}^2}\frac{\partial^2 f}{\partial \dot{y}^2}=-\frac{1}{\dot{x}\dot{y}}\frac{\partial^2 f}{\partial \dot{x}\partial \dot{y}}; \quad . \quad . \quad (3)$$

all these relations arise from the fact that $f(x, y, \dot{x}, \dot{y})$ is homogeneous of the first degree in $\dot{x}$ and $\dot{y}$, and we have in particular another form of the differential equation, viz.,

$$\frac{\partial^2 f}{\partial x\partial \dot{y}}-\frac{\partial^2 f}{\partial y\partial \dot{x}}+f_1(\dot{x}\ddot{y}-\dot{y}\ddot{x})=0 \quad . \quad . \quad (4)$$

The equations (2) and (4) are thus a single differential equation connecting x and y, and this is the same as the equation

$$\frac{d}{dx}\frac{\partial F}{\partial y'}-\frac{\partial F}{\partial y}=0 \quad . \quad . \quad . \quad (5)$$

that would be found by taking the integral in the form (1) of § 2 instead of the form (2) of the same §. It is thus the differential equation of a family of curves, and, being of the second order, a solution can in general be found which represents a curve passing through two given points.

The curves which satisfy the differential equation are known as the *stationary curves* of the integral, and the differential equation is known as the *principal equation.* We have the result that the integral cannot be a maximum or minimum unless every analytic arc of the curve is an arc of a stationary curve.

5. *Condition relative to Points of Discontinuity.*—A stationary curve would be determined if one point on it and the tangent at that point were given, and thus, if the curve sought really consists of arcs of different stationary curves, the junction of two such arcs is a point of discontinuity of direction. The possibility of such a solution of the maximum-minimum problem is restricted by a

condition which can be readily found by adopting a particular type of displacement. If P is a point where two arcs of stationary curves meet, we may choose the functions u and v in such a way that they vanish everywhere except for a very short segment of the curve containing the point P, and then it appears that the variation of the integral cannot be one-signed unless the two arcs meeting at P are such that $\partial f/\partial\dot{x}$ and $\partial f/\partial\dot{y}$ are continuous at that point P, where $\dot{x}$ and $\dot{y}$ (or one of the two) are discontinuous. This condition precludes in most cases the possibility of such points of discontinuity.

As an example we will consider the problem: To find a curve joining two fixed points, which, by revolution about a straight line, in a plane containing the points, traces out a surface of minimum area —— Taking the fixed line as axis of x, the integral to be made a minimum is

$$\int y\sqrt{(\dot{x}^2+\dot{y}^2)}d\theta\,;$$

and the principal equation is

$$\frac{d}{d\theta}\;\frac{y\dot{x}}{\sqrt{(\dot{x}^2+\dot{y}^2)}}=0.$$

The stationary curves are the axis of x, straight lines parallel to the axis of y, and catenaries of the family

$$y=c\cosh\frac{x-a}{c},$$

where a and c are arbitrary constants. The condition stated above shows that the broken line ACDB is the only "curve" with points of discontinuity of direction for which the first variation vanishes. For example, a broken line like AA′B′B is excluded.

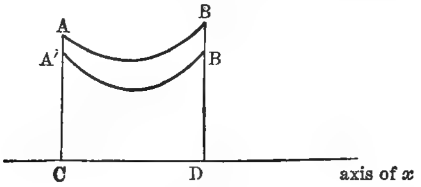

Fig 1

6. *Conjugate Points.*—The conditions obtained from the consideration of the first variation are necessary to secure that the integral is a maximum or a minimum, but they are not sufficient. Until recently attempts to ascertain whether the integral along a stationary curve really possesses the maximum-minimum property were directed exclusively to the determination of the conditions under which the terms in κ^2 in the development of (1) § 4 are necessarily positive or necessarily negative. These terms are known as the *second variation*, and the problem of the transformation of the second variation to a shape in which its sign can be determined by inspection has attracted a great deal of attention. The investigation of this problem by Jacobi led to a very important discovery. Suppose that we consider all the stationary curves of the integral which start from the point A, and that one of them has been found which passes through B; we take this as the original curve. Then, however small a distance ϵ we choose, we can find an infinite number of stationary curves which run so near to the original curve between A and B that the segments they cut off on the normals to that curve are all less than ϵ; such curves may be called *neighbouring stationary curves.* In general, if B is not too distant from A, none of these curves cuts the original curve between A and B; but if any one of them does so, then the point of intersection tends to a limiting position, A′, when ϵ is diminished indefinitely. The point A′ is defined to be the point *conjugate* to A for the curve, and the relation between the points A and A′ is a reciprocal one. The locus of the points such as A′ on different stationary curves starting from A is part of the envelope of this family of curves, and thus A′ is a point of contact of the original curve with the envelope of this family. For any integral of the form under consideration, there is a family of stationary curves, and those which start from a given point have an envelope (which may reduce to the point). When the envelope does not reduce to the initial point it touches any curve of the family in one or more points. If there is one such point distinct from the initial point, it is the point conjugate to the initial point for the curve; if there are two or more of such points, any two of them, between which there is not another, are a pair of conjugate points. It is essential to observe that, if A and A′ are a pair of conjugate points, and P is any point on the curve between them, the arc AA′ does not contain the point conjugate to P; in other words, as A moves along the curve in either sense A′ moves along it in the same sense. We have the theorem:—The integral taken along the stationary curve between A and B is neither a maximum nor a minimum if A and B are conjugate points, or if there is a pair of conjugate points between A and B.

The most familiar examples are antipodal points on a sphere, which are conjugate for the geodesics on the sphere, and the conjugate foci of geometrical optics. In the application of the principle of least action in dynamics, situations of a system which correspond to conjugate points are known as "kinetic foci" (see DYNAMICS, ANALYTICAL, § 7). As another example let us consider the minimal surface formed by revolving a catenary about its directrix, referred to in § 5. Through any point A we can draw catenaries having the axis of x as directrix, and these are stationary curves for the problem; the point conjugate to A for any catenary is the point of contact of the second tangent that can be drawn to that catenary from the point where the tangent at A meets the directrix (Fig. 2). It can be shown that, if one catenary with a given directrix can be drawn to pass through two given points A, B, then another can generally be drawn, and the tangents to one of them at A and B meet on the nearer side of the directrix, and the tangents to the other on the remoter side; thus there are two stationary curves of the catenary family joining the two points, but one of them does not trace out a surface of which the area is a true minimum. Further, it can be shown that, if the tangents at A and B to one catenary intersect on the directrix, there is not a second catenary. If no catenary with the given directrix can be drawn to pass through A and B, there cannot be a minimal surface of the kind sought unless the broken line ACDB of Fig. 1 § 5 can be regarded as the meridian curve of such a surface.

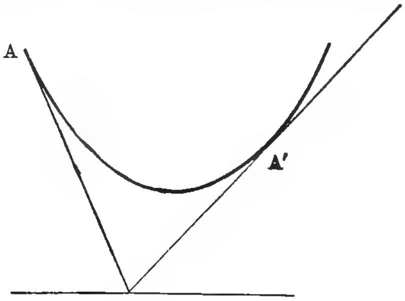

Fig 2

W. F. Osgood (*Amer. Math. Soc. Trans.* ii. p. 166, 1901) has called attention to an exceptional case, in which the integral taken along a stationary curve between two points A and B is a minimum, although A and B are conjugate points. An example is afforded by the equatorial geodesic curve of an oblate spheroid.

7. In the general problem, when there is a stationary curve joining the two fixed points A, B, and the point conjugate to the initial point A does not lie on the arc AB between the fixed points, it can be shown that the second variation of the integral is or is not one-signed, according as the function f_1 of § 4 is or is not one-signed along the curve; if f_1 is positive (negative) at all points of the curve the second variation is positive (negative), and the integral is a minimum (maximum) for displacements of the type considered in § 4. When the integral is taken in the

form $\int F(x, y, y')dx$, the corresponding condition is that

$$\frac{\partial^2 F}{\partial y'^2}dx$$

is positive (negative) for a minimum (maximum).

8. *The Excess Function.*—All the results which we have considered are obtained by subjecting the displacements of a point on the original curve to the condition stated in § 4. We proceed to explain a method of determining whether integrals which satisfy all the conditions so far obtained are maxima or minima for displacements of a more general character. In this connexion we consider a particular type of displacement not subject to the condition so far assumed.

Let APB (Fig. 3) be a stationary curve joining the two fixed points A, B, and let PQ be a straight line meeting it at P. If there is not a pair of conjugate points on the arc AB, any other stationary curve starting from A in a direction sufficiently nearly coincident with that of the curve APB will meet PQ in a point Q which cannot coincide with P. The broken line made up of the stationary curve AQ, the straight line QP, and the stationary curve PB, may be treated as a varied curve, the original curve being the stationary curve APB; and the variation of the integral is the value of

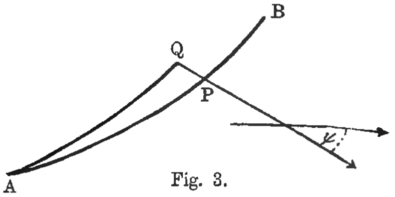

Fig. 3.

(integral along AQ) + (integral along QP) − (integral along AP) (1)

This is most simply expressed by taking the integral in the form

$$\int F(x, y, y')dx;$$

then the integral along QP will have as an approximate expression

$$\nu \cos \psi F(x, y, \tan \psi),$$

where ν is the length of QP, supposed very short, and ψ is the angle between QP in the sense from Q to P and the axis of x in the positive sense. Also the difference

(integral along AQ) − (integral along AP)

consists of two terms: one arises from the variation of the end-value from the x of P to the x of Q, and this has the approximate expression

$$-\nu \cos \psi F(x, y, y');$$

the other arises from the term at the end-value corresponding to P in the first variation when expressed as

$$\int_{x_0}^{x}\left(\frac{\partial F}{\partial y} - \frac{d}{dx}\frac{\partial F}{\partial y'}\right)\eta dx + \Big/_{x_0}^{x}\left(\eta\frac{\partial F}{\partial y'}\right).$$

The integral here written vanishes, and η vanishes at x_0, but the value of η at x is

$$-\nu \cos \psi(\tan \psi - y'),$$

(cf. VARIATIONS, CALCULUS OF, vol. xxiv. p. 86). Thus we have for (1) an approximate expression, correct to the first order of ν, in the form

$$\nu \cos \psi \left\{ F(x, y, \tan \psi) - F(x, y, y') - (\tan \psi - y')\frac{F}{\partial y'}\right\}. \quad (2)$$

The corresponding expression when the integral is taken in the form

$$\int f(x, y, \dot{x}, \dot{y})d\theta$$

is

$$\nu\left\{\left(\lambda\frac{\partial f}{\partial \dot{x}} + \mu\frac{\partial f}{\partial \dot{y}}\right)_{\dot{x}=\lambda,\, \dot{y}=\mu} - \left(\lambda\frac{\partial f}{\partial \dot{x}} + \mu\frac{\partial f}{\partial \dot{y}}\right)_{\dot{x}=l,\, \dot{y}=m}\right\}, \quad (3)$$

where (λ, μ) are the direction cosines of QP in the sense from Q to P, and (l, m) are the direction cosines of the tangent at P to the stationary curve APB in the sense from A to B.

The coefficient of ν in the expression (2), or the equivalent expression (3), has been called *Weierstrass's excess function.* It depends upon the co-ordinates of the point P and the direction of the line QP. We shall refer to QP as the *straight segment.* We have supposed the direction of this segment to be such that the integral can be formed along it, and thus it may happen that some directions for this segment are inadmissible. We define as *admissible directions* those for which the integral is definite and real, and then the application of the above result yields a new condition which must be satisfied if the integral along the stationary curve APB is a maximum (minimum), viz., the excess function must be negative (positive) for all points P of the curve and all admissible directions of the straight segment.

In regard to the first form (2) it is to be observed that the expression has in general a finite limit, different from zero, when $\psi = 0$ and when $\psi = \frac{1}{2}\pi$, if these values are admissible; also when ψ is very nearly equal to the angle ϕ, which the tangent to the original curve makes with the axis x, the expression approaches the value

$$\cos \phi\frac{\partial^2 F}{\partial y'^2}(\tan \psi - \tan \phi)^2,$$

and thus the criterion for maxima and minima yielded by the sign of the excess function includes the special condition of § 7, viz., that the function f_1 of § 4 must be one-signed.

As an example we will consider the problem: to find a curve joining two fixed points so that the integral

$$\int \frac{y^2}{y'^2}dx = \int \frac{y^2\dot{x}^3}{\dot{y}^2}d\theta,$$

taken along it shall be a maximum or a minimum. The principal equation is

$$\frac{d}{d\theta}\left(\frac{y^2\dot{x}^2}{\dot{y}^2}\right) = 0,$$

and the stationary curves include the axis of x, straight lines parallel to the axis of y, and the family of exponential curves $y = ae^{cx}$; we select this family for further discussion. If the initial point is (x_0, y_0) the family of stationary curves starting from it is given by the equation

$$y = y_0e^{c(x-x_0)};$$

these have no envelope, and thus there are no conjugate points. Also the function f_1 becomes $6\dot{x}/\dot{y}^4$, and thus the second variation is positive for curves going to the right from the initial point. The excess function is

$$y^2 \cos \psi(\cot^2\phi - 3 \cot^2\psi + 2 \tan \psi \cot^3\phi)$$

for any direction except $\psi = 0$, which is inadmissible; on putting $\psi = \frac{1}{2}\pi$ we get $2y^2 \cot^3 \phi$, and on putting $\psi = \frac{3}{2}\pi$ we get $-2y^2\cot^3 \phi$. Thus the integral taken along AQ′PB can be made greater than that along APB, and the integral taken along AQPB can be made less than that along APB, by taking AQ and AQ′ stationary curves sufficiently near to AP and drawing QPQ′ parallel to the axis of y. It follows that the integral taken along the curve APB is neither a maximum nor a minimum.

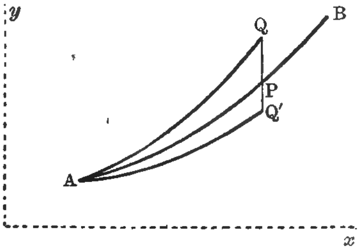

Fig. 4.

It is worth while to observe that the excess function does not in all cases, as it does in this example, change sign when the sense of the straight segment is reversed, or when ψ is replaced by $\pi + \psi$. For example, in the problem of the minimal surface discussed in §§ 5, 6, the excess function is $2y \sin^2 \frac{1}{2}(\psi - \phi)$.

9. *Arbitrary Displacements.*—It can be proved that the condition found in the last section, with those found previously, in general suffices to secure that the integral is a maximum or minimum for any type of displacements for which the locus of the displaced points consists of a finite number of arcs of analytic curves. Thus the necessary and sufficient conditions are in general:

(i.) The original curve is a stationary curve for the integral.

(ii.) The fixed end-points of the curve are not a pair of conjugate points, and there is not such a pair of points on the arc between them.

(iii.) The excess function is one-signed, and in general different from zero at all points of the curve, and for all admissible directions of the straight segment not coinciding with the tangent to the curve. The excess function may vanish at isolated points, or for particular directions of the straight segment, but it must not change sign.

This condition may be taken to include the special condition of § 7, that the function f_1 of § 4 is one-signed.

Further, it can be proved that the only exception to this statement occurs if the excess function can vanish without changing sign at all points of the stationary curve, or of a finite arc of it, otherwise than by the straight segment coinciding with the tangent to the curve. If this can occur, then the co-ordinates of a point on the stationary curve, or on a finite arc of it, must satisfy a certain differential equation of the first order distinct from the principal equation. Such cases would be very exceptional.

In the analysis by which these conclusions are reached the function which plays the most important part is a *generalized excess function.* Instead of forming the excess function for the original curve, a point on it, and a straight segment ending at that point, the function is formed for a neighbouring stationary curve starting from the same initial point A and a straight segment ending at an arbitrary point of that curve. It appears that, in general, when the conditions for a minimum (maximum) are satisfied, it is possible to mark off a region between two stationary curves, both starting from A, and having the original stationary curve AB between them, within which the generalized excess function above described is everywhere positive (negative). Through any point of this region and the point A there passes one stationary curve of the integral, which lies entirely within the region, and these curves do not intersect themselves or each other within the region.

10. *Isoperimetric Problems.*—All the remaining problems of the Calculus of Variations may be regarded as extensions of the first problem. We will consider briefly problems of relative maxima and minima. Restricting ourselves to the simplest case, we seek to determine a curve joining fixed points which has the property that an integral of the form $\int F(x, y, y')dx$ taken along the curve is a maximum or minimum, while another integral of the same form, say $\int \Phi(x, y, y')dx$ taken along the same curve, has a given value. It is at once clear that no result can be obtained by introducing displacements of the type considered in § 4; for if the Φ integral is unaltered by such displacements the curve is a stationary curve for that integral, and if the F integral is a maximum or a minimum for such displacements, the curve is a stationary curve for that integral also; but the two integrals have not the same families of stationary curves. If, however, the displacements are of the type

$$\xi = \kappa_1 u_1 + \kappa_2 u_2, \ \eta = \kappa_1 v_1 + \kappa_2 v_2,$$

where κ_1, κ_2 are constants which can be taken as small as may be wished, and u_1, u_2 and v_1, v_2 are functions of the kind considered in § 4, then it may be shown that these functions can be chosen in an infinite number of ways so that the Φ integral is unaltered and the first variation of the F integral vanishes. This method leads to the ordinary rule (Lagrange's) for determining the curve, if there is one, which yields the solution of the problem. The rule in question appears to have been at first accepted as axiomatic; it was rigorously proved by P. du Bois Reymond.

11. *Extension of the Theory.*—All the theory here explained can be extended to integrals involving a greater number of variables, and differential coefficients of higher orders, to multiple integrals, and to cases where the variations are subject to restrictive conditions. The criteria for the existence of maxima and minima, and for distinguishing between them, are obtained by choosing particular types of functions to represent the alterations of the variables which correspond to displacements in the first problem. When these are subjected to restrictions of the same kind as the displacements in §§ 4 and 10 the same results are arrived at as are commonly obtained by using the symbol δ. These results are the differential equations of the problem corresponding to the principal equation of § 4, and when they are satisfied the integral is said to be *stationary;* thus, for example, the differential equations of theoretical dynamics are the conditions that the action may be stationary, the partial differential equation of minimal surfaces is the condition that the area may be stationary. In many mechanical and physical problems the condition that must be satisfied is really a stationary condition, not a maximum-minimum condition: in others, for example problems concerning stability, it is generally necessary to distinguish between maxima and minima. The use of the symbol δ for finding the stationary condition for different forms of integrals under various restrictions has been explained in the article VARIATIONS, CALCULUS OF (*Ency. Brit.*, 9th ed., vol. xxiv.).

In the solution of any problem in the Calculus of Variations the first step is the formation of the *principal equations,* of which the solutions render the integral under discussion stationary, and the second step is the solution of these equations. Among the integrals of the equations some will usually be adapted to satisfy also the imposed conditions corresponding to the fixing of the end-points in the first problem. The integrals of the equations may be regarded as determining loci in a homogeneous domain of two or more dimensions, and then the notion of a family of such loci, continuously filling up a domain within which they do not intersect, is generally valid if the integral can be a true maximum or minimum.

Some of the further conditions which are necessary in order that the stationary solutions may yield true maxima and minima have been sought by the process of transformation of the second variation. After Jacobi's discovery, referred to in § 6, this process became the subject of numerous investigations, and Jacobi's results were extended to a great number of forms of integrals. Even when this process is carried out, and the necessary conditions are deduced, it may still happen that an integral satisfying all these conditions is nevertheless capable of being increased or diminished by some mode of variation less simple than that implied in the use of the symbol δ, and the question thus raised leads to the extension of Weierstrass's method of the excess function. This extension has been carried out in the case of simple integrals involving differential coefficients of any order, and in the case of double integrals involving differential coefficients of the first order. In both cases it has been shown that the conditions which can thus be obtained, together with those previously known, are sufficient to secure that the integral shall be a maximum or minimum.

12. The investigation of the criteria for distinguishing true maxima and minima from merely stationary solutions is usually complicated, even when the principal equations can be solved, and it has sometimes been sought to evade the process by other considerations. The most famous example of such evasion is the well-known attempt to obtain a proof of the theorem now called *Dirichlet's Principle,* of which a particular case is the existence theorem in the theory of functions of a complex variable:—

Let I denote the integral

$$\iiint \left\{ \left(\frac{\partial V}{\partial x}\right)^2 + \left(\frac{\partial V}{\partial y}\right)^2 + \left(\frac{\partial V}{\partial z}\right)^2 \right\} dxdydz$$

taken through the volume within a given closed surface S, and suppose that the integral is to be made a minimum subject to the condition that the value of V is given at all points of S. Employing the method of the Calculus of Variations, we find the principal equation

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0\,;$$

if we could solve this equation subject to the condition that V has a given value on S, we might then apply the methods of the calculus to determine whether the solution obtained really makes the integral I a minimum. In general we cannot obtain this solution, and the question arises, Does such a solution exist? If we could prove that among the functions which take the given value on S there is one that makes the integral a minimum, then we should know that a solution of the differential equation exists which takes the given value on S—we should have proved the existence-theorem. Now the argument runs: I must be positive, for the subject of integration is necessarily positive, and therefore there is a limit than which it cannot be smaller; hence V can be chosen so as to make it a minimum.

This argument ignores the distinction between a minimum and an *inferior limit.* There is no evidence to show that the limit than which the value of the integral I cannot be smaller exceeds zero, or that such limit is a value "attained" by the integral for some form of V. If for instance L were the limit below which I could not fall, it might be impossible that any form of V should make $I=L$, although there were forms of V which would make $I<L+\epsilon$ however small ϵ was taken. Then L would be an inferior limit for I, but not a minimum value, for it would not be a value of I at all. Weierstrass illustrated this argument by the integral $\int_{-1}^{1} x^2 y'^2 dx$ taken along a curve joining the points $(-1, a)$ and $(1, b)$. This integral also is always positive, and, according to the argument, the principal equation $\frac{d}{dx}(x^2y')=0$ should have a solution subject to the conditions $y=a$ when $x=-1$ and $y=b$ when $x=1$, and this solution would make the integral a minimum; but on the one hand the solution is

$$y=\frac{a+b}{2}-\frac{a-b}{2x}$$

which makes the integral *divergent*, and on the other hand curves can be found which shall make the value of the integral as small as we please; for example, we may take

$$y=\frac{a+b}{2}-\frac{a-b}{2}\frac{\tan^{-1}(x/a)}{\tan^{-1}(1/a)},$$

and then the integral can be made as small as we please by diminishing a.

In the case of the integral $\iint\left\{\left(\frac{\partial V}{\partial x}\right)^2+\left(\frac{\partial V}{\partial y}\right)^2\right\}dxdy$, which corresponds to I in two-dimensional problems relating to the theory of potential, a direct proof of the existence of a minimum has been sketched by D. Hilbert (*Jahresber. d. deutsch. Math.-Vereinigung*, 8, 1900). Very important results may be expected from the development of the method which he employed.

AUTHORITIES.—Among the more important of the recent memoirs on the Calculus of Variations are the following: DU BOIS REYMOND, P. "Erläuterungen z. d. Anfangsgründen d. Variationsrechnung," *Math. Ann.* 15, 1879.—KNESER. "Zur Variationsrechnung," *Math. Ann.* 50, 1898, and "Ableitung hinreichender Bedingungen . . . a. d. Theorie d. zweiten Variation," *Math. Ann.* 51, 1899.—KOBB. "Sur les max. et les min. des intégrales doubles," *Acta Math.* 16, 1892.—MAYER. "U. d. Kriterien d. Max. u. Min. d. einfachen Integrale," *Crelle* 69, 1868; and "Begründung d. Lagrange'schen Multiplicatorenmethode i. d. Variationsrechnung," *Math. Ann.* 26, 1886.—SABININE. "Sur la méthode de distinguer les max. et les min. des intégrales définies multiples," *Bull. acad. imp. sci. St. Pétersbourg*, 15, 1870; also two other memoirs on the same subject, *Bull. sci. math.* 1878, and *Annali di mat.* 1899.—SCHEEFER. "D. Max. u. Min. d. einfachen Integrale," *Math. Ann.* 25, 1885; and "Ü. d. Bedeutung d. Begriffe Max. u. Min. i. d. Variationsrechnung," *Math. Ann.* 26, 1886.—ZERMELO. *Untersuchungen zur Variationsrechnung* (Inaugural Dissertation). Berlin, 1894. A sketch of the theory from a historical point of view was given by PASCAL in the third part of his *Calcolo infinitesimale*, Milan, 1897; and a German translation with the title *Die Variationsrechnung* was published at Leipzig in 1899. Still more recent is KNESER. *Lehrbuch d. Variationsrechnung.* Brunswick, 1900.—An introduction to modern work on the subject will be found in a memoir by OSGOOD, "Sufficient Conditions in the Calculus of Variations," *Annals of Math.* (ser. 2), 2, 1901. (A. E. H. L.)

Varna, a fortified town and the chief seaport of Bulgaria, on the south-west shore of the Black Sea, on a magnificent plain at the mouth of the Devna, on the north side of the Bay of Varna, at the terminus of a railway line from Rustchuk, and of another, opened in 1899, from Sofia, 48 miles east of Shumla, and 325 by rail west-north-west of Sofiá. Among modern buildings are the military barracks, the post office, the National Bulgarian Bank, and higher-class college for girls. The extensive harbour works, in progress for some years, are already affording improved facilities for shipping; and the opening of the railway also tends greatly to the increase of trade. The principal exports are cattle and dairy produce, grain, lamb and goat skins, and coarse cloth; and the imports include fruit, vegetables, fuel, chemicals, oils, earthenware, metals, textiles, machines, ironmongery, &c. A British spinnery has been established which turns out large quantities of cotton yarn.

In 1895 the imports, amounting to 37,360 tons, were valued at £489,200, and the exports, of 97,500 tons, at £580,200. In 1900 the former were 29,400 tons, worth £435,300; and the latter, 52,500 tons, of the value of £349,800, the decline being due to bad harvests. In 1897 the number of vessels that entered the port was 767 of 458,172 tons, their cargoes amounting to 175,350 tons, and the cargoes of the vessels that cleared amounting to 245,292 tons; in 1899 the number of vessels that entered was 546 of 424,819 tons, their cargoes amounting to only 35,274 tons, while the cargoes of vessels that cleared amounted to only 52,294 tons. The population in 1892 was 28,174, and in 1900 it was 33,443. Less than one-fourth of the population are Turks, and Greeks and Bulgarians number each about one-third of the whole.

Vasa, or NIKOLAISTAD, a town of Russia, in the grand duchy of Finland, capital of the province of Vasa, on the east coast of the Gulf of Bothnia, 327 miles by rail north-west of Helsingfors. It has two classical lyceums for boys, a high school for girls, a *real*-school, and various primary schools; also a large cotton mill and a number of small factories showing an aggregate return of over 4,000,000 marks. Oats, butter, and cattle are exported to Sweden. Vasa was founded on the coast of the Gulf of Bothnia in 1606, but after the great fire of 1852, as the sea had already receded for a considerable distance, the town was rebuilt nearer to the shore and received the official name of Nikolaistad. Population (1897), 13,493.

Vascular System. See PHYSIOLOGY.

Vaslui, a town in Rumania, chief town of the district bearing the same name, prettily situated on a hill at the junction of the rivers Vaslui and Berlad. The church of Biserica Domneasca (Our Lady) is fine. The annual fair is held on 1st–10th September. There are ruins of a palace built by Stephen the Great in 1471. Population (1895), 8500; (1900), 9024.

Vaticanism.—*History since 1870.*—The few months that elapsed between the 18th of July 1870 and the 18th of January 1871 witnessed four events that have been fraught with more consequence to the Papacy than anything else that has affected that institution for the past three centuries. They were as follows:—(1) The proclamation of the Infallibility of the Pope on the 18th of July 1870; (2) the fall of the Napoleonic empire and the establishment of the third French republic on the 4th of September 1870; (3) the occupation of Rome by the Italian forces on the 20th of September 1870, resulting in the incorporation of the remaining States of the Church in the kingdom of Italy; and (4) the foundation of the German empire by the proclamation, on the 18th of January 1871, of the king of Prussia as hereditary German Emperor. These changes, which so greatly disturbed the current of all European relations, could not fail to react upon the Papal policy in various ways. They brought its existing tendencies into greater relief, set before it new aims and diverted it into new channels. Essential modifications could not, of course, be at once effected or even indicated in a Power whose life-blood is tradition, and whose main strength has always lain in calmly abiding the issue of events and in temporizing. The eight years that Pius IX. was permitted to see after the loss of his temporalities entirely harmonize with this character. The veil that hides the negotiations which, during the closing months of the Franco-German war, were carried on between Bismarck and the Pope, through the agency of Cardinal Bonnhose, has not yet been lifted, and perhaps never will be. According to Prince Bismarck's own account of the matter, as given in his *Gedanken und Erinnerungen*, these negotiations were initiated by the Chancellor, who, between the 5th and 9th of November 1870, entertained *pourparlers* with Archbishop Ledochowski on the question of the territorial interests of the Pope. The Chancellor, acting, as he himself says, in the spirit of the adage, "one hand washes the other," proposed to that prelate that the Pope should give earnest of the relations subsisting between him and Germany by influencing the French clergy in the direction of the conclusion of peace. The cool reception his endeavours met with, both at the hands of the French ecclesiastics as well as in Rome, satisfied Bismarck "that the Papal hierarchy lacked either the power or the goodwill to afford Germany assistance of sufficient value to make it worth while giving umbrage to both the German Protestants and the Italian national party, and risking a reaction of the latter upon the future relations between the two countries, which would be the inevitable result were Germany openly to espouse the Papal cause in Rome." These utterances are eminently characteristic. They show how far Bismarck was (even at the close of 1870) from comprehending the traditional policy of the Papacy towards Germany and German interests, and how little he conceived it possible to employ the relations between the future empire and the Vatican as a point of departure for a successful and consistent ecclesiastical policy. Rome, in a certain sense, showed itself possessed of far greater foresight. Even to-day Papal diplomacy, like the French clergy, neither believes in the future of the German empire, nor admits that the overthrow of France has been final and complete. The German politicians and the Prussian diplomatists accredited to Rome had worked too openly at undermining the Papal hierarchy, and had veiled their sympathies for Piedmont far too lightly, to lead the Vatican to expect, after the 20th September 1870, a genuine and firm intervention on the part of Prussia on behalf of the temporal power of the Holy See. To satisfy the demands of Bismarck in November 1870 would have cost the Vatican more than it would ever have gained. It could neither afford to trifle with the sympathies of the French Catholics nor to interrupt the progress of those elements, which would naturally be a thorn in the side of the young German empire, thus undo Bismarck's work, and restore the Vatican policy to its pristine strength and vigour. It was soon to be perceived how carefully the Curia had made its calculations.

The address of the Catholic deputies to the Emperor William in Versailles on the 18th February 1871, pleading for the restoration of the States of the Church and the temporal sovereignty of the Pope, and for the reconstitution of the Catholic Fraction formed in the Prussian Landtag in 1860 as the Centrum or Middle Party in the new Reichstag (April 1871), must not be regarded as the origin, but rather the immediate occasion, of the *Kulturkampf*. The congratulations which the Pope sent to the Emperor William on receiving the announcement of the establishment of the German empire (6th March 1871) were a last exchange of civilities, and the abolition of the Catholic department in the Prussian Kultus Ministry (8th July 1871) quickly followed, together with the appointment of Falk as *Kultusminister* (22nd January 1872), and the School Inspection Law of 9th February 1872.

On 30th January Bismarck took the opportunity of inveighing against the formation of the sectarian Centrum as being "one of the most monstrous phenomena in the world of politics," and he left no room for doubt in the minds of his hearers that he regarded the leadership of Windthorst as constituting, in his eyes, a peril to the national unity. In his *Memoirs* (ii. 126) he declares that the *Kulturkampf* was mainly initiated by him as a Polish question. This declaration, in view of the development of affairs, must appear as strange as the Chancellor's confession (*Memoirs*, ii. 129 and fol.) that he endeavoured to persuade the emperor of the advantage of having a nuncio accredited to Berlin (in lieu of the Catholic department of public worship). The refusal of the Emperor William to entertain this project shows that in such matters his judgment was more correct than that of his counsellor, and the incident proves that the latter had anything but a clear insight into the historical position. He was drifting about with no higher aim than a "hand-to-mouth". policy, whilst the Holy See could feel the superiority with which the consciousness of centuries of tradition had endowed it, and took full advantage of the mistakes of its opponent. The Chancellor never realized the gravity of the onslaught which, with his *Kulturkampf*, he was making upon the conscience and liberty of his Catholic fellow-citizens. He dealt with the great question at issue from the standpoint of the diplomatist, rather than from that of the statesman well versed in ecclesiastical history and possessing an insight into what it implies; and by his violent, inconsiderate action he unwittingly drove into the ranks of Ultramontanism the moderate elements of the Catholic population. This conflict, moreover, brought Ultramontanism the enormous advantage that, even after the abolition of the May Laws, it had still left to it a well-disciplined press, an admirable organization, and a network of interests and interested parties; and all these combined to make the Centrum the strongest and the most influential political party in Germany for the remainder of the 19th century. Owing to these circumstances, the rise and further development of the *Kulturkampf* were viewed in Jesuit and Vatican circles with feelings of the utmost complacency.

The purely ecclesiastical policy of Pius IX. was guided by the earnest desire to see the doctrine of Papal Infallibility brought to universal recognition. The definition of the Immaculate Conception (1854) and the proclamation of the Syllabus (1864) were finger-posts pointing the way to the Council of 1870. The Pope had been persuaded that the proclamation of the new dogma would be effected without difficulty and without discussion; and when the pronouncement actually met with opposition, he was both surprised and embittered. For a moment the idea was entertained of giving way to the opposition and deferring a decision in the matter, or, in the manner of the Fathers in the Council of Trent, adjourning it to the Greek Kalends. But the party that needed for its purposes an infallible Pope readily persuaded Pius IX. that if the Council broke up without arriving at a decision favourable to the Papacy, this would be tantamount to a serious defeat of the Holy See and an open victory for the Gallican system. The consequence was the Bull *Pastor æternus*, which Pius IX. issued on the 15th of July. This did not by any means represent all the demands of the Jesuits, and it was couched in terms which appeared not unacceptable to the majority of the Catholics. The fact that the bishops were prepared to forego their opposition was not unknown in Rome. It was anticipated by the authorities. But in Germany, as also in France, the waves of anti-Infallibility were rolling so high, that the further development of events was viewed with no small concern. Under normal conditions, the situation could not fail to terminate favourably for the Vatican. That the *Kulturkampf* had followed so rapidly upon the war was the greatest piece of good fortune that could have befallen the Papal See. The war demanded both in Germany and France the sacrifice of all available energy and public spirit; while the *Kulturkampf*, by bringing into relief the question of the external existence of the Church, thrust all internal dogmatic interests and problems completely into the background. The egregious blunder in the May Laws was the punitive clauses directed against the inferior clergy. Instead of enlisting them as friends, the Prussian Government contrived by wild and wanton persecution to make them its enemies. The open protection it accorded to the Old Catholic movement contributed in no small measure to estrange those influential elements which, whilst favouring the suppression of Ultramontane tendencies, desired no schism in the Church, and viewed with horror the idea of a National Church in Bismarck's sense. Thus we find that the bitter years of the *Kulturkampf* extricated the Vatican from one of the most difficult situations in which it had ever been placed. Pius IX. could now fold his hands, so far as the future was concerned. It is well known that he fed on inspirations, and expected each day the advent of some supernatural occurrence which should bring about the triumph of the Church. In this frame of mind, on the 24th June 1872, he addressed the German *Leseverein*, and referred to the stone that would soon fall from on high and crush the feet of the Colossus. Yet the stone has not fallen from the summit of the holy hill, and the Colossus of the German empire has not crumbled into dust, which is more than can be said for the Pope's inspirations, which led him to expect the sudden withdrawal of the Italians from Rome, and a solution of the Roman question in the sense inspired by his visionary policy. The Holy See directed all its energies towards the solution of the problem; in the event of its proving to be insoluble, it would take care that it should remain a festering sore in the body of the monarchy.

The documents of the Vatican Council which have been published since 1870 leave no room for doubt that the proclamation of Papal Infallibility was intended to be followed by a further declaration, to the effect that the doctrine of the temporal power of the Pope should be regarded as a revealed article of faith; yet the advantage and necessity of the temporal power were not to be regarded as a revealed dogma properly speaking, but as a truth guaranteed by the doctrinal body of the Holy Church. These articles, contained in the 5th Scheme, and zealously championed by the sectaries of the Jesuit order, reveal the immediate object for which the Council of 1869–70 was convened. The resolutions were devised to save the situation, in view of the impending loss of the temporalities. No one could expect that Pius IX. would recognize the annexation of Rome by Italy. Rome, even in the 19th century, had been a spectator of many changes in the political world. It had seen more than one kingdom rise and fall. No wonder, then, that the Vatican, confronted by a new Italy, observed a passive and expectant attitude, and sanctioned no jot or tittle that could infringe its rights or be interpreted as a renunciation of its temporal sovereignty. It was quite in keeping that Pius IX. availed himself to the full of the (for him) convenient clauses of the Italian "Guarantee Law" (13th May 1871), while refusing the civil list of three and a quarter million francs provided for his use, and inhibiting Italian Catholics from participating in the elections to the House of Deputies (*nè elettori nè eletti*). This step was regarded in Italy as a natural one. Although the Liberal record of the Pope was a thing of the past, and his policy had, since Gaeta, become firmly identified with the reactionary policy of Antonelli, yet the early years of his pontificate were in such lively recollection as to allow of Pius IX.'s appearing to some extent in the light of a national hero. And rightly; for he had always had a warm heart for Italy; and had it not been for the anti-ecclesiastical policy of the house of Piedmont, he would not, in the 'sixties, have been wholly averse from reconciliation. The hitherto unpublished correspondence of the Pope with Victor Emmanuel contains remarkable proofs in support of this contention, and a further corroboration can also be perceived in the conciliatory attitude of Pius IX. on the death of the king.

Pius died on the 7th of February 1878, only a few weeks later than his opponent. He had long passed the traditional years of Peter's Pontificate, had reigned longer than any previous wearer of the tiara, and had seen some brilliant days—days of illusory glory. On his death he left the Church shaken to its very foundations, and in feud with almost every Government. In Italy the Holy Chair was surrounded by a hostile force, whose "prisoner" the Lord of the Vatican declared himself to be. In Spain and Portugal, and also in Belgium, a Liberalism inimical to the Church was in power. Prussia, together with other German States, was in arms against Pope and episcopate. In France the Conservative monarchical party had just shown its inability to preserve the Crown, whilst the Republic had anchored itself firmly by denouncing the Clergy as its enemy. There was hardly a sovereign or a government in Christendom against which Pius IX. had not either protested or against which he had not openly declared war. Such was the heritage that devolved upon Leo XIII. on his election on the 20th of February 1878.

Leo XIII. brought to his new dignity many qualities that caused his election to be sympathetically received. In contrast to his predecessor, he was a man of slow and calm deliberation, and it was natural to suppose that he was little, if at all, accessible to impulses of the moment or to the persuasions of his entourage. He was endowed with a certain scholastic erudition, and enjoyed the reputation of being a good Latinist. As Nuncio in Brussels he had become acquainted with the trans-Alpine world, and had been initiated into the working of the machinery of modern politics and modern parliamentary government. The fact that he had for so long been absent from Rome afforded ground for the belief that he was not inclined to identify himself with any of the parties at the Vatican court. These were the considerations that had caused the Moderates in the Sacred College to fix their eyes upon him. The appointment of Franchi as secretary of state was a bid for peace that was viewed by the Irreconcilables with ill-disguised vexation. The following years of Leo XIII.'s pontificate only tended to increase their dissatisfaction. The first care of the new Pope was to pave the way for the restoration of peace with Prussia and the German empire. The correspondence which was interchanged during the regency of the Crown Prince in 1878 clearly manifests that both sides were eager to arrive at a reconciliation. But, as a matter of fact, there were great difficulties in the way; for, on the one side, the Prussian Government and the Chancellor were not inclined definitely to abolish the May Laws and to content themselves with the system of discretionary powers; and on the other, the Pope had also to deal with elements that were nourished by the *Kulturkampf*, and owed their very existence to it. The great patience, persistence, and energy which Leo XIII. employed in overcoming these difficulties, so that ultimately his labours for peace were crowned with victory, must be commended. The Holy Chair made on this occasion many concessions which appeared to the *Zelanti* to be excessive, and made even still greater ones to France and Russia, to the great distress of the Poles. But at last Leo XIII. could boast not only of having re-established diplomatic relations with most of the Powers, but also of having entered into a convention with the Great Powers of the North, which accorded him, in conjunction with the three emperors, a leading position as champion of the conservative interests of humanity. How proud Leo XIII. was of his importance in this position is shown by the beautiful Encyclical, *De Civitatum Constitutione Christiana* ("Immortale Dei," of 1st November 1885), in which he adopted the strongest attitude against the principle of the sovereignty of the people (*ex iis autem Pontificum præscriptis illud omnino intelligi necesse est, ortum publicæ potestatis a Deo ipso, non a multitudine repeti posse*), refuting the notion that the principle of public power emanates from the will of the people alone (*principatum non esse nisi populi voluntatem*), and absolutely rejecting the sovereignty of the people as such. But this attitude was adopted by Leo XIII. not as an end but as a means. The real aims of his rule were disclosed in the second phase of his pontificate.

At its very commencement, the Pope in his first Encyclical (Easter 1878) proclaimed the necessity of a temporal hierarchy. This was at the time regarded merely as a formality imposed by circumstances, and one not to be seriously entertained; but it became more and more evident that the recovery of the temporalities was the real mainspring of Leo's whole policy. In the negotiations with Germany, it was clearly seen that it was from that side that the Pope expected intervention in favour of restitution; and, according to all appearances, Bismarck did for a while keep alive these representations, though with more tact than candour. After peace had been concluded, Leo, by the agency of Galimberti, reminded the Chancellor of the settlement of the Roman question. Bismarck replied that he was "unaware of the existence of any such question." The two visits paid by Emperor William II. to the Vatican could not fail to remove any doubts in the mind of the Pope as to the fact that Germany did not dream of giving him back Rome. The Austro-German-Italian triple alliance was a dire blow to his expectations, and Crispi's policy with its irritating and galling pin-pricks caused the cup to overflow.

Thus slowly, but yet deliberately, between 1887 and 1893, a transformation took place in Leo's spirit and policy, and with it was brought about one of the most momentous changes in the attitude of the Church towards the problems of the times and their impelling forces. A *rapprochement* with France inevitably entailed not only an alliance with modern democracy, but also a recognition of its principles and aims. In Rome there was no room for both Pope and King. The note of the Pope to Rampolla of 8th October 1895, in consequence of the celebrations on 20th September, declared, in terms more decided than any that had until then been uttered, that the Papacy required a territorial sovereignty in order to ensure its full independence, and that its interests were therefore incompatible with the existence of the kingdom of Italy as then constituted. The inevitable consequences ensued. Italy regarded the Pope more than ever as a foe within its walls; and the policy of the Pope, as regards Italy, aimed at replacing the kingdom by one or more republics, in which the temporal power should, in some form or other, find a place. But the continuance of the Republic in Paris was a condition precedent to the establishment of a republic in Rome, and the first had no chance of existence if the democracy in France did not remain in power. The result was the policy of the *Ralliement.* Instructions were given to the French Catholics to break with monarchical principles, and both externally and internally to cleave to the Republic as representing the best form of constitutional government. In carrying out the régime of Rampolla, which was, in every respect, a bad imitation of that of Antonelli, the Vatican left no stone unturned in its attempt to coerce the conscience of the French royalists; it did not even stop at dishonour, as was evidenced by the case of the unhappy Mgr d'Hulst, who, in order to evade the censorship of his pamphlet on Old Testament criticism, had to abandon both his king and his principles, only to die in exile of a broken heart. The case was characteristic of the whole Catholic monarchical party, which, owing to the Pope's interference in French politics, became disintegrated and dissolved, a fate that was all the more painful seeing that the *Ralliement* failed to influence the course of events. The "atheistic" Republic did not for one moment think of putting on sackcloth, or even of giving the Church a single proof of esteem and sympathy.

In one respect it was impossible for the Papacy to continue on the path it had taken. In his first Encyclical, Leo XIII. had sounded the clarion for battle against the Social Democracy; his Encyclical *Novarum Rerum* endeavoured to show the means to be employed, mainly in view of the condition of things in Belgium, for solving the social question on Christian lines. But the Christian Democracy, which, starting in Belgium and France, had now extended its activity to Italy, Austria, and Germany, and was striving to arrive at this solution, degenerated everywhere into a political party. The leaders of this party came into close contact with the Social Democrats, and their relations became so cordial that Social Democracy everywhere declared the "Démocratie Chrétienne" to be its forerunner and pioneer. The electioneering alliances, which were everywhere in vogue, but particularly in Germany, between the Catholics and popular party and the Social Democrats, throw a lurid light upon the character of a movement that certainly went far beyond the intentions of the Pope, but which it was now difficult to undo or to hold in check. For it is the essence of the matter that there were further considerations going far beyond the Roman question and forcing the Curia to adhere to the sovereignty of the people.

The external rehabilitation of the Church had become, in many points, a *fait accompli*, but, internally, events had not kept pace with it. Catholic romanticism had withered away in France, as it had in Germany. "Liberal Catholicism," which was its offspring, had died with Montalembert, after being placed under a ban by Rome. The national religious movement, associated in Italy with the great names of Rosmini and Gioberti, had similarly been disavowed and crushed. The development of the last decade of the 19th century had clearly shown that the educated *bourgeoisie*, the *tiers état*, in whose hands the supreme power had since 1848 become vested throughout Europe, was either entirely lost to the Church or, at all events, indifferent to what were called Ultramontane tendencies. The educated *bourgeoisie*, which controls the fields of politics, science, finance, administration, art, and literature, does not trouble itself about that great spiritual universal monarchy which Rome, as heir of the Cæsars, claimed for the Vatican, and to which the Curia of to-day still clings. This *bourgeoisie* and the modern state that it upholds stand and fall with the notion of a constitutional state, whose Magna Charta is municipal and spiritual liberty, institutions with which the ideas of the Curia are in direct conflict. The more the hope of being able to regain these middle classes of society disappeared, the more decidedly did the Curia perceive that it must seek the support and the regeneration of its power in the steadily growing Democracy, and endeavour through the medium of universal suffrage to secure the influence which this new alliance was able to offer.

The pontificate of Leo XIII. in its first phase aimed at preserving a certain balance of power. Whilst not openly repelling the tendencies of the Jesuits, Leo yet showed himself well disposed towards, and even amenable to, views of a diametrically opposite kind; and as soon as the Vatican threw itself into the arms of France, and bade farewell to the idea of a national Italy, the policy of equilibrium had to be abandoned. The second phase in Leo's policy could only be accomplished with the aid of the Jesuits, or rather, it required the submission of the ecclesiastical hierarchy to the mandates of the Society of Jesus. The further consequence was that all aspirations were subjected to the thraldom of the Church. The pontificate of Leo XIII. is distinguished by the great number of persecutions, prosecutions and injuries inflicted upon Catholic *savants*, from the prosecution of Antonio Rosmini down to the proscription directed against the heads of the American Church. Episodes, such as the protection so long extended to the Leo Taxil affair, and to the revelations of Diana Vaughan (the object of which last was to bring Italian freemasonry and its ostensible work, the unity of Italy, into discredit), together with the attitude of the Ultramontane press in the Dreyfus affair, and later towards England, the invigoration of political agitation by the Lourdes celebration and by anti-Semitism, were all manifestations that could not raise the "system" in the estimation of the cultured and civilized world. Perhaps even more dangerous was the employment of the whole ecclesiastical organization, and of Catholicism generally, for political purposes.

No one will be so foolish or so unjust as to hold Leo XIII. responsible for the excesses committed by the subordinate departments of his government, in disclosing, prosecuting, and sometimes even fraudulently misrepresenting his aims and ends. But all these details, upon which it is not necessary to dwell, are overshadowed beyond all doubt by the one great fact that the ecclesiastical régime of the present day not only takes under its wing the solution of social questions, but also claims that political action is within the proper scope of the Church, and, moreover, arrogates to itself the right of interfering by means of "Directives" with the political life of nations. This, as is well known, is nothing new, for as early as 1215 the English barons protested against it. But the weakening of the pontificate had allowed this claim to lapse for centuries. To have revived it, and to have carried it out as far as is possible, is the work of Leo XIII., and the very essence of the Vatican policy of modern times.

It would be both presumptuous and premature to pass a final verdict at present upon the value and success of a policy to which, whatever else be said, must be accorded a certain meed of praise for its daring. As long ago as 1892 Spüller, in his Essay upon Lamennais, pointed out how the latest evolution of Catholicism was taking the course indicated by Lamennais in his *Livre du Peuple* (1837), and how the hermit of "La Chênaie," who departed this life in bitter strife with Rome, declared himself to be the actual precursor of modern Christian Socialism. He hinted that the work of Leo XIII. was, in his eyes, merely a new attempt to build up afresh the theocracy of the Middle Ages upon the ruins of the old monarchies, utilizing to this end the inexperience of the young and easily-beguiled democracies of the dawning 20th century. To comprehend these views aright, we must first remember that what in the first half of the 19th century, and also in the days of Lamennais, was understood by Democracy was not coincident with the meaning of this expression as it is now used, and as the Christian Socialists understand it. Down to 1848, and even still later, "Democracy" was used to cover the whole mass of the People, pre-eminently represented by the broad strata of the *bourgeoisie;* in these days the Democratic party itself means by this term the rule of the labouring class organized as a nation, which, by its numerical superiority, thrusts aside all other classes, including the *bourgeoisie*, and excludes them from participation in its rule. In like manner it would be erroneous to confuse the sense of the expression as it obtains on the Continent with what is understood under this term in England and America. In this latter case the term "Democracy," as applied to the historical development of Great Britain and the United States, denotes a constitutional state in which every citizen has rights proportionate to his energy and intelligence. The Socialistic idea, with which the "Démocratie Chrétienne" has identified itself both in France and Belgium, regards numbers as the centre of gravity of the whole State organism. As a matter of fact it recognizes as actual citizens only the labourer, or, in other words, the proletariat.

On surveying the situation, certain weak points in the policy of the Vatican become manifest. They may be summed up as follows: (1) An unmistakable decline of religious fervour in church life. (2) The intensifying and nurturing of all the passions and questionable practices which are so easily encouraged by practical politics, and are incompatible in almost all points with the priestly office. (3) An ever-increasing displacement of all the refined, educated, and nobler elements of society by such as are rude and uncultured, by what, in fact, may be styled the ecclesiastical "Trottori." (4) The naturally resulting paralysis of intelligence and scientific research, which the Church either proscribes or only sullenly tolerates. (5) The increasing decay and waxing corruption of the Romance nations, and the fostering of that diseased state of things which of late has displayed itself in France in so many instances, such as the Dreyfus case, the anti-Semitic movement, and the campaign for and against the Assumptionists and their newspaper, the *Croix.* (6) The increasing estrangement of German and Anglo-Saxon feeling. As against these, there are also noteworthy reasons to be urged in favour of the new development. It is maintained that the faults just enumerated are only cankers inseparable from every new and great movement, and that these excrescences will disappear in course of time, and the whole movement enter upon a more tranquil path. Moreover, it is pointed out that in the industrial districts of Germany, for example, the Christian industrial movement, supported by Protestants and Catholics alike, has achieved considerable results, and proved a serviceable means of combating the seductions of Socialism. It is finally urged that we must not ignore the fact that in these days the Church has reminded the wealthy classes of their duties to the sick and toilers, and that by making the social question its own it has gone a long way towards permeating all social and political conditions with the spirit of Christianity.

These are the arguments that can be urged against and for the policy of Leo XIII. We refrain from commenting upon matters that are still in course of development, and leave it to the 20th century to make up the balance-sheet of this account. (F. X. K.)

Vaucluse, a department of the south-east of France, traversed by the Alps of Provence and watered by the Rhône.

Area, 1381 square miles. The population, 241,787 in 1886, numbered only 235,457 in 1901. The births in 1899 were 4517, of which 215 were illegitimate; deaths, 5191; marriages, 1790. Four hundred and sixty-five schools in 1896 were attended by 29,000 pupils, 5 per cent. of the population being illiterate. The land under cultivation in 1896 amounted to 679,250 acres; 405,080 acres arable, and 44,460 acres under vines. The wheat raised in 1899 was valued at £744,000; oats, £74,320; potatoes, £283,000; mangold-wurzel, £105,000; beetroot, £11,800. The vintage of 1899 was valued at £569,000. The sericultural production in 1898 amounted to 17,200 cwt. of cocoons. The live stock numbered (1899) 13,510 horses, 15,200 mules, 3560 cattle, 238,200 sheep, 42,100 pigs, and 14,380 goats. In 1898, 2774 metric tons of lignite and 8100 tons of sulphur were mined. The distilleries produced 74,000 gallons of alcohol in 1898. Other industries are in paper, linen stuffs, silk, and chemical products. Avignon, the capital, had in 1901, 46,209 inhabitants.

Vaud, one of the Swiss cantons. Its total area is 1247·6 square miles. Of this no fewer than 1056·8 square miles are classed as "productive," forests covering 282 square miles, and vineyards 25½ square miles. Of the "unproductive" 190·8 square miles, 4·3 square miles are occupied by glaciers, while 123½ square miles is the cantonal share of the Lake of Geneva, 33·1 square miles that of the Lake of Neuchâtel, and 3·6 square miles that of the Lake of Morat. The population in 1888 was 247,655; in 1900 it was 284,673, or 226 inhabitants to each square mile. The great majority of the people are Protestant and French-speaking, the Roman Catholics being about one-thirteenth of the whole and the German-speakers about one-eleventh. The capital is Lausanne. In 1897 the state revenue was 9,132,547 francs (a rise of 86¾ per cent. since 1885), and the state expenditure, 9,212,652 francs (a rise of 89¾ per cent. since 1885), while the public debt was 10,656,000 francs. The canton is divided into nineteen administrative districts. In 1888 Vevey had 7925 inhabitants, increased in 1899 to 10,482, so that it is the second town in the canton. "Montreux" is a general name for a number of villages scattered along the shore of the lake. From Glion, above Territet-Montreux, there is now a funicular railway up to the Rochers de Naye. Yverdon had 6275 inhabitants in 1888, and 7980 in 1900. The political cantonal constitution of 1885 is still in force.

See *Dictionnaire géographique et descriptif du Canton de V.* Vevey, 1827. *Documents relatifs à l'hist. du Pays de Vaud, 1293–1750.* Geneva, 1817.—P. MAILLEFER. *Histoire du Canton de Vaud.* Lausanne, 1902.—*Mémoires and Documents* (published by the Soc. de l'Hist. de la Suisse Romande). Lausanne. From 1838.—MEREDITH READ. *Historic Studies in Vaud, Bern, and Savoy*, 2 vols. London, 1897. (W. A. B. C.)

Vegetarianism.—This comparatively modern word, which came into use about the year 1847, is applied to the practice of living upon foods from which fish, flesh, and fowl are excluded. There have from time to time been various sects or schools of thought that have advocated narrower views. Some of these have excluded all animal products—such as milk and eggs and cheese. Some have excluded all cooked foods, and have preached the virtues of fruits and nuts and grains in their natural ripe state. Some have abstained from all underground-grown roots and tubers, and have claimed special benefits from using only those fruits and vegetables that are grown in the sunlight. Some have given up all grain and pulse foods, and have declared that old age can be best resisted by living entirely upon fruits, salads, nuts, soft water, and milk products. Some have added fish to their dietary; but, speaking generally, all who are called vegetarians will be found to abstain from the use of flesh and fowl and almost invariably also from fish as food.

The fact, however, must not be overlooked that while vegetarian societies claim as "vegetarians" all who abstain from flesh foods, there is a large and growing number of people who repudiate the name of "vegetarian" because of its associations, but who none the less, for some of the reasons detailed below, abstain from eating anything that has been killed. The Order of the Golden Age, for example, of which the headquarters are Barcombe Hall, Paignton, South Devon, has adopted the words "Fruitarian" and "Fruitarianism" to denote the dietary of its members. The rule laid down by the Order is abstinence so far as possible from all foods which are obtained by the cruel infliction of pain, and the minimum that is set is complete "abstinence from flesh and fowl," while net-caught fish may be used by associate members.

The reasons that are advanced for the practice of fruitarianism or vegetarianism are very comprehensive, but the principal ones may be considered to be the following:—

1. *Health.*—(*a*) On the ground that animals are affected by diseases which are communicable, and are actually communicated, to man by the ingestion of their flesh, *e.g.*, parasites, tuberculosis; (β) on the ground that the flesh of artificially-fed animals is full of excretory substances, and that, therefore, *under modern conditions*, flesh-eating is injurious, and may be a cause of excretory substance and uric acid deposits or rapid tissue-destroying diseases in man; *e.g.*, gout, cancer.
2. *Economy.*—On the ground that the assimilable nutriment from a given weight of selected fruit and grain and nut and vegetable foods will cost less than the same nutriment obtained from flesh foods.
3. *Social Economy.*—On the ground that an acre of cultivable land under fruit and vegetable cultivation will produce from two to twenty times as much food as if the same land were utilized for feeding cattle.
4. *Racial Improvement.*—On the ground that the aim of every prosperous community should be to have a large proportion of hardy country yeomen, and that horticulture and agriculture demand such a high ratio of labour, as compared with feeding and breeding cattle, that the country population would be greatly increased by the substitution of a fruit and vegetable for an animal dietary.
5. *Character Improvement.*—On the ground that after the virtues of courage and valour and fearlessness have been taught in the lower stages of evolution, the virtue of gentle humaneness and extended sympathy for all that can suffer should be taught in the higher cycles of the evolutionary spiral. Flesh eating entailing necessarily an immense volume of pain upon the sentient animal creation should be abstained from by the "higher classes" in the evolutionary scale.

Organizations have been established to advocate this method of living under the name of "Vegetarian Societies" in many countries—chiefly the United Kingdom, America, Germany, France, Austria, Holland, and Australia. Propagandism is carried on by lectures, literature, cookery demonstrations, and restaurants. In England, the oldest and one of the most important societies is "The Vegetarian Society," of which the headquarters are at Oxford Street, Manchester. There are also several small London societies, and an active London Association. A few provincial towns, too, have small societies. An attempt has been made to organize the various vegetarian societies of the world under the title of "The Vegetarian Federal Union." The headquarters of the London societies and of the "Union" are at Memorial Hall, Farringdon Street, E.C.

There are nominally about 35 organized societies in existence, but the extent to which public opinion and practice in the matter of dietary has been affected during the last decade of the 19th century is not to be gauged by the membership of such organizations. There are in England some 60 vegetarian restaurants and boarding-houses, one hospital and one or two sanatoria. In Germany and America there are many institutions where flesh is only prescribed in special cases. Flesh food is not included in the dietary of the chief hospitals and orphanages of the Native States of India, excepting in the wards devoted to Europeans.

The athletic side has been represented in national and international races by vegetarians winning the Berlin and Dresden walking match (125 miles), the Carwardine Cup (100 miles) and Dibble Shield (6 hours) cycling races (1901 and 1902), the amateur championship of England in tennis (4 successive years up to 1902) and racquets (1902), the cycling championship of India (3 years), half-mile running championship of Scotland (1896), world's amateur cycle records for all times from 4 hours to 13 hours (1902), 100 miles championship Yorkshire Road Club (1899, 1901), tennis gold medal (5 times).

In the religious world the Seventh Day Adventists (who are connected with many sanatoria and the manufacture of food specialities) and some Bible Christians, the worshippers of Vishnu and the Swami Narang and Vishnoi sects, amongst others preach abstinence from flesh food. The Salvation Army, the Tolstoyans, and the Doukhobors encourage it. A number of Orders in the Roman Catholic Church (*e.g.*, the Trappists) and in the Hindu faith (*e.g.*, the Dadupanthi Sadus) are pledged abstainers.

Social movements are in certain directions tending also towards vegetarianism. Members of societies, like the various anti-vivisection societies and the animal protection societies, are being met with the rejoinder to their propaganda, that if they want to convert other people to abstain from the infliction of pain upon animals they must themselves set the example by abstaining from foods which are obtained by the infliction of much pain.

The enormous importation of fruits, and the great development in the methods of preparing and preserving vegetable foods, are making it increasingly easy for people to live as luxuriously as has been their wont without being obliged to use animal foods. The general conclusion appears to be that while the middle and lower classes are now eating more meat than they used to do, there is growing up a wide conviction that people are eating "too much" meat, and the pendulum is swinging towards the teaching of the Fruitarian School.

The literature on the subject is considerable, but the two classics are perhaps *The Ethics of Diet*, by HOWARD WILLIAMS, and *The Perfect Way in Diet*, by Dr ANNA KINGSFORD. In former years the "Vegetarian Society" was the most active in producing literature, but since about 1901 the Order of the Golden Age has come to the front with new and up-to-date books, booklets, and leaflets, and the Ideal Publishing Union has reprinted much of the earlier literature. The chief periodicals are the *Vegetarian* (weekly), the *Herald of the Golden Age* (monthly), the *Vegetarian Messenger* (monthly), the *Vegetarian* (American monthly), the *Children's Garden* (monthly). (J. O.)

Veitch, John (1829–1894), Scottish philosophical writer, was born at Peebles in 1829, and educated at Edinburgh University. During the years 1855 and 1856 he acted as assistant lecturer to Sir William Hamilton and his successor Professor Campbell Fraser. In 1860 he was appointed to the chair of logic, metaphysics, and rhetoric in St Andrews, removing four years later to the corresponding chair in Glasgow. He published a translation of Descartes' *Discours de la méthode* in 1850, and of the *Meditations*, with selections from the *Principes*, in 1852. In conjunction with Dr Mansel he prepared Sir W. Hamilton's lectures for publication in 1859, and wrote a memoir of the latter. Among his other works are *Institutes of Logic*, in which he adopts his master's innovation of the quantifying of the predicate, and *Essays in Philosophy: Knowing and Being and Monism and Dualism.* In these essays he exhibits the peculiarly critical and analytic cast of his mind. In philosophy he was an Intuitionist, dismissing the Idealist arguments with some abruptness. He was a great lover of poetry, and was an authority on Scottish Border ballads. He wrote also on *The Theism of Wordsworth.* He died 3rd September 1894.

Vejer de la Frontera, a town of Spain, in the province of Cadiz, near the coast, on the right bank of the river Barbate, on a hill some five miles north of Cape Trafalgar. It has an old parish church, San Salvador, with several convents, and two other more modern churches, several hermitages, and a bridge of four arches on the Barbate. The surrounding country is very picturesque, hilly, with lovely vegetation, abounding in fruit and other agricultural produce, live stock, especially bulls bred for the ring, and famed for their agility and ferocity. The town was taken from the Moors in 1248 by San Fernando, and long remained a fief of the dukes of Medina-Sidonia. Population (1887), 7760; (1897), 10,861.

Vejle, a seaport town of Denmark, capital of the county of Vejle, at the head of a fjord on the eastern side of Jutland, 69 miles by rail north-west of Odense. The harbour is entered and cleared by about 140,000 tons annually. Population (1890), 9015; (1901), 14,592.

Veliko-Mikhailovka, a village of Russia, in the government of Kursk, 44 miles east-north-east of Byelgorod railway station. It carries on a considerable trade in grain and animal products. Population (1897), 20,700.

Velletri, a town and episcopal see of the province of Rome, Latium, Italy, at the south-east foot of the Alban mountains, 20 miles south-east of Rome. In 1883 a monolith was erected to commemorate Garibaldi's victory in 1849 over the Neapolitan troops. It is the see of the bishop of Ostia, and has a statue of Pope Clement VIII., and a technical school. Good wine is made. Population (1891), about 13,500; (1900), about 16,500.

Vellore, a town of British India, in the North Arcot district of Madras, on the river Palar, with a station on the South Indian Railway, 80 miles from Madras city. Population (1891), 44,925; (1901), 43,458; municipal income (1897–98), Rs.59,770. It is still a military cantonment, and has a special manufacture of perfumery. An American mission manages a high school (raised to the rank of a college in 1898). There are five printing-presses and three reading-rooms.

Vendée, a department of western France, bordering on the Atlantic Ocean and watered by the Sèvre Niortaise and the Sèvre Nantaise.

Area, 2692 square miles. The population, 434,808 in 1886, had increased to 439,637 in 1901. The births in 1899 were 10,246, of which 358 were illegitimate; deaths, 8224; marriages, 3309. The 881 schools were attended in 1896 by 68,000 pupils, and 6 per cent. of the population was illiterate. The land under cultivation in 1896 amounted to 1,538,810 acres, of which 1,081,860 acres were arable and 41,990 acres under vines, a considerable area consisting of grass lands. The yield of wheat in 1899 was valued at £1,604,000; oats, £256,000; barley, £83,800, the other cereals yielding but insignificant values. The potato crop was worth £248,300; mangold-wurzel, £272,900; the green crops (trefoil and lucerne), £201,200; natural pastures and grass lands, £495,300. The vintage of 1899 was valued at £638,000. The horses numbered (1899) 26,500; cattle, 356,437; sheep, 166,800; pigs, 77,205; goats, 3403. The milk produced in 1899 was valued at £840,000. Mining in 1898 turned out 23,200 metric tons of fuel, and 48,318 tons of sea-salt were produced. Apart from starch-making and tanning, industry is in a backward state. La Roche-sur-Yon, the capital, had 12,710 inhabitants in 1901.

Venetia, a territorial division of North Italy, lying between the Alps and the Adriatic, and stretching from the frontier of Carinthia and Istria (Austria) in the north-east to the lower Po and Lombardy in the south-west. It comprises the provinces of Belluno, Padua, Rovigo, Treviso, Udine, Venice, Verona, and Vicenza, and has an area of 9476 square miles. Population (1881), 2,814,173; (1901), 3,130,429. The crops principally grown are maize, wheat, rice, wine, mulberry, tobacco, chestnuts, potatoes, and hemp. Copper and lignite are mined, and turf is extracted. The chief industries are the manufacture of woollens, cottons, silks, glass, laces, tobacco, straw-plait, paper, sugar, and hemp, the breeding of silkworms, iron-works and foundries, saw-mills, and shipbuilding. Its history is that of its chief towns, especially Venice. The peasantry suffer much from the miserable disease of pellagra. The principal towns are Venice, Padua, Verona, Vicenza, Udine, Treviso, Belluno, Rovigo, Chioggia, Vittorio, Legnago, and Este.

Venezuela, a country and republic of South America, lying on the Caribbean coast, and bounded inland by the frontiers of Colombia, Brazil, and British Guiana. It stretches from about 1° 40′ to 12° 26′ N. and about 59° 43′ to 73° 30′ W. The boundary towards Colombia was in the main determined by Spanish arbitration, under the convention of 16th March 1891, that towards Brazil having been fixed under the convention of 1883. In the dispute with Great Britain as to the boundary on the eastern side, the Venezuelan Government sought the intervention of the United States, and, under a treaty ratified 14th June 1897, the question was referred to a court of arbitration, which sat at Paris and gave its decision on 3rd October 1899. According to this award the boundary starts from Point Playa on the Caribbean coast, and, crossing the river Barima, runs to the point where the rivers Haiowa and Amakuru unite. Thence it follows the line known as the Schomburgk Line as far as the point of confluence of the Cuyuni and Wenamu rivers, whence it ascends the Wenamu to its most westerly source, there rejoining the Schomburgk Line, which it follows for the rest of its course.

Area and population. The area of Venezuela in 1891, inclusive of the regions awarded to Colombia and Great Britain since that year, was variously estimated at from 396,400 to 593,940 square miles, and the population was put at 2,323,530. Though the territorial claims of the Republic are now largely reduced, the population within Venezuelan boundaries is only slightly altered, the greater part of the disputed regions being very sparsely inhabited. The population (1891) consisted of 1,137,140 males and 1,186,390 females. Whites, mulattoes, and negroes numbered 1,997,530, and Indians 326,000, of whom 240,000 were domesticated, 20,000 were subjugated, and 66,000 were independent. In 1894 the total population was put at 2,444,816. In the year 1897–98 the number of marriages within the Republic was returned at 3940; of births, 61,835; of deaths, 48,761; the registration results are, however, of little or no value. There is practically no immigration. Various schemes announced since 1896 for the introduction of Italian and other immigrants have come to nothing. The purely white element of the population gradually decreases, while the negro becomes stronger. The principal towns, with their populations, are Caracas, the capital (75,000), Valencia (38,000), Maracaibo (30,000), Barquisimeto (25,000), Victoria (15,000), Ciudad de Cura (12,000), Ciudad Bolivar (11,000), Barcelona (12,000), Puerto Cabello (10,000), La Guayra (8000).

Government. The constitution in force is that of 29th March 1901, which provides for the representation of the twenty states, for the reorganization of which, as they existed in 1864, an Act was passed in 1899. The Congress consists of the Senate and the Chamber of Deputies. Each state appoints (through its legislature) two senators for the term of six years. The Chamber of Deputies is composed of representatives of the states, elected by direct popular vote for six years, one deputy for every 40,000 inhabitants, and another if there are over 20,000 inhabitants more. The President of the Republic is elected for six years, and is assisted by a cabinet of ministers. Each state has its own separate legislature. Federal territories are administered under the direction of the central Government.

Education. The school system requires that primary instruction be free and compulsory. Certain revenues, including the proceeds of the sale of stamps, fines for the infraction of the law as to school attendance, duties on tobacco imports, and other taxes, amounting in 1898 to £105,000, have been assigned for educational purposes. The educational result, however, is unsatisfactory. There is nothing to show that the revenues nominally assigned to instruction are applied to that purpose, and it is clear that education is neglected, the great majority of the lower classes being unable either to read or write. In the principal towns there are schools, and there the clergy render some assistance, but they make no effort in the country districts where few schools exist, and the owners of coffee estates and other employers of labour are indifferent. For secondary instruction there are schools in various parts of the country; at Caracas there is a university, and at Merida, Valencia, Maracaibo, Ciudad Bolivar, and Barquisimeto there are similar institutions. But the defects of these schools and colleges are such that the wealthier Venezuelans send their sons to the German school in Caracas, or to the British colony of Trinidad, or even to the United States or to Europe to be educated.

Justice. Justice is administered by the Federal High Court and the Supreme Court of Appeal, and by many local courts for civil and for criminal cases. In the civil courts, however, legal process is dilatory, and in the criminal it is seldom that offences are effectively dealt with. Away from the towns scarcely any attempt is made to protect life and property by an efficient system of police.

The army consists of about 3600 men, and there is a national militia in which all citizens may be required to serve. The Republic possesses three steamers and a sailing vessel.

Finance. The Federal revenue is derived chiefly from import duties and stamps; the expenditure is devoted mainly to internal administration and debt charges. In 1898 the revenue was £1,337,200 and the expenditure £1,821,700, and in 1901–02 they were estimated to balance at £1,480,000 (25 bolivares being taken as £1). Besides the national revenue, the Federal Government collects and accounts for the state revenues, which are derived entirely from an additional import tax (substituted for the former state tax on goods in transit), and from the proceeds of sales of salt and of mining and waste lands. The municipal revenues are obtained from taxes on house property and on certain industries. The external debt in the middle of the year 1901 amounted to £4,577,290, besides £593,858 arrears of interest, for the payment of which no arrangement had been concluded. At the end of 1898, according to Venezuelan accounts, the whole debt, internal and external, stood at £7,803,400, or 195,084,071 bolivares. The principal obligations, besides the external loans of 1881 and 1896, were the consolidated internal debt of £2,494,400, or 62,358,643 bolivares, the Caracas waterworks loan, £422,600, and the diplomatic debt (arising out of damage to property of foreigners), £267,600. The rates of interest range from 3 to 13 per cent. per annum. The total charge amounts to about £496,000. There is also a large floating debt.

Agriculture. The chief agricultural industries are the cultivation of coffee, cocoa, and the sugar-cane, but natural products such as vegetable ivory, mahogany and other woods are collected. The principal source of wealth is coffee, and its cultivation extends over all the northern districts. In 1896 the area under cultivation was estimated at 180,000 acres, yielding on the average 5 cwt. per acre. Owing to revolutionary disturbances and the low prices obtained for coffee, the plantations tend to diminish. In 1900 the exports of coffee from Venezuelan ports amounted to 43,217 tons (Maracaibo, 20,050 tons; Puerto Cabello, 12,994; La Guayra, 10,160; Cindad Bolivar, 13). Cocoa is cultivated in the warm and moist lower lands. The shipments of raw cocoa in 1900 were: from La Guayra, 5650 tons; from Puerto Cabello, 455 tons; from Maracaibo, 181 tons; from Ciudad Bolivar, 37 tons. A considerable quantity, in addition, is stated to leave the country in the form of manufactured chocolate. The sugar industry is only kept alive by the prohibition of the import of foreign sugar, neither the soil nor the climate being specially adapted for this culture. Minor agricultural products are maize, beans, fruits, and vegetables cultivated for local consumption; cocoa-nuts, grown partly for their oil, partly for export to the United States; tobacco of inferior quality for local consumption. Mahogany, *lignum vitæ*, and other hard woods are worked in the Orinoco district, but the trees are widely scattered and the cost of transport is high. The number of cattle is estimated at between four and five millions, but the development of the cattle industry has been hindered by the chronic political troubles, all the parties to every quarrel making free use of the herds grazing on the *llanos*. The animals are small-bodied and long-horned, the descendants of those introduced by the early Spanish colonists. They were formerly of value mainly for their hides, but large numbers of living animals have been shipped to Cuba. Other live stock consists of horses, mules, donkeys (indispensable for transport), sheep, goats, and swine, but of the numbers of these animals there is no really trustworthy estimate.

Mining.

Gold mining, formerly prosperous, has fallen into disrepute. The mines are to the south of the Orinoco, and in the Andine district in the west. In 1890 gold was exported to the value of £349,234; in 1894 the value was £180,000; in 1898, £111,068; in 1899, £120,975; in 1900, £63,904; in 1901, £89,151. Copper mining has practically ceased. In 1890 the export of copper ores amounted to £97,990; since 1894 none has been exported. The iron ores found in the Imataca mountains, near the Orinoco, are being worked by a British syndicate, whose operations, however, are retarded by the difficulty of obtaining a clear title from the Government. Coal is worked near Guanta; the salt mines continue to yield a large revenue.

The number of persons employed in the agricultural, pastoral, and mining industries is estimated at 60,500, of whom 41,000 work on coffee, cocoa, and sugar plantations; 10,000 on agricultural farms; 8000 on cattle ranches, and 1500 at the mines. Other industries, such as brewing, leather-work, candle-making, are of strictly local interest.

Commerce.

In recent years commerce has suffered from the reaction following a period of undue inflation. During the twelve years 1883–1894 about £10,000,000 of European capital was introduced for the construction of railways, port works, and other purposes, and when the inflow of money ceased, trade fell off. The commercial depression was subsequently deepened by the general decrease in the price of coffee, the staple product. Trade statistics are largely estimates, but the following figures indicate the value of the imports and exports in various years:—

Year.	Imports.	Exports.
1893 . . .	£4,395,000	£3,456,800
1895 . . .	3,900,000	4,458,200
1897 . . .	2,748,530	3,729,800
1898 . . .	1,711,900	2,979,902

Of the imports about 44 per cent. in value are supplied by the United States, chiefly in the form of flour, petroleum, rape, lard, &c.; Germany sends hardware and beer; Great Britain, cottons and other manufactured goods; and France, wines and oils. The exports are mainly coffee, cocoa, hides and skins, and cattle, but rubber and gutta-percha, copra, fustic, divi-divi, fish sounds, feathers, quina bark, and copaiba are sent abroad in considerable quantities. Germany and the United States take most of the coffee; France, most of the cocoa; the United States, the hides and skins. The Venezuelan merchandise imported into Great Britain is mainly gutta-percha and ornamental feathers. There are few British or United States merchants within the Republic. Germans are numerous, Venezuelans coming next in importance, then French, Italians, and Spaniards.

Shipping and communications.

The principal port is La Guayra, which has a breakwater about 2050 feet in length, within which there is accommodation for vessels drawing 26 feet of water. In 1900 La Guayra was visited by 315 vessels; Maracaibo, by 403; Puerto Cabello, by 267; Ciudad Bolivar, by 74. Five lines of steamers connect La Guayra with American and European ports. On the Orinoco, Apure, and other rivers steam and sailing vessels maintain communication between the coast and inland towns. Roads are in general mere mule tracks. There are 434 miles of railway, of which the Government owns 12 miles, the remainder being the property of nine companies. In the postal system there are 214 post-offices. The Government telegraph line extends 3880 miles, and is served (inefficiently) by 113 telegraph offices. A French cable connects Venezuela with the rest of the world. Two telephone companies are at work in Caracas and other towns.

Credit.

The currency is on a gold basis, 12,000,000 bolivares in gold, and 8,000,000 in silver being in circulation. All foreign gold has fixed legal value, the bolivar for all purposes of calculation being taken as a franc. In official statistics, sums of money are stated in bolivares, but in general commerce values are stated in pesos, or "soft" dollars of four bolivares, as distinguished from "hard" dollars of five bolivares. Gold coins of 20 and 25 bolivares are minted, and a few of 50 and 100 bolivares. The silver coins in circulation are the dollar (5 bolivares), 50-, 40-, 20-, 10-, and 5-cent pieces. Nickel coins of 2 cents and 1 cent are used, and a few copper pieces of the same value. Bank-notes, issued by the banks of Venezuela and Caracas, are everywhere accepted at their face value. The Venezuelan Government has steadily refused the many offers made to establish a state bank to issue notes having the force of legal tender. This firm attitude has saved the country from a flood of inconvertible paper-money.

There are three banks, the Bank of Caracas, the Bank of Venezuela, and the Bolivar Bank, the first two being old-established institutions. The Bolivar Bank, established in 1897 with a capital of 20,000,000 bolivares, administers the salt deposits, receiving 10 per cent. of the net salt revenue. The bank gives the Government a credit of 6,000,000 bolivares at 8 per cent. interest, and has also agreed to lend to farmers a sum of 10,000,000 bolivares.

The old Spanish weights and measures still linger, though the metric system is officially adopted.

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(W. W. R.; I. P. A. R.; C. E. A.)

Recent History.—For two decades after the close of the revolutionary troubles in 1870 the supreme power in Venezuela was, for all practical purposes, in the hands of Señor Guzman Blanco. He evaded the clause in the Constitution prohibiting the election of a President for successive terms of office by invariably arranging for the nomination of some adherent of his own as chief of the executive, and then pulling the strings behind this figurehead. The tenure of the Presidential office was for two years, and at every alternate election Guzman Blanco was declared to be duly and legally chosen to fill the post of chief magistrate of the Republic. In 1889 there was an open revolt against the dictatorial system so long in vogue; and President Rojas Paul, Blanco's *locum tenens*, was forced to flee the country and take refuge in the Dutch colony of Curaçoa. A scene of riot and disorder was enacted in the Venezuelan capital. Statues of Blanco, which had been erected in various places in the city of Caracas, were broken by the mob, and wherever a portrait of the dictator was found it was torn to pieces. No follower of the Blanco régime was safe. An election was held and General Palacios was nominated to the office of President. A movement was set on foot for the reform of the Constitution, the principal objects of this agitation being to prolong the Presidential term to four years, to give Congress the right to choose the President of the Republic, and to amend certain sections concerning the rights of persons taking part in armed insurrection arising out of political issues. All might have gone well for President Palacios had he not allowed ambitious ideas to lead him to suppose that this extension of the Presidential period might be made to apply to himself. His attempt to force this question produced violent opposition in 1891, and ended in a rising headed by General Joaquin Crespo. This revolt, which was accompanied by severe fighting, ended in 1892 in the triumph of the insurgents, Palacios and his followers being forced to leave the country to save their lives. General Crespo became all-powerful; but he did not immediately accept the position of President. The reform of the Constitution was agreed to, and in 1894 General Crespo was duly declared elected to the Presidency by Congress for a period of four years. One of the clauses of the reformed Constitution accords belligerent rights to all persons taking up arms against the State authority, provided they can show that their action is the outcome of political motives. Another clause protects the property of rebels against confiscation. Indeed, a premium on armed insurrection is virtually granted.

In April 1895 the long-standing dispute as to the boundary between British Guiana and Venezuela was brought to a crisis by the action of the Venezuelan authorities in arresting Inspectors Barnes and Baker, of the British Guiana police, with a few of their subordinates, on the Cuyuni river, the charge being that they were illegally exercising the functions of British officials in Venezuelan territory. Messrs Barnes and Baker were subsequently released, and in due course made their report on the occurrence. For the moment nothing more was heard of this boundary question by the public, but General Crespo instructed the Venezuelan minister in Washington to ask for the assistance of the United States in the event of any demand being made by the British Government for an indemnity. Whilst this frontier difficulty was still simmering, an insurrection against General Crespo was fomented by Señor Rojas Paul, the representative of the Blanco régime, and came to a head in October 1895, risings occurring in the northern and southern sections of the Republic. Some desultory fighting took place for three or four months, but the revolt never was popular, and was completely suppressed early in 1896. The Guiana boundary question now began to assume an acute stage, the Venezuelan minister in Washington having persuaded President Cleveland to take up the cause of Venezuela in vindication of the principles of the Monroe Doctrine. On 18th December 1895 a message was sent to the United States Congress by President Cleveland practically stating that any attempt on the part of the British Government to enforce its claims upon Venezuela as regards the boundary between that country and Guiana without resort to arbitration would be considered as a *casus belli* by his Government. The news of this message caused violent agitation in Caracas and other towns. A league was formed binding merchants not to deal in goods of British origin; patriotic associations were established for the purpose of defending Venezuela against British aggression, and the militia were embodied. The question was subsequently arranged in 1899 by arbitration (see vol. xxv. p. 558), and by the payment of a moderate indemnity to the British officers and men who had been captured. Diplomatic relations between the two countries, which had been broken off in consequence of the dispute, were resumed in 1897.

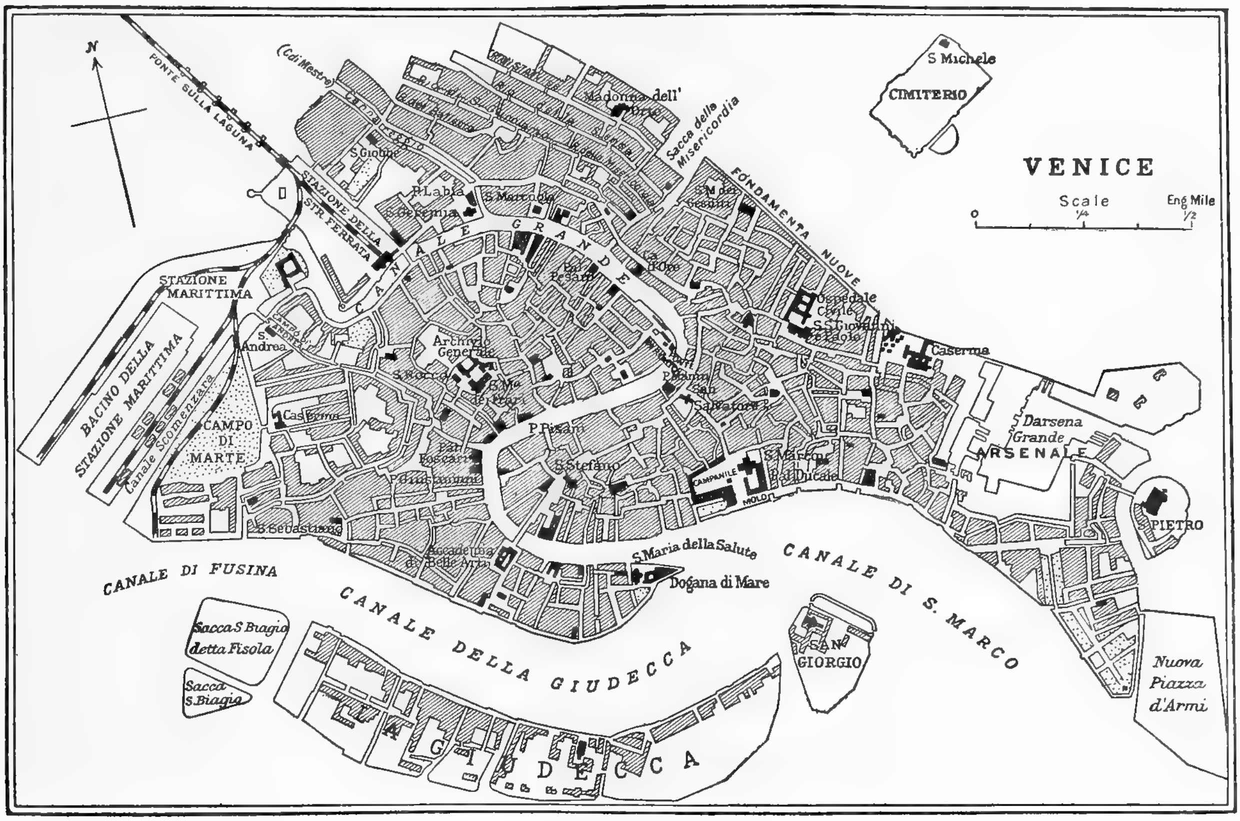
In 1898 General Crespo was succeeded as President by Señor Andrade, who had represented Venezuela in Washington during the most acute stage of the frontier question. Towards the end of the year a revolutionary movement took place with the object of ousting Andrade from power. The insurrection was crushed, but in one of the final skirmishes a chance bullet struck General Crespo, who was in command of the Government troops, and he died from the effects of the wound. A subsequent revolt overthrew President Andrade in 1900. General Castro then became President. During 1901 and 1902 the internal condition of the country remained disturbed, and fighting went on continually between the Government troops and the revolutionists.

Nominally in Venezuela the inhabitants have a right to vote for the members of Congress, but in reality this privilege is not exercised by them. Official nominees are invariably returned without any opposition, the details of the voting having been previously arranged by the local authorities in conformity with instructions from headquarters. In these circumstances the administration of public affairs fell into the hands of an oligarchy, who governed the country to suit their own convenience. It is this system which is the constant cause of revolutionary outbreaks. Since Venezuela became independent there have been about fifty revolutions within her borders, and ten of these proved successful. (C. E. A.)

Venice, a maritime city in the north-east of Italy, at the head of the Adriatic. Since 1880 Dryden's "dream upon the sea," which for most foreigners is one vast but inert monument, has undergone considerable change and development. Its industries have become flourishing, its commerce has extended, its hygienic conditions have improved, and its population increased from 132,826 in 1881 to 167,184 in 1898, exclusive of the garrison, and to 169,749 in 1899, according to the municipal estimate. With the increase of population and commerce the wealth of the community has also grown, the city budget having shown a constant surplus since 1881. In 1899 the surplus was £5430 on a total income and expenditure of £407,560. The municipal debt, which at the end of 1895 amounted to £273,987, has been reduced by more than £20,000, and is expected to be almost entirely extinguished in 1920. The ancient glass-bead industry (*conterie*), which some years since suffered severely from over-production, has now regained its position through the union of the different factories, by which the output is controlled in such a way as to render trade profitable. Venetian beads are now sent in large quantities to the various colonies in Africa from Marseilles, Bordeaux, London, Liverpool, and Amsterdam, and are largely shipped to India, Sumatra, and Borneo direct from Venice by the Suez Canal. Similarly, the glass industry has revived and is now as flourishing as in the most prosperous periods of the Republic of Saint Mark. Many new factories have been founded at Venice and Murano, new amalgams and methods of colouring have been discovered, and fresh forms have been diligently studied. Special progress has been made in the production of mirrors, electric lamps, candelabra, and mosaics. New industries, which have already acquired a firm footing, are those of tapestry, brocades, imitation of ancient stuffs, cloth of silver and gold, and Venetian laces. The secret of lace-making was believed to have been lost, but the late Signor Fambri discovered at Chioggia an old woman who knew it, and placed her at the head of a lace school. Fambri was ruined by his enterprise, but other manufacturers, more expert than he, drew profit from his initiative and founded flourishing factories at Pellestrina and Burano. Other important industries are wood-carving (of an artistic excellence long unknown), artistic iron-working, jewelling, bronze-casting, the production of steam engines, machinery, matches (largely exported to Turkey, Egypt, Russia, Austria-Hungary, and Greece),

Nationality.	Entrances.				Clearances.			
	1897.		1899.		1897.		1899.	
	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.
Italian	1708	444	1880	543	1566	435	1640	539
Austro-Hungarian	1042	298	937	343	942	297	891	349
British	255	360	253	380	262	381	242	373
German	36	42	31	40	33	38	33	42
Greek	34	37	27	28	34	36	26	28
Swedish and Norwegian	28	19	11	10	27	19	11	9
Totals (including others)	3117	1208	3163	1359	2877	1203	2864	1334

clock-making, wool-weaving, and the manufacture of chemical manures. In addition, an industrial and electrical company transmits to Venice electrical power generated by the torrent Cellina, which descends from Belluno and flows into the Meduna near Pordenone. The trade of the port consists chiefly of goods in transit. This transit trade necessitated the construction of a wharf, or maritime station, with direct railway sidings, which was opened on 1st May 1880. It covers an area of 87 acres in the lagoon, and is traversed by the Buranei canal. It comprises a square landing stage extending as far as the Grand canal, across which a two-span iron bridge, 63 yards long, has been built to connect the wharf with the railway. A foot-bridge connects the wharf with the Campo di Sant' Andrea. Upon the wharf stand the custom houses, railway offices, and warehouses, covering a total area of over 2 acres. A mole or jetty of an average width of 98 yards runs along the Scomenzara canal, opposite the Campo di Marte, and is used for unloading vessels of less than 13 feet draught. Between the jetty and the so-called Sacca Marginata is a basin for larger sea-going ships, 780 yards long and 211 yards broad, with a depth of 26 feet at high tide. This accommodation is now insufficient for the needs of the port, and considerable extensions are projected. The importance of Venice has developed so rapidly that while, in 1881, it held only the sixth place, it now holds the second place among Italian ports, coming next after Genoa.



Plan of Venice.

The table on the previous page gives the shipping (steam and sail) statistics for 1897 and 1899 (tonnage in thousands of tons).

The development of the port has stimulated enterprise. In 1898 the Società Veneta di Navigazione placed the ancient flag of Saint Mark once more upon the high seas; on 1st January 1901 inland navigation was reopened between Venice and Pavia along the Po and inland canals; the building and fitting out of large iron steamers is being undertaken; a new line of railway from Venice to Trieste, *viâ* San Giorgio di Megaro, has reduced the journey to three and a half hours instead of the six required for the sea passage. Within the city and between the islands of the estuary and Chioggia and Fusina rapid and cheap communication is maintained by the steamers, large and small, of the Società Veneta Lagunare, which constitute the tramways of Venice. During the bathing season these steamers run to the Lido, which has been revolutionized since 1880, a clean, populous, well-lighted seaside and bathing resort having replaced the former squalid village. The port of Lido, long rendered unserviceable by sandbanks, has been reopened by the construction of two moles, one, $2\frac{1}{4}$ miles long, running north-east and the other, $1\frac{3}{4}$ miles long, running south-west, at a cost of £240,882. These moles, which rise $6\frac{1}{2}$ feet above high-water mark, have, by creating a channel 380 yards long, had the effect of greatly reducing the sandbanks, so that vessels of 23 feet draught can now enter the port. In order completely to remove the sandbanks it will be necessary to lengthen the moles. £3000 has also been spent in laying two gas buoys, in accordance with the requirements of the Washington Conference. The arsenal of Venice, which has kept pace with the developments of the port, has furnished thirteen war vessels and cruisers to the Italian navy since 1879. The arsenal has been enlarged by the addition of new docking basins and modern plant. It gives constant employment to 6000 workmen.

The public elementary schools impart instruction to some 9000 scholars of both sexes (5300 boys, 3700 girls), of which 7400 (4300 boys, 3100 girls) belong to the lower, and 1600 (980 boys, 620 girls) to the upper standard. These figures do not include the four communal infant asylums, which maintain 295 male and 252 female children. As far as possible special school buildings have been constructed on hygienic principles, and efforts have been made to deal with the problem—especially difficult at Venice, where space is limited—of physical education. About 1880 a wealthy Venetian, Signor Combi, bequeathed a fund for clothing and feeding poor children during the winter, and an association entitled Pro Schola, with similar objects, has been formed with the help of the municipality. In addition, the commune subsidizes a superior girls' school and a girls' professional school, both for the poorer classes and both imparting technical instruction. Private educational institutions are numerous. They include eighteen infant schools, twelve elementary boys', six elementary girls', and seven mixed schools. About half are lay and half religious; but only four of the female and none of the male teachers belong to the clergy. All are required to possess Government diplomas. Some of the private educational institutes, like the Instituto Manin and the foundling hospitals, are really charitable institutions with resources of their own, which good administration and frequent legacies continually increase.

Since 1890 public charity has been regulated by a special law. Statistics for 1892–97 show the number of families relieved during that period to have been 16,709, exclusive of the Jews, whose poor are looked after by the Fraterna Generale Israelita, to which the Charity Commissioners assign a proportionate revenue. During the same period the number of Venetian charitable institutions was 173, of which 28 were managed by the municipality and 132 by the parochial clergy. A form of charity almost peculiar to Venice is the Caliatico, or subsidies to poor mothers with unweaned children under eight months. A special hospital for children exists at the Lido. For working girls, sewing institutes with sewing-machines have been opened. The unemployed are cared for by a provident society subsidized by the commune. The commune has also joined the savings bank in constructing workmen's dwellings in place of the unhealthy houses demolished in accordance with the city reconstruction and improvement scheme. By means of an aqueduct Venice has been provided with excellent drinking water, and the ancient rainwater cisterns have been abolished. The question of the aqueduct was first raised in 1866, but financial and technical difficulties prevented the commencement of the work until 1881, when the Compagnie Générale des Eaux pour l'Etranger received a concession for sixty years. A supply (capable of increase) of 183,600 cubic feet of water per day is brought into the city from the Fontanelle di Sant' Ambrogio, near Castelfranco, the water of the Brenta, originally used, having proved impure. The aqueduct, which consists of a pitch-coated iron tube 2½ feet in diameter and 7000 yards long, crosses the marshes and passes under the lagoon to a reservoir at Sant' Andrea. Careful bacteriological examinations of the water both at Sant' Ambrogio and Sant' Andrea are constantly made. It is proposed to lay a new tube, at a cost of £22,000, in order to extend direct water-supply to Giudecca, San Giorgio, Santa Maria delle Grazie, San Servolo, and the Lido. An important investigation undertaken by the Bacterioscopical Laboratory, with regard to the pollution of Venetian canals by the city sewage, led to the discovery that the water of the Venetian lagoons and canals possesses auto-purifying power, not only in the large canals but even in the smallest ramifications of the waterways. The investigation was carried out with scrupulous scientific rigour upon samples of water taken in every part of the city, at high tide and low tide, under various atmospheric conditions.

Closely connected with the question of hygiene is the so-called Piano di Risanamento, or Reconstruction and Improvement Scheme, consisting of twenty-four projects, most of which were adopted in 1891, and of which eight have already been carried out. The scheme contemplates the demolition of unhealthy houses and the enlargement of streets—work especially arduous at Venice, where the total street area is only 160 acres, and where it is necessary quickly to rebuild accommodation for the tenants of the houses destroyed. The most important new streets are a *Calle larga*, called after Giuseppe Mazzini, in place of the old Calle della Scimmia at San Salvatore; the *Calle larga* Giacinto Gallina, formed by widening the Calli della Panada, Del Fabbro, and Del Cavallo, at SS. Giovanni and Paolo; and the enlargement of the Calle Trono della Piavola at Saint Mark's. These changes have caused the destruction of several interesting relics, among others the house where Canova died. Less justifiable, because less necessary, was the restoration in 1880 of the Fontego dei Turchi, a splendid palace of the 13th century in Byzantine style, and the installation there of the offices of the municipality. This palace was originally the property of the Pesaro family, and afterwards of the duke of Este, and finally of the Republic, which used it as a dwelling-place for royal guests before letting it to Turkish merchants.

Unfortunately, in 1880 the mania for placing all ancient monuments in "perfect condition" was prevalent—a mania from the barbarous consequences of which even Saint Mark's suffered on two occasions, first during the restoration of the north façade in 1843, and again during that of the south façade, begun in 1865 and finished in 1878. The latter façade was completely reconstructed upon 2200 piles driven to great depths, with the result that the general harmony of the monument—the effect of time and of atmospheric conditions—was completely lost. A lively agitation all over Europe, and particularly in England (conducted by Ruskin and William Morris), led the Italian Government to discard the Austrian plan of restoration, at least as regards the interior of the Basilica, and to respect the ancient portions which had stood the test of time and had escaped "renewal" by man. In 1880 a Vigilance Committee was appointed to watch over the restoration of the interior. The committee secured much *verde antico* and porphyry for the restoration of the pavement, in place of the common marbles which it had been intended to use, and organized special workshops for the restoration and preservation of the ancient mosaics, which it had been intended to detach and replace. Pieces already detached were restored to their original positions, and those blackened by damp and dust were carefully cleaned. Breaks were filled up with cubes obtained from fragments of contemporary mosaics previously demolished. In this way the mosaics of the two arches of the atrium and those of the Zeno chapel were cleaned and preserved. An annual report of the work done is published by the director-general of the Basilica restoration. On 14th July 1902 Venice suffered severe loss by the collapse of the Campanile of Saint Mark, which had formed the most prominent architectural feature of the city for 1000 years. The exact cause of the misfortune is not yet precisely known, but it is considered to have been due to negligence on the part of the architects appointed to watch over and repair the monument, and especially to careless incisions in one of the walls near its base. The removal of the débris was at once undertaken under the superintendence of Signor Giacomo Boni, and all other prominent Venetian monuments are being minutely examined. It is probable that Saint Mark's Tower will be reconstructed on the same spot and in the same form as before.

Contemporaneously with the restoration of the southern façade of Saint Mark's, the restoration of the colonnade of the Ducal Palace towards the Piazzetta and the Mole was undertaken at a cost of £23,000. The chief work was executed at the south-west angle, where the columns of the arcade had become so broken and distorted as to menace the safety of the whole building. The corner towards the Ponte della Paglia was also restored, and the hideous device of walling up the five last arches, adopted in the 16th century by the architect Da Ponte, was removed without prejudice to the stability of the structure. This piece of restoration met with approval in Italy and abroad, although the architect was accused of having removed twelve of the thirty-six capitals of the columns of the arcade (magnificent work of the 14th and 15th centuries) without absolute necessity. Among these capitals that of the corner column was so badly reproduced as to be refused by the authorities, and the sculptor died heartbroken. The ancient capitals now stand in an inaccessible room on the ground-floor of the Palace. In order to lighten the Palace the Venetian Institute of Science, Letters, and Arts removed its headquarters and its natural history collection to the Palazzo Pisani at Santo Stefano. For the same reason the Biblioteca Marciana with its 350,000 volumes will shortly be moved to the Old Mint, opposite the Ducal Palace. The space thus cleared has been used for the rearrangement of the Archæological and Artistic Museum, a great part of which had not before been accessible to the public, or had been piled up in the private apartments of the Doges. The Renaissance bronzes were placed in one of the new halls, and the collection of gems, with the famous cameo of Giove Egioco, arranged in the centre. The marbles of the archæological collection were arranged in the halls previously occupied by the institute, thus liberating the room of the Scarlatti or Gritti Barbarigo. The collection of Greek reliefs has remained untouched in the entrance gallery, on account of the danger of placing weighty statues in the Palace, but the entrance gallery itself has been transformed into an exit, and the other arm of the Golden Stair reopened to the public. Side by side with these changes has proceeded the reorganization of the Royal Gallery of Ancient Art, which, created by Napoleon I. for the students of the adjoining Academy of Fine Arts, gradually acquired such importance that in 1882 the Government divided it from the Academy and rendered it autonomous. Although lack of space precluded ideal arrangement of the pictures, the Gallery now constitutes a unique collection of Venetian paintings from the most ancient artists down to Tiepolo, one hall only being reserved for other Italian schools and one for foreign schools. Altogether the Gallery contains twenty rooms, one being assigned to the complete cycle of the "History of Saint Ursula," by Carpaccio; another to Giambellino and to the Celliniani; and a whole wall of a third being occupied by the famous Veronese, "Il Convito in casa di Levi." Titian's "Presentazione al Tempio," painted for the Scuola della Carita, which is now the seat of the Gallery, has been placed in its original position. The hall of the Assumption has been left untouched. Nineteenth-century pictures have been eliminated as foreign to the character of the collection, and inferior works relegated to a side passage. The reorganization of the Archæological and Artistic Museum and of the Royal Gallery of Ancient Art coincided with the inauguration in April 1895 of a series of biennial International Art Exhibitions, arranged in order to celebrate the silver wedding of the king and queen of Italy. A special brick structure was erected in the public gardens to receive the works of contemporary artists, both Italian and foreign. The selection of works was made by an international jury from which Venetian artists were excluded. The second exhibition, visited by 336,500 persons, was held in 1897, and a third in 1899. The success of this exhibition (visited by 407,930 persons) led to the organization of a fourth exhibition in 1901, largely devoted to the works of Ruskin. The institution of these exhibitions has furnished Prince Giovanelli with an opportunity to found at Venice a Gallery of Modern Art with pictures bought by him at the three exhibitions. Other purchasers having followed his example, the Gallery has been provisionally installed in the Palazzo Foscari, pending its definitive establishment in the Palazzo Pesaro, bequeathed to the city by the late Princess Bevilacqua la Masa. (V. MA.)

Venlo, a town in the Dutch province of Limburg, on the Maas, 43 miles below Maestricht, now the junction of the railway lines Maestricht–Nimeguen, Cologne–Flushing, and Paris–Hamburg. The town, narrow and irregularly built, is not of the ordinary Dutch type in the style of its buildings. There are a fine town hall and a college for the higher education of Roman Catholic priests. Population (1899), 14,399.

Venosa, a town and bishop's see of the province of Potenza, Basilicata, Italy, on the eastern side of Mount Vulture, 22 miles north of Potenza and 52 by rail south-south-east of Foggia. It has a cathedral, a 15th-century castle, and an abbey (1058), in which lie the remains of Robert Guiscard. It is the ancient *Venusia*, the birthplace of the Roman poet Horace (65 B.C.), and a Roman colony after 291 B.C. There are remains of an ancient amphitheatre. Near by are Jewish catacombs, with inscriptions in Hebrew, Latin, and Greek, discovered in 1853. Bricks and pottery are made. Population (1881), 8014; (1899), about 8500.

Ventilation.—The air which we breathe consists chiefly of two gases, oxygen and nitrogen, with certain small proportions of other gases, such as carbonic acid, ozone, argon, &c. Oxygen, which is the active and important constituent, and on which life and combustion depend, provides about one-fifth of the whole, nitrogen, which is inert and acts as a diluent, forming nearly four-fifths. Of this mixture, according to a well-recognized authority, each adult person breathes some 2600 gallons or 425 cubic feet in twenty-four hours. In air that has passed through the lungs the oxygen is reduced and the carbonic acid increased; this is because the air has come into contact with the blood, which it has re-oxygenated, in return becoming itself more or less carbonized. Anything which has passed through the human body ought to be treated as excreta and rejected. Just as sewage is thrown away into the drains, so air that has passed through the human lungs should be got rid of at the earliest possible moment without allowing it to go through the lungs of any one else.

Buildings.

In the ventilation of all large buildings three main points have to be considered:—(1) The area of floor to be provided for each person, (2) the cubic capacity of the room required for each occupant, and (3) the number of cubic feet of air per minute which must be brought in, and then extracted, for each individual. Nos. 1 and 2 will depend upon the objects to which the room is devoted, whether a ward of a hospital, or a school, or a place of public assembly; there are numerous text-books on hygiene which will afford sufficient guidance in such cases. As to No. 3 there is great diversity of opinion, but no great harm will occur to an audience occupying the room for a comparatively short time, if 30 cubic feet of air per minute is provided for each person. The United States Book on School Architecture gives a practical application to its remarks on this subject as follows:—

> The amount of fresh air which is allowed to hospital patients is about 2500 cubic feet each per hour. Criminals in French prisons have to content themselves with 1500 cubic feet per hour. Assuming that we care two-thirds as much for the health of our children as we do for that of our thieves and murderers, we will make them an allowance of 1000 cubic feet each per hour, or about 16 cubic feet per minute. Forty-eight children will then need an hourly supply of 48,000 cubic feet. Definite provision must therefore be made for withdrawing this quantity of foul air. No matter how many inlets there may be, the fresh air will only enter as fast as the foul escapes, and this can only find an outlet through ducts intended for that purpose, porous walls and crevices serving in cool weather only for inward flow. What, then, must be the size of the shaft to exhaust 48,000 feet per hour? In a shaft 20 feet high, vertical and smooth inside, with a difference in temperature of 20°, the velocity will be about 2½ feet per second, or 9000 feet per hour; that is, it will carry off 9000 cubic feet of air per hour for every square foot of its sectional area. To convey 48,000 cubic feet, it must have a sectional area of 5½ square feet.

Such a supply of fresh air should not be regarded as satisfactory, but merely as an improvement upon the present state of things. The standard of purity suggested is low, and ought to be exceeded, but it might deter many from moving in the matter if a proper and higher standard were to be laid down at first. A volume of 30 to 40 cubic feet or more per minute ought to be obtained wherever possible. One of the most important points is the proper warming of the fresh air introduced into buildings, for unless that be done, when a cold day occurs all the ventilating arrangements will probably be closed. The fact should not be lost sight of that the air in a room may on the one hand be quite cold and yet very foul, and on the other, warm and yet perfectly fresh. To avoid draught the air should enter through a large number of small orifices, so that the currents may be thoroughly diffused. This is done by gratings. The friction of their bars, however, seriously diminishes their capacity for passing air, and careful experiments show conclusively that very ample grating area is required to deliver large volumes. The same remark applies to extracting-flues. Owing to the small size and the roughness of the surface the velocity of the upward current is small, and the quantity of air that passes out is often much less than is requisite.

No large building can be successfully ventilated without some mechanical force furnished by steam, electricity, falling water, or some such agency. Fans can then be worked with assured results, especially if both plenum and exhaust systems be combined; whereas automatic extractors not infrequently become inlets, thus reversing the whole system, and pouring cold air on the heads of the audience. As regards the plenum system, whatever may be its merits and its success, open windows should also be provided to aërate, when required, the whole building in sections, and these should be so arranged that no corner can be left stagnant or unswept by the purifying current. The Victoria Hospital at Glasgow, and the Royal General Hospital at Birmingham, are, however, ventilated on the plenum system, without the above-named method of open windows, so far, it is said, with satisfactory results. The extraction of foul air should in most cases be effected at the top of a room or building, so as to utilize the natural tendency of warm air to rise; but at Birmingham and elsewhere the outlets are near the floor, the fresh air being brought in half-way up the walls and directed towards the ceiling. The air-inlets should be Tobin tubes or similar devices, placed some 4 or 5 feet above the floor, and so arranged that the air should be passed through radiators or pipes to warm it before entering. In the case of a building for one of the American legislatures the warmed fresh air is allowed to enter on the level in front of the desk of each member, so that he secures a proper volume of fresh air for his own use before it is breathed by his neighbour. In the Houses of Parliament at Westminster, which were designed and built for the public business in 1836, considerable attention is devoted to the question of the purification of the air, but the arrangements are lamentably antiquated. The supply of fresh air, instead of being taken from a point as high up as possible, such as the top of the Victoria Tower or of the Clock Tower, is taken from the terrace at the river front. The result is that the miasmatic vapours of the river are drawn in; the air-passages are exceedingly tortuous and restricted, and the bulk of the air, after passing through the various chambers and rooms, and finding its way to the top of the building, has to be dragged down against its specific gravity into the basement prior to its being discharged into the ventilating furnace at the foot of the Victoria Tower.

The use of the anemometer or air-meter for testing the ventilation of buildings would soon reveal the objectionable state of affairs that frequently exists. Such instruments are in constant use in collieries and mines, but the great difficulty is to obtain an accurate measurement of the air actually passing through the ventilating-machine. No two anemometers are alike, the flow of air is constantly varying in direction, and it is rarely, if ever, that two similar readings are obtainable. Yet, notwithstanding these drawbacks, the use of the anemometer is of the greatest value.

The introduction of rapidly-revolving, but silent, fans, driven by electricity, is a great advance which places within the reach of the engineer or architect the means for solving the problem of ventilation of buildings. The fan and motor combined extend the advantages of positive mechanical ventilation to all who have access to electric current, with the further benefit that the extreme simplicity of the electric driving of the fans greatly facilitates the control and distribution of ventilating effect. The moderate speed and power required by these fans for a given duty has contributed greatly to their extended use. The question of silence in running, in such places as houses of parliament, law courts, churches, and chapels, is of paramount importance, and no fan should be accepted until it is proved by actual working to be noiseless.

Mines.

The ventilation of mines was dealt with at considerable length in the ninth edition of the *Ency. Brit.* vol. vi. p. 70, and in vol. xvi. p. 460. The large volume of air required in coal-mines is rendered necessary not merely by the vitiation of the air in the mine by men and horses, and by the decay of timber, but also by the large "blowers" of inflammable gas which come from the beds of coal. Under the action of a falling barometer these "blowers" are sometimes of enormous volume, and therefore machinery of such design and power as to provide a largely increased supply of fresh air should be furnished in case more fresh air be required. Explosions are prevented by deluging the mines with such large volumes of air as will dilute the fiery gases to below explosion point.

Some important and interesting facts are given by Dr Haldane, F.R.S., in his report to the Home Office on the subject of colliery explosions, and the deaths occurring in consequence (1896). He points out that while the presence of carbon dioxide is at once shown by the extinction of the lights, carbon monoxide is much more difficult of detection, and consequently is much more dangerous. A man may go a long distance into a pit before he feels its effects, and when he does feel them he may be quite unable to escape. Dr Haldane, finding the influence of carbon monoxide to be far more rapid on small animals than on man, suggests that a few white mice should be kept near at hand, and used by the men engaged in rescue work. Carried in a small cage, so soon as a dangerous percentage of the gas was present, they would begin to pant and show signs of weakness; should they become unconscious it would be an indication to the men that they must retire.

The Guibal ventilating fan (Fig. 1) has been described (*Ency. Brit.* vi. 70), and still maintains its name for efficiency and good work. It is now only desirable to call attention to electricity as a motive power for high-speed fans. By using electric motors the position of the boilers becomes a matter of indifference, and the constant "torque" of the motor, in contrast with the reciprocating action of a steam engine, is in many cases a great advantage. Since 1888 large numbers of electric fans (Figs. 2, 3) have been fixed for ventilating mines in Great Britain, the United States, Germany, France, and elsewhere. They give in some cases as much as 265,000 cubic feet per minute, with the high water-gauge of 15 inches, and a useful effect claimed to be from 60 per cent. to 70 per cent. They seldom exceed 16 feet in diameter, and are run at high speed, sometimes by steam and sometimes by electricity.

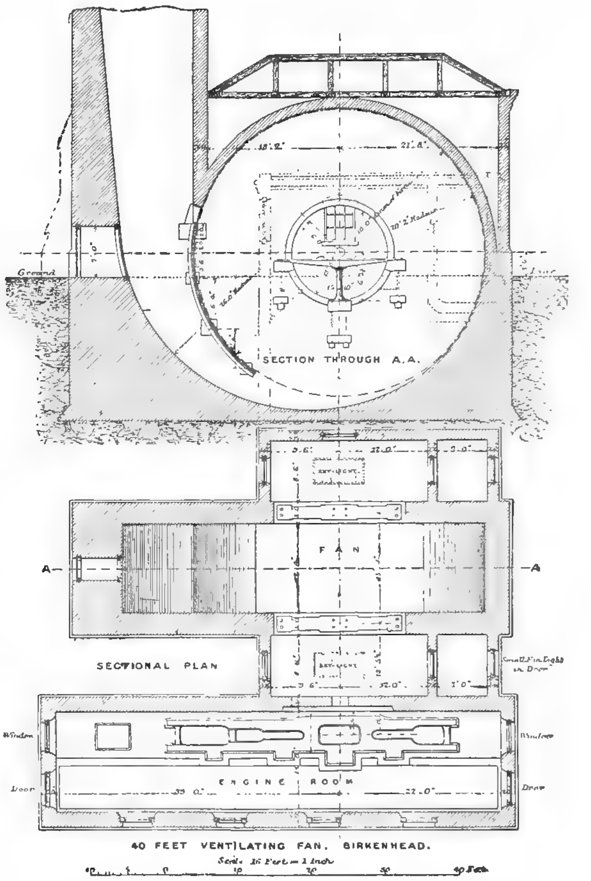


Fig. 1.—Guibal Ventilating Fan (from a diagram in the *Proceedings of the Institution of Civil Engineers*).

The ideal engine is one which has only one rotating part, and in which the direction of movement is never reversed. Engineers have for many years been aware of this fact, and much time and money have been expended in the endeavour to perfect the rotary engine. Since the introduction of such an engine in 1884, many improvements have been effected, and at the present time the steam turbine is recognized to be an efficient and practical engine and is being applied to ventilating fans (Fig. 4).

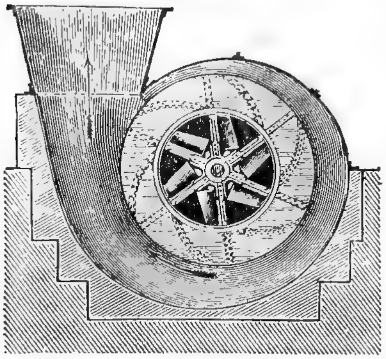


Fig. 2.—Electric Ventilating Fan. (*After Capell.*)

Tunnels.

The grave inconveniences arising from smoke and bad air have necessitated the study of the question of ventilating tunnels, and great progress has been made since 1885. The Metropolitan Railway in London is a notorious instance of bad ventilation, for there the blow-holes set up no regular current, and the products of combustion increase the proportion of carbonic acid gas in the air to such high figures as 60, 69, 78, and even 89 parts in 10,000, when it ought not to exceed from 10 to 15 parts. In long tunnels on steep gradients, such as exist in Italy and elsewhere, artificial ventilation is imperatively needed. In the cases of the Pracchia tunnel, 3000 yards in length on a gradient of 1 in 40; the Mont Cenis tunnel, with its peculiar longitudinal section and gradients of 1 in 40 at both ends; the spiral tunnels, with gradients of 1 in 40, on the St Gothard route; and the long tunnel of Ponte Decimo near Genoa, serious inconvenience, and even worse, results. Asphyxiation is not unknown, and the loss of life attending the collision of the 11th August 1898, at the mouth of the last-named tunnel, in which twelve persons were killed and forty injured, was the direct result of bad air.

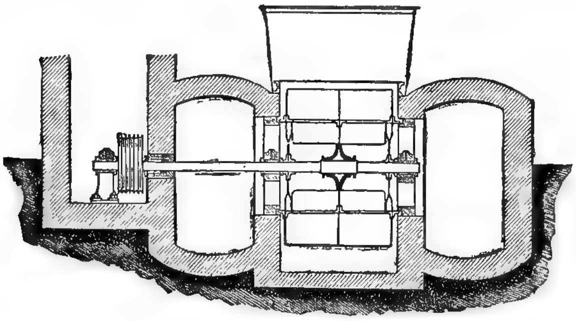


Fig. 3.—Electric Ventilating Fan. (*After Capell.*)

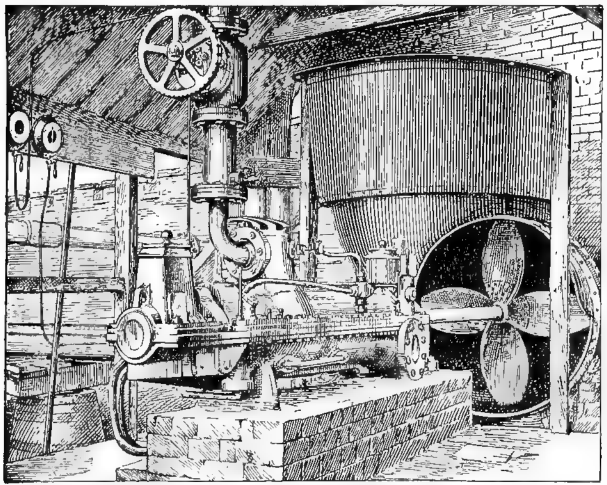


Fig. 4.—Ventilating Fan at a Colliery, driven by Parsons Steam Turbine (2000 revolutions per minute).

The Pracchia is one of fifty-two single-line tunnels, with a gradient of 1 in 40, on the main line between Florence and Bologna, built by the late Mr Thomas Brassey. The traffic has greatly increased of late years, and has to be worked by heavy locomotives. Under any condition of wind the state of this tunnel, about 3000 yards in length, is bad; but when the wind is blowing in at the lower end at the same time that a heavy goods or passenger train is ascending the gradient, the condition of affairs becomes almost insupportable. The engines, working with the regulators full open, often emit large quantities of both smoke and steam, which travel concurrently with the train. The goods trains have two engines, one in front and another at the rear of the train, and when, from the humidity in the tunnel, due to the steam, the wheels slip, and possibly the train stops, the state of the air is indescribable. A heavy train with two engines, conveying a royal party and their suite, arrived on one occasion at the upper exit of the tunnel with both enginemen and both firemen insensible; and on another occasion, when a heavy passenger train came to a stop in the tunnel, all the occupants were seriously affected. Proper ventilation would not only be of the greatest comfort to the men, but would probably double the life of rails, the corrosion of which is at present very rapid.

Careful tests made in the Box and Severn tunnels of the Great Western Railway, to ascertain if possible the loss that takes place in the weight of rails owing to the presence of corrosive gases, gave the following results:—

Box Tunnel (1 mile 66 chains in length).

Percentage of Wear per annum.

	Per cent.		℔ per yard per annum.
Down line, gradient falling 1 in 100—			
At east mouth	0·439	=	0·377
28 chains from east mouth	1·800	=	1·540
48 ,, ,, ,,	2·110	=	1·810
1 mile 8 chains from east mouth	2·880	=	2·480
At west mouth	0·640	=	0·553
Up line, gradient rising 1 in 100—			
At east mouth	0·620	=	0·575
1 mile 8 chains from east mouth	1·500	=	1·380
1 mile 28 chains from east mouth	1·520	=	1·310
At west mouth	0·680	=	0·587

Severn Tunnel (4 miles 28½ chains in length).

Percentage of Wear per annum.	Per cent.		℔ per yard per annum.
Down line, outside and quite clear of tunnel, Bristol end, gradient falling 1 in 100	0·280	=	0·240
Up line, outside and quite clear of tunnel, Newport end, gradient falling 1 in 90	0·440	=	0·390
At Bristol mouth, gradient falling 1 in 100	1·200	=	1·020
33 chains from Bristol mouth, gradient falling 1 in 100	2·160	=	1·860
3 miles 75½ chains from Bristol mouth, gradient rising 1 in 90	1·900	=	1·630
At Newport mouth	0·310	=	0·270
Down and up line under main-shaft level	3·200	=	2·750

It will be seen that the maximum wear and corrosion together reached the extraordinary weight of 2½ ℔ per yard per rail per annum—a very serious amount that involved great expenditure. The wear occurred over the whole of the rail, but the top, over which the engine and train passed, wore at a greater rate, presumably on account of the surface being kept bright and the gases being able to act on it. The Great Western Company tried the experiments in the Severn tunnel of boxing up the rails, so that the ballast approached their surface within 1 inch or 1½ inches. It was found, however, that—in the case, at any rate, of the limestone ballast—the cure was almost worse than the disease, the result being a maximum wear of 2½ ℔ and an average wear of just under 2 ℔ per yard per rail per year. The average on the open line would be about 0·25 ℔ in the same time.

The first application of mechanical or fan ventilation to railway tunnels was made in the Lime Street tunnel of the London and North-Western Railway at Liverpool, which has since been replaced by an open cutting. At a later date fans were applied to the Severn and Mersey tunnels.

The principle hitherto acted upon, where mechanical ventilation has been adopted, has been to exhaust the vitiated air at a point midway between the portals of a tunnel, by means of a shaft with which is connected a ventilating fan of suitable power and dimensions. In the case of the tunnel under the river Mersey (Fig. 5), such a shaft could not be provided, owing to the river being overhead, but a ventilating heading was driven from the middle of the river (at which point entry into the tunnel was effected) to each shore, where a fan 40 feet in diameter was placed. In this way the vitiated air is drawn from the lowest point of the railway, while fresh air flows in at the stations on each side to replenish the partial vacuum, as indicated by arrows in the accompanying longitudinal section of the tunnel. The principle was, that fresh air should enter at each station and "split" each way into the tunnel, and that thus the atmosphere on the station platforms should be maintained in a condition of purity. The air has to travel towards a point midway between the stations, becoming more and more smoky as it goes, and is then extracted from the tunnel by the ventilation heading leading to the fans. In the Severn, owing to the middle of the tunnel being nearly at the Gloucestershire side of the river, a vertical shaft is sunk, and a fan, 40 feet in diameter, extracts the vitiated air at this point.

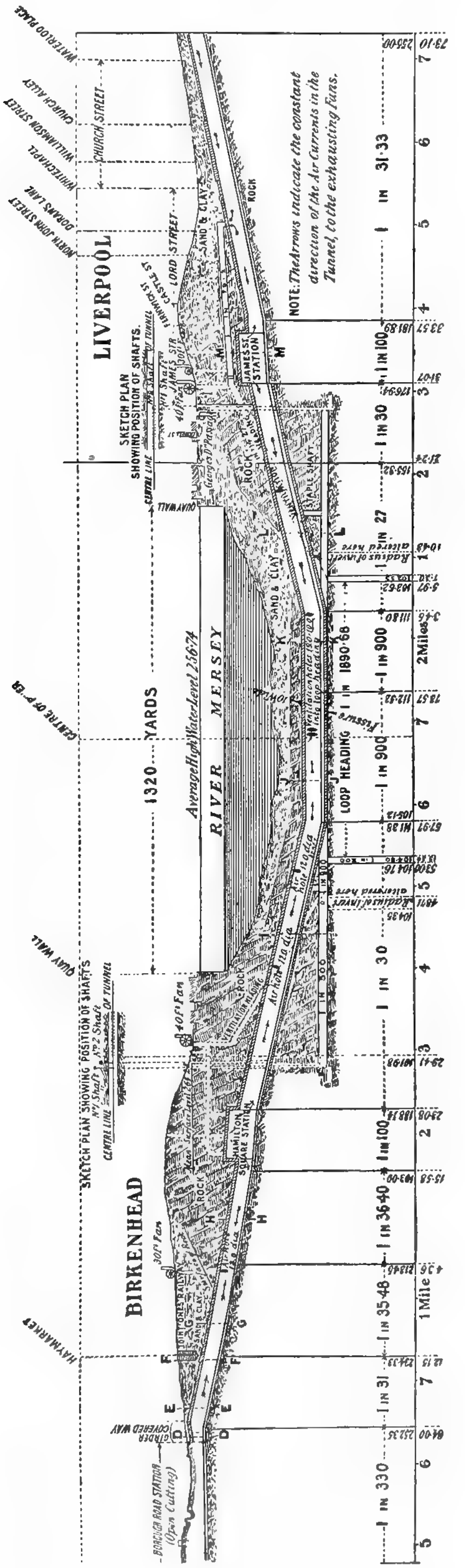


Fig. 5.—Longitudinal Section of the Mersey Tunnel, showing Method of Ventilation (from a diagram in the *Proceedings of the Institution of Civil Engineers*).

The fans in the Mersey tunnel are somewhat similar to the well-known Guibal fans, with the exception of an important alteration in the shutter. With the Guibal shutter, the top of the opening into the chimney from the fan has a line parallel to that of the fan-shaft and of the fan-blades, and, as a consequence, as each blade passes this shutter, the stoppage of the discharge of the air is instantaneous, and the sudden change of the pressure of the air on the face of the blade whilst discharging and the reversal of the pressure, due to the vacuum inside the fan-casing, cause the vibration hitherto inseparable from this type of ventilator. As an illustration of the effect of the pulsatory action of the Guibal shutters the following figures may be given: a fan having ten arms and running, say, sixty revolutions per minute, and working twenty-four hours per day, gives (10 × 60 × 60 × 24 =) 864,000 blows per day transmitted from the tip of the fan-vanes to the fan-shaft; the shaft is thus in a constant state of tremor, and sooner or later reaches its elastic limit, and the consequent injury to the general structure of the fan is obvious. This difficulty is avoided by cutting a Λ-shaped opening in the shutter, thus gradually decreasing the aperture and allowing the air to pass into the chimney in a continuous stream instead of intermittently. The action of this regulating shutter increases the durability and efficiency of the fans in an important degree. In towns like Liverpool and Birkenhead any pulsatory action would be readily felt by the inhabitants, but with the above arrangement it is difficult to detect any sound whatever, even when standing close to the buildings containing the fans. The admission of the air on both sides is found in practice to conduce to smooth running and to the reduction of the side thrust which occurs when the air is admitted on one side only. The fans (Fig. 5) are five in number; two are 40 feet in diameter by 12 feet wide, and two 30 feet in diameter by 10 feet wide, one of each size being erected at Liverpool and at Birkenhead respectively. In addition, there is a high-speed fan 16 feet diameter in Liverpool which throws 300,000 cubic feet.

The following table gives the result of experiments made with the ventilating fans of the Mersey railway:—

Fan at	Diameter of Fan in feet.	Width of Blade in feet.	Number of Revolutions per minute.	Area of Drift-way in square feet.	Water-gauge in inches.	Velocity of Air in feet per minute.	Volume of Air in cubic feet per minute.
Hamilton Street, Birkenhead .	30 ×	10	47	113	1·30	1,895	214,135
Shore Road, Birkenhead .	40 ×	12	45	41	2·50	3,288[1]	134,685
James Street, Liverpool .	40 ×	12	45	72	2·45	2,465	178,880
James Street, Liverpool .	30 ×	10	60	60	2·30	2,062	123,720
Bold Street, Liverpool .	16[2]	...	...	...	...	...	300,000
						Total	951,420

The Severn tunnel (Fig. 6), which is 4 miles 624 yards in length, is ventilated by one fan placed on the Monmouthshire side of the Severn. This fan, which is 40 feet in diameter by 12 feet in width, ejects from the tunnel 400,000 cubic feet per minute, and draws in an equivalent volume of fresh air from the two ends. Whether this quantity of air will prove sufficient for the increasing amount of traffic passing through the tunnel remains to be seen.

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[1] In the case of this circular drift-way (cut by the Beaumont boring machine) a velocity of 4000 feet per minute has since been attained.

[2] Quick-running fan.

The consumption of coal by a locomotive during the passage through a tunnel having been ascertained, and 29 cubic feet of poisonous gas being allowed for each pound of coal consumed, the volume of fresh air required to maintain the atmosphere of the tunnel at the necessary standard of purity of 20 parts of carbon dioxide in 10,000 parts of air is ascertained as follows:—The number of pounds of fuel consumed per mile, multiplied by 29, multiplied by 500, and divided by the interval in minutes between the trains, will give the volume of air in cubic feet which must be introduced into the tunnel per minute to maintain it in a sufficiently pure state to avoid inconvenience. As an illustration, assume that the tunnel is 1 mile in length, that the consumption of fuel is 32 ℔ per mile, and that one train passes through the tunnel every five minutes in each direction; then the volume of air required per minute will be

$$\frac{32 \text{ ℔} \times 29 \text{ cubic feet} \times 500}{2\frac{1}{2} \text{ minutes.}} = 185{,}600 \text{ cubic feet;}$$

and the air will be maintained at a standard of purity in which the carbon dioxide does not exceed 20 parts in 10,000. It has been found by investigation and experiment that the air in a tunnel is satisfactory if this amount of carbonic acid is not exceeded.

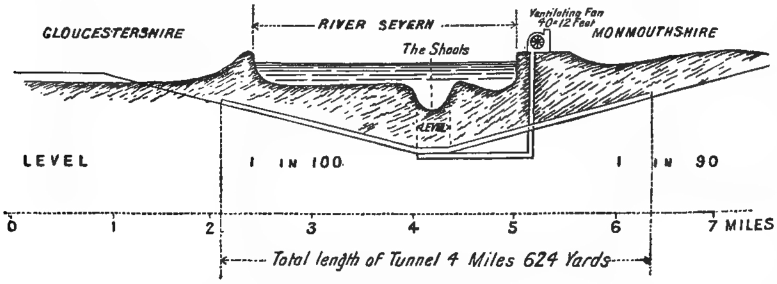

FIG. 6.—Section of Severn Tunnel. (*Fox.*)

The simplest method for ventilating a railway tunnel is to have numerous and wide openings to daylight at frequent intervals. If these are the full width of the tunnel, at least 20 feet in length, and not farther apart than 200 yards, it can be naturally ventilated and all expense of installing and maintaining machinery avoided.

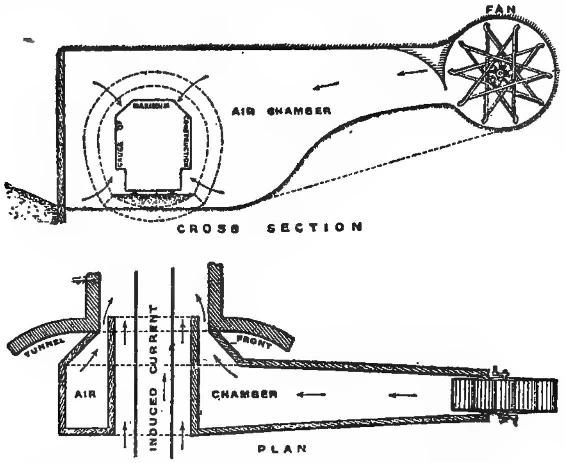

FIG. 7.—Diagram illustrating the Saccardo System for ventilating Tunnels (from the *Proceedings of the Institution of Civil Engineers*).

About the year 1896 an excellent system was introduced by Signor Saccardo, the well-known Italian engineer, which to a great extent has minimized the difficulty of ventilating long tunnels under mountain-ranges where shafts are not available. This system, which is not applicable to tunnels in which underground stations exist, is illustrated in the diagram (Fig. 7), which represents its application to the single-line tunnel through the Apennines at Pracchia. The tunnel was extended for about 15 or 20 feet by a structure either of timber or brickwork, the inside line of which represented the line of maximum construction, and this was allowed to project for about 3 feet into the tunnel. The space between this line and the exterior constituted the chamber into which air was blown by means of a fan. Considering the length of tunnel it might at first be thought there would be some tendency for the air to return through the open mouth, but nothing of the kind happened. The whole of the air blown by the fan, 164,000 cubic feet per minute, was augmented by the induced current yielding 46,000 cubic feet per minute, making a total of 210,000 cubic feet; and this volume was blown down the gradient against the ascending train, so as to free the driver and men in charge of the train from the products of combustion at the earliest possible moment. Prior to the installation of this system the drivers and firemen had to be clothed in thick woollen garments, pulled on over their ordinary clothes, and wrapped round and round the neck and over the head, but in spite of all these precautions they sometimes arrived at the upper end of the tunnel in a state of insensibility. The fan, however, immensely improved the condition of the air, which is now pure and fresh.

In the case of the St Gothard tunnel, which is 9⅓ miles in length and 26 feet in width, the Saccardo system was installed in 1899, with most beneficial results. The Mont Cenis tunnel, 8¼ miles in length and 26 feet in width, possesses no shaft. Owing to an alteration during construction, the Bardonnecchia entrance is at a considerably lower level than that originally intended, necessitating the introduction of an ascending gradient of 1 in 40 for a length of nearly 1000 yards from the portal. The tunnel is then level for nearly 3½ miles, when a descending gradient of about 1 in 40 occurs for nearly 4 miles towards the French entrance. This rise of level in the middle has compromised the ventilation, and sometimes great difficulty is experienced in carrying on the traffic. At the Bardonnecchia entrance there is a somewhat obsolete installation of seven overshot water-wheels, 5 metres in diameter, and 6 metres in length on the breast, over which in succession a mountain stream is conducted. These work air-compressors, the air being delivered under a pressure between 4½ and 6 atmospheres, and discharged at points 1 kilometre apart throughout the tunnel. The quantity of air is so small, amounting only to 70 cubic metres per minute of air at 75 ℔ pressure per square inch, that for purposes of tunnel ventilation it has little effect, but it is of great advantage to the men employed in the tunnel. At intervals of 1 kilometre there are refuges—supplied with fresh air, water, and a telephone—into which they can retire when the smoke is thick, and wait for an engine to take them out. The corrosion of rails is very rapid, and about 300 tons have to be relaid every year. With proper ventilation a saving of 150 tons would be effected annually, which would probably far more than pay for the necessary machinery. The Saccardo system is under consideration also for this tunnel.

The Hoosac tunnel in America, for a time, relied for its ventilation upon a central shaft which exists half-way, and which brought the cold air of the mountain above into the tunnel, driving the smoke out at the two ends. Now a fan has been installed 16 feet in diameter with a width of 8 feet. The two inlets, one on either side, are 9 feet in diameter, and the number of revolutions is 108 per minute, at which speed the volume of air thrown is 384,000 cubic feet per minute. If the fan run at 200 revolutions a minute, a yield of 700,000 cubic feet it is estimated will be obtained.

The introduction of electrical traction in the deep railway tunnels now being rapidly extended under London simplifies to a great extent the question of ventilation, since the absence of smoke and products of combustion of coal and coke renders necessary only such quantity of air as is required by the passengers and staff. This is but small, but arrangements are being made for changing the air of the tunnels twice every hour by means of electrically-driven fans.

Under compressed air.

The air supplied to divers and diving-bells has to be forced in by pumps, the pressure being that due to the hydrostatic "head." It is drawn from the ordinary atmosphere, and being pure and compressed the volume required for each diver is about 250 to 300 cubic feet, or in the case of diving-bells 1300 cubic feet per hour. Where work is carried on under pressure, as in foundation caissons or in tunnels, an air-lock is provided which enables men to pass in and out of the chamber without allowing the pressure beyond the air-lock to be reduced. Fig. 8, which is from a model, shows the action of this apparatus.

The shaft marked A is under ordinary atmospheric pressure, say 15 ℔ to the square inch. The chamber at D is under the pressure due to the depth below water, which we will assume to be 30 ℔ additional, or 45 ℔ in all. The portion marked B is reached by a door at top, A, and another at the bottom, C. By closing these doors the pressure inside B can be raised or lowered either to 15 ℔ or 45 ℔ by means of valves. When A and B are both at 15 ℔ the door at A can be opened, and men or material can pass into B. The door is then closed and the 45 ℔ pressure in D is allowed to enter B; this effectually seals the door at A, but permits the door at C to be opened, and the men and material can enter the chamber at D, where excavation and work are going on.

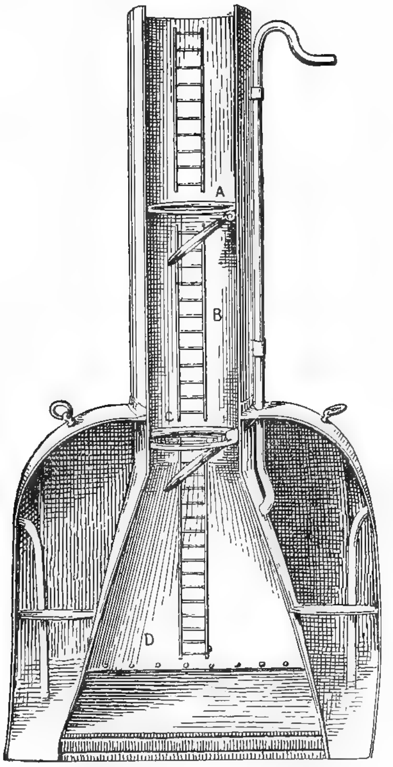

Fig. 8.—Type of Air Lock for Subaqeous Work. (*Siebe, Gorman and Co.*)

The ventilation of chambers or tunnels under compressed air demands much attention, as upon it depends the health of the men engaged. Far greater necessity exists for purity in compressed air than in air under the ordinary pressure. Under pressure, in the case of a man entering the lock, the air is absorbed by the blood, carrying with it any gaseous impurities in its constitution; consequently, if it be at all high in carbonic acid gas the blood receives that impurity. In coming out of the compressed air, it is of great importance to be "locked out" slowly. It is well known that blood in the presence of air tends to coagulate, and investigations of cases which occurred in the deep sinking of cylinders at Newcastle and elsewhere showed that when the pressure was taken off, so that globules of air were released in the blood, there was the same tendency to coagulation. Where deaths have occurred, post-mortem examination has shown the veins and arteries to be filled with coagulated blood. If the pressure be allowed to pass away slowly this risk is reduced. The danger lies in the possibility of the formation of a clot in the system.

Under ordinary atmospheric pressure the carbonic acid seems simply a measure of the impurities, and not in itself seriously detrimental, even in considerable quantities. But when compressed air is dealt with it is very different. If the working pressure is above 20 ℔ to the square inch, any percentage of carbonic acid gas which rises above 1 to $1\frac{1}{4}$ parts per 1000 is almost sure to make itself felt on some men, and may have serious results. At the Blackwall tunnel and at the Hudson tunnel it was found necessary, in order to keep the air at the right degree of purity—that is, at about 1 to $1\frac{1}{4}$ parts per 1000—to analyse it regularly. The provision of a constant volume per man, as gauged by the revolutions of the engine, was useless, for it was found on one occasion, when the Blackwall tunnel was passing under the old Isle of Dogs sewer, that the air was very impure, even when 6000 to 8000 cubic feet were being delivered. It is, therefore, absolutely necessary to give a varying supply, according to the analyses, in compressed-air works, and the limit should be about 1 to $1\frac{1}{4}$ per 1000. An ample allowance in ordinary works is between 3000 and 4000 cubic feet per man per hour, and even less would do at pressures below 30 ℔ per square inch. In both the above tunnels men suffering from the pressure, or what is known as the "caisson disease," derived great benefit from a special chamber in which those who were overcome on coming out for the first time could be re-immersed in fresh air under similar pressure.

See Fox. "Ventilation of Tunnels and Buildings," *Proc. Inst. C. E.*, vol. cxxxvi. part ii.—HALDANE. *Report to Secretary of State for Home Department on the Causes of Death in Colliery Explosions.* (F. Fo.)

Ventimiglia, a frontier fortress, seaport town, and episcopal see of the province of Porto Maurizio, Liguria, Italy, 94 miles west by south of Genoa by rail, and 4 miles from the Franco-Italian frontier. The cathedral is built on the site of a temple to Juno, and the church of St Michael on the site of a temple to the Dioscuri. A collection of Roman antiquities is preserved in the town hall. Population (1881), 6567; (1899), about 7000.

Ventnor, a watering-place and railway station in the Isle of Wight parliamentary division of Hampshire, England, on the south coast of the island, 12 miles south by west of Ryde. St Catherine's, the parish church, has been enlarged, and St Catherine's Home for Consumptives rebuilt. Population (1891), 6566; (1901), 5866.

Vera Cruz, a city and port of Mexico, in the state of Vera Cruz Llave, and situated on the Gulf of Mexico, with a population of 24,085. It is the most important commercial port of the republic. The development of domestic industries, owing to a high protective tariff coupled with the cheapness of labour and the depreciation of silver, has greatly reduced the list of imported articles, which can no longer compete in price with the native. The principal articles of import are machinery, hardware, vehicles, raw cotton, petroleum, textile fabrics. The exports are ores and precious metals, coffee, tobacco, skins, vanilla, dyewoods, beans, &c.

The movement of shipping in the port is shown in the subjoined table:—

Year.	Entered.		Cleared.	
	Ships.	Tonnage.	Ships.	Tonnage.
1890	313	493,410	313	494,203
1895	374	486,678	310	463,860
1901	338	913,698	321	916,336

The value of the trade of this port is shown in the following table. The figures expressing the values for 1901 represent Mexican currency, inasmuch as reducing them into any other currency would destroy their practical value as statistics on account of the great fluctuation of exchange during that year:—

Year.	Imports.	Exports.
1890	£2,484,083	£3,291,083
1895	£3,225,175	£2,737,763
1901	$22,349,788	$21,954,876

The climate is hot and unhealthy. The death-rate in 1895 was 48·62 per 1000; in 1896, 49·44; in 1897, 54·13. Harbour improvements in the way of dredging, breakwaters, lighthouses, reclaiming the foreshore, customs pier, and necessary railway connexions are being steadily carried on. A practical system of drainage and the provision of an adequate water supply have been undertaken.

Vera Cruz Llave, a state of Mexico, bounded on the N. by Tamaulipas, on the W. by San Luis Potosi, Hidalgo, and Puebla, on the S. by Oaxaca, and on the E. by the Gulf of Mexico. Area, 29,210 square miles. Population (1879), 542,918; (1900), 960,570. It rises gradually from the coast line to the crest of the Sierra Madre. In the south part is the snow-capped volcanic peak of Citlatepetl or Orizaba (5295 metres). Agriculture, stock-raising, and mining are the principal industries. There are, however, many manufacturing interests, cotton and woollen mills, saw-mills, paper-mills, foundries, and other minor ones. The railway system of the state is extensive, and its ports (Vera Cruz, Tuxpan, and Coatzacoalcos) are much frequented by shipping, both foreign and domestic. The state is divided into eighteen cantons, subdivided into municipalities. The capital, Jalapa, has 18,168 inhabitants. Among the chief towns are Orizaba (31,512), Vera Cruz (24,085), San Andres Tuxtla (8855), Coatepec (8623), Cordoba (7974), Huatusco (6299), Santiago Tuxtla (5865), Tlacotalpan (5770), Tuxpan (5697).

Vercelli, the chief town of an administrative district (*mandamento*), province of Novara, Italy, situated upon the right bank of the Sesia, half-way on the line of railway from Turin to Milan. It is the seat of an archbishopric, and an important railway centre. Its population numbers 31,150, not including a garrison of 1350 men. Since 1880 its inhabited area has greatly increased, especially upon the quadrilateral zone, 180,000 square metres in extent, formerly occupied by the western fortifications of the city. Trade is considerable, on account of the exportation of cereals and especially of rice, for which Vercelli is one of the principal Italian centres. Corn and rice mills of large size are in a flourishing condition, while cotton and woollen mills and factories of artificial manure have attained importance. Electric power is derived from the Ivrea canal. Municipal finances are in equilibrium, the annual budget of income and expenditure amounting to nearly £40,000. Elementary and infant schools have been increased; the technical institute, the technical schools, the lyceum-gymnasium, and the female normal school have been reorganized; the library has been enriched, since 1875, with 40,000 volumes. Three political journals are published. Numerous hospitals, asylums, and other charitable institutions have been opened. There are thirty mutual benefit societies; the savings bank has a capital of nearly £100,000. Numbers of valuable pictures of the Vercelli school are preserved in the Basilica of Sant' Andrea, the Church of San Cristoforo, and in the gallery of the Fine Arts Institute. Monuments have been erected to Victor Emmanuel II., Garibaldi, Cavour, and General Bava.

Verden, a town of Prussia, province of Hanover, near the right bank of the Weser, 22 miles south-east of Bremen by the railway to Hanover. The most noticeable edifices are the Gothic cathedral (1290) and a couple of other churches. It was the see of a bishopric founded in the first quarter of the 9th century, or earlier, and secularized in 1648. The duchy of Verden was ceded to Sweden, then in 1720 to Hanover, in 1810 to the kingdom of Westphalia, and in 1866 to Prussia. Population (1885), 8594; (1900), 9842.

Verdi, Giuseppe Fortunino Francesco (1813–1901), Italian composer, was born on 10th October 1813 at Le Roncole, a poor village near the city of Busseto. His parents kept a little inn, combined with a kind of village shop. Verdi received some instruction from the village organist, but his musical education really began with his entrance into the house of business of Antonio Barezzi, a merchant of Busseto. Barezzi was a thorough musician, and under his auspices Verdi was speedily introduced to such musical society as Busseto could boast. He studied under Giovanni Provesi, who was *maestro di cappella* of the cathedral and conductor of the municipal orchestra, for which Verdi wrote many marches and other instrumental pieces. These compositions are now the principal treasures of the library of Busseto. Among them is Verdi's first symphony, which was written at the age of fifteen and performed in 1828. In 1832 Verdi went to Milan to complete his studies. He was rejected by the authorities of the Conservatorio, but remained in Milan as a pupil of Vincenzo Lavigna, with whom he worked until the death of Provesi in 1833 recalled him to Busseto. A clerical intrigue prevented him from succeeding his old master as cathedral organist, but he was appointed conductor of the municipal orchestra, and organist of the church of San Bartolomeo. After three years in Busseto, Verdi returned to Milan, where his first opera, *Oberto Conte di San Bonifacio*, was produced in 1839. His next work, a comic opera, known variously as *Un Giorno di Regno* and *Il Finto Stanislao*, was written in peculiarly distressing circumstances, the composer having had the misfortune to lose his wife and two children in the course of two months. *Un Giorno di Regno* was a complete failure, and Verdi, stung by disappointment, made up his mind to write no more for the stage. He kept his word for a year, but was then persuaded by Merelli, the impresario of La Scala, to look at a libretto by Solera. The poem took his fancy, in a short time the music was written, and in 1842 the production of *Nabucodonosor* placed Verdi in the front rank of living Italian composers. The success of *Nabucodonosor* was surpassed by that of its two successors, *I Lombardi* (1843) and *Ernani* (1844), the latter of which was the first of Verdi's operas to find its way to England. With *Ernani* Verdi became the most popular composer in Europe, and the incessant demands made upon him reacted upon his style. For several years after the production of *Ernani* he wrote nothing which has survived to our time, nothing which deserved to survive. In *Macbeth* (1847) there are passages of some power, and passages too which indicate an approaching transition to a less conventional method of expression. In *Luisa Miller* (1849) also there is a noticeable increase of refinement in style, which contrasts favourably with the melodramatic vulgarity of his earlier manner.

It was unfortunate that *I Masnadieri*, which was written for the English stage and produced under Lumley's management at Her Majesty's Theatre in 1847, should have been one of the worst of the many bad works which Verdi composed at this period of his career. Not the

Giuseppe Verdi.

presence of the composer, who travelled to England to conduct the first performance, nor the genius of Jenny Lind, who sang the part of the heroine, could redeem it from failure. In 1851 Verdi won one of the greatest triumphs of his career with *Rigoletto*, a triumph which was fully sustained by the production two years later of *Il Trovatore* and *La Traviata.* In these works Verdi reached the culminating point of what may be called his second manner. His development had been steady though gradual, and it is only necessary to compare the treatment of voice and orchestra in *Rigoletto* with that in *Ernani* to realize how quickly his talent had developed during these seven years. The popularity of *Rigoletto*, *Il Trovatore*, and *La Traviata* was enormous, and consolidated Verdi's fame outside the frontiers of Italy. In 1855 he received a commission to write an opera for the Paris Opéra, to be produced during the Universal Exhibition. He wrote *Les Vêpres Siciliennes*, a work which though temporarily successful has not retained its popularity. It contains some fine music but suffers from the composer's perhaps unconscious attempt to adopt the grandiose manner of French opera. Of the works written during the next ten years only *Un Ballo in Maschera* (1859) has maintained a fitful hold upon public attention. *La Forza del Destino* (1862) and *Don Carlos*, the latter of which was written for the Paris Exhibition of 1867, have the faults incident to works written during a period of transition. At this point in his career Verdi was preparing to emancipate himself from the fetters of conventionality which had hitherto hindered his development. In these two works there are indications of an aspiration towards a freer method of expression, which harmonize ill with the more conventional style of the composer's earlier years. In *Aida*, an opera upon an Egyptian subject, written in response to an invitation from Ismail Pasha, and produced at Cairo in 1871, Verdi entered upon the third period of his career. In this work he broke definitely with the operatic tradition which he had inherited from Donizetti, in favour of a method of utterance, which, though perhaps affected in some degree by the influence of Wagner, still retains the main characteristics of Italian music. In *Aida* the treatment of the orchestra is throughout masterly, and shows a richness of resource which those who knew only Verdi's earlier works scarcely suspected him of possessing; nevertheless, the human voice was still the centre of Verdi's system. Verdi kept thoroughly abreast of modern musical development, but his artistic sense prevented him from falling into the excesses of the German school. In the *Requiem*, which was written in 1874 to commemorate the death of Manzoni, Verdi applied his newly-found system to sacred music. His *Requiem* was bitterly assailed by pedants and purists, partly on the ground of its defiance of obsolete rules of musical grammar and partly because of its theatrical treatment of sacred subjects, but by saner and more sympathetic critics, of whom Brahms was not the least enthusiastic, it has been accepted as a work of genius. There are passages in it with which Protestant feeling can scarcely sympathize, but its passionate intensity and dramatic force, and the extraordinary musical beauty with which it abounds, amply atone for what to some may seem errors of taste. In 1881 a revised version of *Simon Boccanegra*, an earlier work which had not been successful, was produced at Milan. The libretto had been in part rewritten by Arrigo Boito, and Verdi wrote a great deal of new music for the revival, which was eminently successful. After this it was generally supposed that Verdi, who had reached an advanced age, had finally relinquished composition, but after a lapse of some years it became known that he was at work upon a new opera, and in 1887 *Otello* was produced at Milan. The libretto, a masterly condensation of Shakespeare's *Othello*, was the work of Boito. *Otello* recalls *Aida* in the general outlines of its structure, but voices and orchestra are treated with greater freedom than in the earlier work, and there is a conspicuous absence of set airs. In so far as regards the essential qualities of the music, *Otello* is an immense advance upon anything Verdi had previously written. It has a dramatic force and a power of characterization for which it would be vain to look in his earlier work, and which are all the more remarkable as appearing for the first time in this high degree of development in a work written in extreme old age. All that has been said of *Otello* may be repeated of *Falstaff*, which was produced in 1893, when the composer was in his eightieth year, with the addition that the later work contains, besides the dramatic power and musical skill of the earlier work, a fund of delicate and fanciful humour which recalls the gayest mood of Mozart. The libretto of *Falstaff*, which is the work of Boito, is an adaptation of *The Merry Wives of Windsor*, with the addition of a few passages from *Henry IV*. After the production of *Falstaff*, Verdi wrote nothing for the stage. In 1898 he produced four sacred pieces, settings of the *Ave Maria*, *Laudi alla Virgine* (words from Dante's *Paradiso*), the *Stabat Mater*, and the *Te Deum*, the first two for voices alone, the last two for voices and orchestra. In these pieces Verdi abandoned to a certain extent the theatrical manner of the *Requiem* for one more restrained and more in keeping with ecclesiastical traditions. In imaginative power and musical beauty these pieces yield to none of Verdi's works. With the exception of these and the *Requiem*, Verdi has written little save for the stage. Among his minor works may be mentioned a string quartet, composed in 1873, a Hymn written for the opening of the International Exhibition of 1862, two sets of songs, a *Paternoster* for five part chorus, and an

Ave Maria for soprano solo, with string accompaniment. The venerable composer died at Milan on 27th January 1901.

The following is a complete list of Verdi's operas, with the dates and places of production: *Oberto* (Milan, 1839); *Un Giorno di Regno* (Milan, 1840); *Nabucodonosor* (Milan, 1842); *I Lombardi* (Milan, 1843); *Ernani* (Venice, 1844); *I Due Foscari* (Rome, 1844); *Giovanna d'Arco* (Milan, 1845); *Alzira* (Naples, 1845); *Attila* (Venice, 1846); *Macbeth* (Florence, 1847); *I Masnadieri* (London, 1847); *Il Corsaro* (Trieste, 1848); *La Battaglia di Legnano* (Rome, 1849); *Luisa Miller* (Naples, 1849); *Stiffelio* (Trieste, 1850); *Rigoletto* (Venice, 1851); *Il Trovatore* (Rome, 1853); *La Traviata* (Venice, 1853); *Les Vêpres Siciliennes* (Paris, 1855); *Simon Boccanegra* (Venice, 1857: revised version, Milan, 1881); *Aroldo* [a revised version of *Stiffelio*] (Rimini, 1857); *Un Ballo in Maschera* (Rome, 1859); *La Forza del Destino* (St Petersburg, 1862); *Don Carlos* (Paris, 1867); *Aida* (Cairo, 1871); *Otello* (Milan, 1887); *Falstaff* (Milan, 1893). (R. A. S.)

Verdun, a town and first-class fortress of France, in the department of the Meuse, and on the river of that name, which here divides into five arms, at the junction of the important railway lines Sedan–Toul and Rheims–Conflans (Metz). The military strength of Verdun consists in its strategical ring of detached modern forts which extend along a circle some 25 miles round. They are eleven in number, four lying on the left and seven on the right bank of the Meuse, the latter being connected by a chain of defence works with the group of forts surrounding Toul. Since the Franco-German war and the loss of Metz, Verdun has been made the strongest defended town in eastern France. It has some manufactures of hardware, leather, liqueurs, and sweet-stuffs. Population (1891), 18,195; (1901), 13,097.

Vergara, a town of Spain, in the Basque province of Guipuzcoa, on the right bank of the river Deva, with a station on the line from Bilbao–Durango to Zumarraga. The older streets full of massive Basque houses with iron-railed balconies, projecting carved roofs, doors embossed with heavy nails as knockers, much valued by antiquaries, stone coats of arms, are in marked contrast with the very modern mills of every kind with their tall chimneys and incessant activity. Paper, cloths, cotton and linen goods, and matches are manufactured in this old seat of theocracy and of Jesuits and despotism. Vergara has several convents and monasteries, good primary schools, a seminary founded in 1776, hospitals, some noble mansions, a parish church of San Pedro in the heart of the town with a square tower, another parish church of Santa Maria with three naves supported by heavy handsome columns, and containing a few good paintings and tombs of local worthies. Vergara was prosperous in the 15th and 16th centuries owing chiefly to its arms factories, that afterwards decayed. It was long the headquarters of the Carlists in the first rising of 1834–40. The Liberal commander-in-chief, Espartero, captured it in August 1839, a few days before the celebrated Convenio of 27th August of that year, by which the Carlist leader Maroto, with several others, and about five thousand men, betrayed the Pretender and secured the recognition of their rank and pensions from the Government of Isabella II. Population (1897), 6500.

Verkhne-Dnieprovsk, district town of Russia, in the government and 35 miles by rail north-west of the town of Ekaterinoslav, near the right bank of the Dneiper. It was founded in 1760, and has a steam flour-mill, candle works, a public library, and a hospital maintained by the *zemstvo* (provincial council). Four fairs are held annually in grain, cattle, and animal products. Population (1897), 11,607.

Verkhne-Udinsk, a district town of Asiatic Russia, East Siberia, province of Transbaikalia, on the right bank of the Uda, at its junction with the Selenga, 102 miles by rail (Trans-Siberian Railway) east of Lake Baikal, to which steamers also ply.

It was founded as a small fort in 1668, and is now a fairly well-built town, rapidly growing in importance as a centre for the overland trade in tea with China, and as an emporium both for grain and animal products, which are exported, and for metals, machinery, and manufactured goods, which are imported. Its yearly fair is a centre for all the trade in Transbaikalia, and yields returns estimated at about 2,000,000 roubles. It has a progymnasium for girls, a number of primary schools, a public library, and a hospital. Population (1897), 8002.

Verkhne-Uralsk, a district town of Russia, in the government of Orenburg, on the left bank of the Upper Ural river, 205 miles east-south-east of Ufa. It was founded under the name of Verkho-Yaitsk in 1734, and has several tanneries and distilleries, and carries on an active trade with the Kirghiz. Population (1897), 11,802.

Verlaine, Paul (1844–1896), the most personal and exquisite French lyric poet of his generation, was born at Metz, 30th March 1844. His first volume of poems, the *Poèmes Saturniens* (1866), was written under Parnassian influences, from which the *Fêtes Galantes* (1869), as of a Watteau of poetry, began a delicate escape. He married in 1870. In 1871 the strange young poet Rimbaud came somewhat troublingly into his life, into which drink had already brought a lasting disturbance. With Rimbaud he wandered over France, Belgium, England, until a pistol-shot, fortunately ill-aimed, against his companion brought upon him two years of imprisonment at Mons. Solitude, confinement, and thought converted a pagan into a Catholic, without, however, rooting out what was most human in the pagan; and after many years' silence he published *Sagesse* (1881), a collection of religious poems, which, for humble and passionate conviction, as well as originality of poetic beauty, must be ranked with the finest religious poems ever written. *Romances sans Paroles*, composed during the intervals of wandering, appeared in 1874, and shows us Verlaine at his most perfect moment of artistic self-possession, before he has quite found what is deepest in himself. During the rest of his life he lived in poverty, often in hospital, but always with the heedless and unconquerable cheerfulness of a child. After a long obscurity, famous only in the Latin Quarter, among the cafés where he spent so much of his days and nights, he enjoyed at last a European celebrity. In 1894 he paid a second visit to England, this time as a distinguished poet, and lectured at London and Oxford. He died in Paris on 8th January 1896. His eighteen volumes of verse (among which may be further mentioned *Jadis et Naguère*, 1884; *Amour*, 1888; *Parallèlement*, 1889; *Bonheur*, 1891) vary greatly in quality as in substance; they are all the sincere expression, almost the instantaneous notation, of himself, of his varying moods, sensual passion, the passion of the mystic, the delight of the sensitive artist in the fine shades of sensation. He brought into French verse a note of lyrical song, a delicacy in the evocation of sound and colour, which has seemed almost to create poetry over again, as it provides a language out of which rhetoric has been cleansed and a rhythm into which a new music has come with a new simplicity. (A. Sy)

Vermont, one of the New England states of the American Union. Since 1870 the population has been nearly stationary. The census of 1890 gave a total of 332,422, a gain of but 136 over the previous enumeration. In 1900 the population was 343,641, an increase during the preceding decade of 11,219, or 3·4 per cent. The density of the population per square mile in 1900 was 37·6. In 1890 the density per square mile was 36·4, giving nearly 19 acres to each inhabitant; males of militia age (18 to 44 years inclusive) numbered 67,203, and those of voting age (21 years or over), 101,697, of whom 82,011 were native-born. In 1900 the males of militia age numbered 70,850, and those of voting age 108,356, of whom 87,465 were native-born and 20,891 were foreign-born. Of these native-born adult males in 1900, 3673 were illiterate (unable to write), and of the foreign-born 4871 were illiterate. There were only 826 negroes in the state. In 1900 there were 175,138 males and 168,503 females. In 1890 the urban population (persons in towns of over 4000 inhabitants) was 40,213, or 12·1 per cent. of the total population; in 1900 it had increased to 72,048, or 21 per cent. In the decade from 1890 to 1900, 171 towns out of 246, and 6 of the 14 counties, showed a decrease in population; the gains were chiefly in manufacturing and mining towns. In 1900 only 13 incorporated cities and villages had a population of more than 2000 each; of these the largest were Burlington (18,640), Rutland (11,499), and Barre (8448). The number of families in 1890 was 75,869, or 4·38 to each family (ratio 5·36 in 1850); number of dwellings, 69,817, or 4·76 to a dwelling (5·57 in 1850); 46,584 families own their homes and farms. The whole number of marriages between 1890 and 1896 was 20,305; the number of divorces reported in the same seven years 1462, or one divorce to every 13·88 marriages.

State Institutions.—The state institutions are situated as follows: the State Prison at Windsor, the House of Correction at Rutland, the Soldiers' Home at Bennington, and the State Hospital for the insane at Waterbury. Previous to the opening of the last-named in 1891, the insane had been cared for chiefly at the Vermont Asylum or Retreat, opened at Brattleboro in 1836. This was aided by the state and is under its inspection. There are public hospitals at Burlington, St Albans, Montpelier, Rutland, and Colchester. At Burlington there are also five private hospitals (one for mental diseases), two homes for children, one for aged and one for friendless women, and one endowed foundation for the relief of the poor.

Education.—The public schools are supported by the income of the United States deposit fund of 1837, Vermont's share being $669,086, by the income of the Huntington legacy, $211,130, by a state tax first voted in 1890, which chiefly benefits the smaller towns, and by local taxation. The total expenditure in 1900 was $1,074,222, or $16·28 per pupil. The number of children of school age (from 5 to 21) was 90,648, of whom 65,964 were in attendance. The teachers numbered 3742, of whom 3232 were females; of the whole number 632 were graduates of Vermont normal schools and 201 of colleges. After twenty-two years' discussion, the old district system was abolished in 1892, since which date there has been gratifying progress throughout the state. Licences to teach have been granted by county examiners since 1890. In 1890 there were enrolled in private schools 4553 pupils; in denominational (including parochial) schools, 5671. In 1898 the state had 3 normal schools, 22 academies and 57 high schools. In 1901 the State University at Burlington had in the departments of arts and sciences 35 instructors and 295 students; in its medical college, 32 instructors and 155 students. In the latter a four years' course has been adopted, to which admission is gained by examination, and the curriculum has been extended from 575 hours of teaching to nearly 2000 hours. The library contains 63,000 volumes. Middlebury College has a teaching staff of 10 and 113 students, with a library of 25,000 volumes. Norwich University at Northfield was made the state military school in 1898, and money appropriated for its uses. In 1899 the erection of Dewey Hall was begun. In 1901 it had 10 instructors and 73 students. Its library contains 6000 volumes. Thirty state scholarships were voted in 1888 to each of the three colleges, and these have since been continued. The state agricultural experiment station is connected with the university. In 1898 the state established a bacteriological laboratory at Burlington, and authorized the expenditure thereon of $8000 annually; in the following year the first systematic and gratuitous school for health officers in the United States was held in the same city.

Libraries.—In November 1900 151 towns had libraries, 117 of these being entirely free. Some of these are housed in handsome and substantial buildings; twenty-one have over 4000 volumes each, eight above 10,000. This list omits the state library at Montpelier (38,200 volumes), the college libraries, and private collections. There are 94 newspapers, of which 8 are issued daily, 76 weekly, 1 twice a week, 1 twice a month, and 8 monthly.

Religion.—The number of religious organizations of all denominations in 1890 was 904; of edifices, 802; of sittings, 273,000. The total valuation of church property was $4,643,800. The communicants numbered 106,315, or 31·98 per cent. of the population. The leading denominations are Roman Catholics (42,810 communicants); Congregationalists (20,465); Methodists (17,268); Baptists (11,258).

Agriculture, &c.—A little more than 50 per cent. of the population is engaged in agriculture. There were, in 1900, 33,104 farms, averaging 142·7 acres; of these 85·50 per cent. were cultivated by the owners. In 1880 there were 35,522 farms. The valuation of farms was, in 1900, $108,451,427; of farm products, $33,570,892. Between 1850 and 1900 the production of sheep decreased from 1,014,122 to 182,167, that of cheese from 8,720,834 ℔ to 406,659 ℔, and of potatoes from 4,951,014 bushels to 3,547,829 bushels. In the same period the production of horses increased from 61,057 to 85,531; of milch cows from 146,128 to 270,194; of butter from 12,137,980 ℔ to 18,834,706 ℔; of hay from 866,153 tons to 1,336,499 tons; of barley from 42,150 bushels to 380,940 bushels; and of Indian corn from 2,032,396 bushels to 2,322,450 bushels. Apples produced in 1889 1,176,822 bushels. The state continues its efforts to stock the streams and lakes with fish, and to protect game birds.

Manufactures.—Between 1890 and 1900 the number of manufacturing establishments increased from 3031 to 4071; of employés from 22,119 to 29,455; of wages paid from $8,427,553 to $12,237,684; the value of products from $38,340,066 to $57,646,715; and of capital from $32,763,291 to $48,547,964. Among the most important products in 1900 were: lumber and timber products, valued at $6,131,808; cheese, butter, and condensed milk (factory product), at $5,656,265; of monuments and tombstones, at $4,045,611; and of flour and grist mill products, at $3,222,347; of woollen manufactures, at $2,822,646; and of paper and wood pulp, at $3,384,773.

Minerals.—The total value of mineral products in 1889 was $5,674,022. Of this thirty-six marble quarries produced $2,169,560; the total of marble for all the rest of the United States being $1,318,560. Of the finer grades of marble Vermont produces seven times as much as any other state. Of granite in 1880 Vermont produced 187,140 cubic feet; in 1889, 1,073,586 cubic feet; in 1897 the output of eighty-seven companies was valued at $1,512,543. In 1896 only Massachusetts and Maine produced more granite than Vermont. In 1898 Vermont produced more than Maine and within 6 per cent. of as much as Massachusetts. Of slate, in 1889, the product of sixty-one firms was valued at $842,013, only Pennsylvania producing more.

Finance.—There is virtually no state debt, what might figure as such being funds held in trust for colleges, schools, or towns. In the fiscal year ending 30th June 1901 the state treasurer paid auditor's orders to the amount of $690,958, the whole sum passing through his hands being $1,283,970. The total combined debt of towns, &c., in 1890 was $3,785,373, being $11·39 per caput—less than in any other state of the North Atlantic group. The valuation of real and personal property in 1850 was $92,205,049, or $210 per caput; and in 1890, $265,567,323, or $740 per caput.

On 30th September 1901 there were forty-seven national banks, with a total capital of $6,435,000, and a surplus of $1,449,163; loans and discounts amounted to $12,818,334; deposits, $11,200,202; the actual money reserve was $3,875,827. Deposits in forty-one savings banks, 30th June 1901, amounted to $40,209,059, being $326·50 to the credit of each of 123,151 depositors; gain in resources in 1900–01, $2,029,758. The business failures in 1898 were ·83 per cent., against 1·10 per cent. for the United States and 1·64 per cent. for the whole of New England.

Commerce.—There are two United States collection districts, comprising in all sixteen customs offices. At Burlington, the port of entry for the district of Vermont, during the year ending 31st December 1901, the value of the imports was $3,540,234, and of exports, $9,035,596. At Newport, the port of the district of Memphremagog, the imports for the same period amounted to $17,790,907; of exports, to $2,260,318.

Transportation.—In 1898 there were 992·06 miles of railway. An additional line from Burlington to Montreal, 41 miles in length, through the islands of Lake Champlain, was completed in 1900. In 1890 there were but 13·33 miles of street railways; in 1899 there were 66 miles of electric lines. The water power, in which the state abounds, is increasingly utilized to work electric plant for the production of both light and power. A state road tax has been levied annually since 1892, the proceeds of which are expended under state supervision. Upon Lake Champlain there were in 1889 22 steam vessels and 25 schooners; total tonnage, 9061, of which 3837 tons were owned in Vermont; freight carried, 1,760,549 tons; passengers, 87,139. The number of craft owned in the Vermont district on 1st July 1901 was 26, with a tonnage of 4195.

Politics.—The political complexion of the state is strongly Republican in general elections. In the Presidential election of 1900 McKinley received 42,569 votes, and Bryan 12,849. In the election for governor in the same year the Republican candidate received 48,441 votes, and the Democrat, 17,129. Though the state sends but two representatives to Congress, ten members of that body are natives of Vermont, a larger ratio to the population than is shown by any other state.

Recent History.—The policy of prohibition has been steadily maintained since its adoption in 1852. In spite of considerable opposition from a few of the larger towns, nearly every assembly enacts still more stringent legislation. In 1888 the payment of a United States licence tax was made *primâ facie* evidence that its holder was a common seller, and his place of business a nuisance. In 1898 anti-saloon leagues began to be organized throughout the state for the enforcement of the law, and in the next year druggists were vigorously prosecuted as holders of such licences, and not a few placed under injunction by the courts. A state Board of Trade was appointed in 1888. The incidence of taxation has been sensibly modified by a tax laid on corporations in 1883, from which $453,543 was realized in 1901. The Supreme Court ceased in 1892 to make the circuit of the several counties, and since that date holds three general terms at the capital in January, May, and October. Sentences to the state prison or house of correction for a maximum or minimum term were legalized in 1898, the prisoner to be paroled on probation at the expiration of the shorter term, if the prison commissioners approve. At the outbreak of the Spanish-American war, the state promptly sent a full regiment of 1030 men, about twice the quota first called for, and voted in special session $7 a month additional pay to its volunteers, and to all residents of Vermont who should enlist in the navy or marine corps.

AUTHORITIES.—In addition to the books cited in vol. xxiv. p. 168 of the 9th edition of this Encyclopædia, the following may be consulted with advantage:—ROBINSON. *History of Vermont.* 1892.—WILLIAMS. *History of Vermont*, 2 vols. 1809.—B. H. HALL. *History of Eastern Vermont.* 1858.—R. C. BENTON. *Vermont Settlers and New York Speculators.* 1894.—HEMENWAY. *Vermont Historical Gazetteer*, 6 vols. 1860–1902.—PALMER. *History of Lake Champlain.* 1852.—GILMAN. *Bibliography of Vermont.* 1897.—IRA ALLEN'S *History of Vermont* (London, 1798) is reprinted in vol. i. of the *Collections of the Vermont Historical Society*, and the *Haldimand Papers* in vol. ii. (J. E. G.)

Verne, Jules (1828– ——), French author, was born at Nantes on 8th February 1828. After completing his studies at the Nantes lycée, he went to Paris to study for the bar. About 1848, in conjunction with Michel Carré, he wrote librettos for two operettas, and in 1850 his verse comedy, *Les Pailles Rompues*, in which Alexandre Dumas fils had some share, was produced at the Gymnase. For some years his interests alternated between the theatre and the bourse, but some travellers' stories which he wrote for the *Musée des Familles* seem to have revealed to him the true direction of his talent—the delineation, namely, of delightfully extravagant voyages and adventures to which cleverly prepared scientific and geographical details lent an air of verisimilitude. Something of the kind had been done before, after kindred methods, by Cyrano de Bergerac, by Swift and Defoe, and more recently by Boistard and Mayne Reid. But in his own particular application of plausible scientific apparatus Verne undoubtedly struck out a department for himself in the wide literary genre of *voyages imaginaires.* His first success was obtained with *Cinq Semaines en Ballon*, which he wrote for Hetzel's *Magazin d'Éducation* in 1862, and thenceforward, for a quarter of a century, scarcely a year passed in which Hetzel did not publish one or more of his fantastic stories, illustrated generally by pictures of the most lurid and sensational description by Riou. The most successful of these romances include: *Voyage au Centre de la Terre*, 1864; *De la Terre à la Lune*, 1865; *Vingt Mille Lieues sous les Mers*, 1869; *Les Anglais au Pôle Nord*, 1870, and *Voyage autour du Monde en quatre vingts Jours*, which first appeared in *Le Temps* in 1872. The adaptation of this last (produced with immense success at the Porte St Martin Theatre, 8th November 1874) and of another excellent tale, *Michael Strogoff* (at the Châtelet, 1880), both dramas being written in conjunction with Adolphe d'Ennery, proved the most acceptable of Verne's theatrical pieces. The novels were translated into the various European languages, and had an enormous success in England. But after 1877, when he published *Hector Servadac*, a romance of existence upon a comet, the writer's invention began to show signs of fatigue (his kingdom had been invaded in different directions and at different times by such writers as R. M. Ballantyne, Rider Haggard, and H. G. Wells), and he even committed himself, somewhat unguardedly, to very gloomy predictions as to the future of the novel. Jules Verne's own novels will certainly long continue to delight readers by reason of their sparkling style, their picturesque *verve*—apparently inherited directly from Dumas—their amusing and good-natured national caricatures, and the ingenuity with which the love element is either subordinated or completely excluded. M. Verne, who was always extremely popular in society, divided his time for the most part between Paris, his home at Amiens, and his yacht. He was made a member of the Legion of Honour, and several of his romances were crowned by the French Academy. A brother, Paul Verne, has contributed to the *Transactions* of the *French Alpine Club*, and wrote an *Ascenscion du Mont Blanc* for his brother's collection of *Voyages Extraordinaires* in 1874.

Vernon, a town of Tolland county, Connecticut, U.S.A., with an area of 19 square miles of hill country, situated in the northern part of the state. It contains Rockville city, and the villages of Vernon, Vernon Centre, and Talcottville. Rockville is on a line of the New York, New Haven and Hartford Railroad, and manufactures cotton, woollen, and silk goods. Population of the town (1880), 6915; (1890), 8808; (1900), 8483; of the city of Rockville (1880), 5902; (1890), 7772; (1900), 7287, of whom 2548 were foreign-born.

Verona, a fortified city of Italy, in the division of Venetia, on the river Adige, 72 miles west of Venice by rail. In recent years it has seen important changes. In consequence of the disastrous flood of 1882, important embankment works were executed along the Adige at a cost of £300,000. These works preclude all danger of future inundation. In addition to the Adige embankment, other hydraulic works have been either completed or undertaken. An irrigation canal, deriving water from the Segà, furnishes 11½ cubic metres per second to the fields of the upper Veronese district. The Camuzzoni industrial canal, which runs from the Chievo di S. Massimo to the suburb of Tombetta, furnishes 26 cubic metres of water per second, and generates 4000 horse-power. The cutting of this canal led to the construction of an aqueduct for drinking water, which, besides supplying the city, furnishes an ice factory with enough water to make 200 quintals of ice per day. The motive-power generated by the Camuzzoni canal is utilized by a large nail factory, flour mills, paper mills, cotton mills, and works for the distribution of electric energy.

The Adige embankment gave an impetus to building enterprise, the banks of the river being now flanked by villas and large dwelling-houses. The growth of industry and the development of the suburbs have led to the extension of the tramway system. Steam tramways run from Verona to Vicenza, and from Verona to Albaredo. The chief centres of the province are connected with the city by the Verona-Caprino Railway.

Care for education has kept pace with the growth of the city. The number of schools has been increased from eighteen to twenty, and almost all are now communal property. The number of school children in 1901 was 4349.

Especial progress has been made in regard to charitable institutions since 1880. The hospital for the aged has been extended so as to accommodate a hundred more inmates. An asylum has been erected to provide shelter for beggars and unemployed paupers. It contains 700 places, but efforts are being made to obtain its enlargement. Public dormitories, with room for 150 persons, have been opened, and an institute capable of receiving a hundred waifs and strays has been founded. A private society cares for the children of poor parents, keeping them off the streets after school-hours, and providing them with food and recreation. The Alpine Colony Society sends 200 children per annum to recruit in the Alps, and the *Asili Aportiani* shelter and feed 800 children. In addition to these institutions there exist a female orphanage and a deaf and dumb institute, where those unable to speak and hear are taught, as far as possible, to articulate, sing, and understand spoken language.

Praiseworthy, if not always entirely satisfactory, efforts have been made to preserve and restore ancient monuments. In 1875, or thereabouts, the north-east corner of Santa Anastasia was isolated from the houses which surrounded it, and the four chapels which flank the high altar were restored to their original form. During the work some terra-cotta bas-reliefs of the 15th century (representing the Passion) were discovered in the Cappella Pellegrini on the right of the high altar. The only defect of the work was the introduction of some stained glass scarcely in keeping with the style of the church. In 1900 measures were taken to save the celebrated fresco by Pisanello (San Giorgio) from nitrous infiltrations.

The cathedral has been the object of care on the part of Cardinal Canossa. The pavement has been repaired with coloured marbles. Splendid frescoes have been discovered on the walls, and the cloister has been restored. The steps before the façade have been renewed in their original proportions, and a wall removed so as to allow a full view of the side of the building. The belfry of the great Campanile has been strengthened.

Equal care has been taken of the churches Santissima Trinità, Santa Maria Antica, and San Pietro Martire. The ancient Roman theatre was carefully preserved from harm during the construction of the Adige embankment, and the arena partially restored and explored. Many Roman and mediæval remains were brought to light during these operations, and during the excavation for the Adige embankment. They have been placed in the civic museum. Population (1881), 68,121; (1901), 73,917. (H. W. S.)

Versailles, chief town of the department of Seine-et-Oise, France, 12 miles west-south-west of Paris, with which it is connected by rail and tram. The library contains 75,000 volumes; besides other institutions are a museum of the Revolution and a municipal school of music. Distilleries, engineering workshops, and market gardening employ many of the people, but the town has scarcely any specially characteristic industry. Population (1901), 54,081.

Verviers, a town of Belgium, on the Vesdre, an affluent of the Ourthe, and on the railway from Brussels to Cologne, capital of an administrative arrondissement of the province of Liége, almost entirely on the left bank of the Vesdre. It presents one part low, long, and narrow, stretching along the valley, and another high (770 feet above sea-level), forming a new quarter (dating from 1875) with boulevards, connected with the old town by the Escalier de la Paix, so called because it is crowned by a statue of Peace in bronze. The upper part of the town is industrial. The centre is commercial and has the appearance of a fine city. The educational institutions comprise a royal athenæum, a school of manufactures, a school of music, a normal school, a middle-class boys' school and a middle-class girls' school. Besides a state hospital for old people of both sexes, there are orphanages for boys and girls, and a society for the building of working-men's houses. Verviers is an important centre of the cloth industry. The manufacture of cloths and woollen tissues (including the spinning of carded and combed wool, the washing of the wool, and the dressing and dyeing of yarn and tissues) employs altogether 6000 workers. The wools are imported from the Argentine, the Cape, and Australia. The export in 1898 of woollen yarns, carded and dyed, amounted to over 17½ million lb, the greater part of which went to Great Britain, the export of woollen tissues to over 5 million lb. Mechanical tool-making employs 600 workers, exclusive of other accessories of the textile industry. Population (1876), 37,828; (1900), 49,067.

Veshenskaya, a Cossack village of Russia, in the province of the Don Cossacks, on the river Don, 133 miles from Sebryakovo railway station. Its inhabitants are chiefly engaged in gardening and cattle-breeding, and there is some trade in cattle. Population (1897), 28,938.

Vianna do Castello, a seaport town of Portugal, capital of the district of Vianna, at the mouth of the river Lima, 38 miles north of Oporto. It has manufactures of lace and milk foods. Fishing is followed, and both salmon and lampreys (fresh and preserved) are exported. Population (1890), 9682; (1900), 9851. The district of VIANNA DO CASTELLO has an area of 866 square miles, and population (1900), 214,599; density, 248 inhabitants to the square mile. Vegetation grows luxuriantly. The principal product is wine. There exist medicinal mineral waters at Monção, near the river Minho. Cattle, sheep, and goats are kept in considerable quantities. Of the industries the first place is taken by butter-making. Lace is also made.

Viareggio, a maritime town and sea-bathing resort of the province of Lucca, Tuscany, Italy, on the Mediterranean, 13 miles north-west of Pisa by rail. Being sheltered by dense pine-woods on the north, and its malaria having been banished by drainage, it is frequented as a winter resort, and in summer by some thousands for its sea-bathing. It possesses a school of navigation and a technical school, and carries on some shipbuilding. Population (1881), 10,190; (1900), 16,000.

Viborg, a market town of Denmark, capital of the county of Viborg, in the middle of Jutland, 54 miles by rail north-west of Aarhus. The most notable building is the cathedral (1130–69, reconstructed 1864–76). Other buildings are the Blackfriars' church (13th century), a museum, with specimens of the Stone, Bronze (collection of urns), and Iron Ages, also mediæval antiquities, a town hall, and the Jutland archives (1890–91). The industries embrace distilleries, iron foundries, and manufactures of cloth. Population (1890), 8352; (1901), 8623.

Vicenza, a town, episcopal see, and capital of the province of Vicenza, Venetia, Italy, 42 miles west of Venice by rail. The modern buildings include a Renaissance theatre (1886); and there is a statue to Garibaldi (1887), and a monument (1880) and triumphal arch (1866) to Victor Emmanuel. There are an industrial institute and a technical school, and the Olympic Academy of Arts and Sciences (1555). The principal industries are silk-spinning, pottery and majolica, brick-works, iron-works and foundries, and the making of woollens and cottons, linen and hemp, furniture, watches, sugar, chemicals, and pianofortes. Population (1881), 39,431; (1901), 44,261.

Vichy-les-Bains, a town and railway station, arrondissement of Lapalisse, department of Allier, France, 33 miles, in direct line, south by east of Moulins. In the immediate vicinity are thirty springs, exclusive of those of the neighbouring cantons. The Lucas Spring, used chiefly for baths, and the Puits Carré yield, respectively, about 40,000 and 25,500 gallons in the twenty-four hours.

Queen Victoria.

(From a Photograph by Chancellor and Sons, Dublin.)

The annual number of visitors is nearly 50,000, and 7,000,000 bottles of mineral water are exported. The so-called Vichy linen is manufactured at Roanne and Thizy. Population (1891), 10,425; (1901), 14,046.

Vicksburg, the largest and most important city of Mississippi, U.S.A., capital of Warren county, on the cliffs above a "cut-off" lake of the Mississippi river, in the western part of the state, at an altitude of 192 feet. It has a beautiful situation, a regular street plan, an abundant water supply, and a good sewerage system. Two railways, the Queen and Crescent, and the Yazoo and Mississippi Valley, pass through it, and these, with boats on the river, afford outlets for its extensive commerce in cotton and lumber. The surrounding country is one of the finest cotton regions in the United States, while the uncultivated land is clothed with yellow pine timber. The city contains railway works, cotton and oil factories, and other manufactures. Population (1890), 13,373; (1900), 14,834, of whom 660 were foreign-born and 8147 negroes.

Victor Emmanuel III. (1869– ——), King of Italy, son of King Humbert I. and Queen Margherita of Savoy, was born at Naples on 11th November 1869. Carefully educated by his mother and under the direction of Colonel Osio, he outgrew the weakness of his childhood and became expert in horsemanship and military exercises. Entering the army at an early age he passed through the various grades and, soon after attaining his majority, was appointed to the command of the Florence Army Corps. During frequent journeys to Germany he enlarged his military experience, and upon his appointment to the command of the Naples Army Corps in 1896 displayed sound military and administrative capacity. A keen huntsman, and passionately fond of the sea, he extended his yachting and hunting excursions as far east as Syria and as far north as Spitsbergen. As representative of King Humbert he attended the coronation of Tsar Nicholas II. in 1896, the Victorian Jubilee celebrations of 1897, and the festivities connected with the coming of age of the German Crown Prince in 1900. The Prince's intellectual and artistic leanings were well known; in particular, he was a collector of historic Italian coins, on which subject he became an authority. At the time of the assassination of his father, King Humbert (29th July 1900), he was returning from a yachting cruise in the eastern Mediterranean. Landing at Reggio di Calabria he hastened to Monza, where he conducted with firmness and tact the preparations for the burial of King Humbert and for his own formal accession, which took place on 9th August and 11th August 1900. The manly, earnest tone of his first speech from the throne, delivered in the presence of both Houses of Parliament, created an exceedingly favourable impression. Upon the fall of the Saracco Cabinet in February 1901 King Victor Emmanuel evinced his Liberal tendencies by entrusting the premiership to Signor Zanardelli, leader of the Left, although it was evident that the latter could not govern without the support of the Socialist forces. He possesses the intrepidity and promptness in action characteristic of the House of Savoy, as was admirably proved on the occasion of a railway accident at Castel Giubileo, near Rome, in August 1900. On 24th October 1896 he married Princess Elena of Montenegro, who, on 1st June 1901, bore him a daughter named Yolanda Margherita.

VICTORIA, QUEEN.

VICTORIA (ALEXANDRINA VICTORIA), Queen of the United Kingdom of Great Britain and Ireland, Empress of India (1819–1901), only child of Edward, Duke of Kent, fourth son of King George III., was born in Kensington Palace, on 24th May 1819. Her parents had been living at Amorbach, in Franconia, owing to the Duke of Kent's straitened circumstances, but they returned to London on purpose that their child should be born in England; and the Duke was so anxious for the safety of his wife that he himself drove the carriage over all the land part of the journey from Bavaria. The Duchess of Kent was the Princess Victoria Mary Louisa of Coburg, who had been married first to Prince Emich Karl of Leiningen, and by him had two children. The birth of the Duke of Kent's baby was not considered at the time an event of much importance, for several lives and many possibilities stood between the infant and her chance of succeeding to the throne. George III. was still alive—aged, blind, and insane—and two brothers of the Prince Regent older than the Duke of Kent were living also. The first of these, the Duke of York, was not likely to have children; but the Duke of Clarence had been married on the same day as the Duke of Kent to the Princess Adelaide of Saxe-Meiningen, and he was to have two daughters, both of whom, however, died during infancy. The question as to what name the Duke of Kent's child should bear was not settled without bickerings. The Duke of Kent wished her to be christened Elizabeth, after England's greatest Queen, but the Tsar Alexander I. had promised to stand sponsor, and his Ambassador in London, Prince Lieven, made great efforts to get the child named Alexandrina. On the other hand, the Prince Regent desired that his niece should be called Georgiana. In the end the Regent yielded to the Tsar, but said that as the name of George could stand second to none, that of Georgiana should not be conferred at all. The baptism was performed in a drawing-room of Kensington Palace on 24th June by Dr Manners Sutton, Archbishop of Canterbury, who used the gold font which figures among the Regalia in the Tower. The Prince Regent, who was present, named the child Alexandrina; then, being respectfully requested by the Duke of Kent to give a second name, he said, rather abruptly, "Let her be called Victoria, after her mother, but this name must come after the other," upon which the Duke of York, as proxy for the emperor of Russia, made a low bow. Six weeks after her christening the Princess was vaccinated. This was the first occasion on which a member of the Royal Family underwent the operation, and it helped greatly to diminish the prejudice against Jenner's discovery among ignorant people. In January 1820 the Duke of Kent died, five days before his brother, the Prince Regent, succeeded to the throne as George IV. The widowed Duchess of Kent was no longer in her first youth. She was a woman of thirty-four, handsome, homely, a German at heart, and with little liking for English ways. But she was a woman of experience and shrewd; and fortunately she had in her brother, Prince Leopold of Coburg, afterwards King of the Belgians, a safe and affectionate adviser. This Prince had been the husband of the Princess Charlotte of Wales, daughter of the Regent and direct heir to the British Crown, who died in 1817 with her new-born child, and this double bereavement had destroyed both his domestic happiness and his political expectations. In his sorrow he had never had the courage to look upon the face of his infant niece before her father's death, but

Early years.

from that day he took the child under his guardianship, lavishing as much devotion on her as if she had been his own daughter. The Prince lived at Claremont, and this became the Duchess of Kent's occasional home; but she was much addicted to travelling, and spent several months every year in visits to watering-places. It was said at Court that she liked the demonstrative homage of crowds; but she had good reason to fear lest her child should be taken away from her to be educated according to the views of George IV. Between the King and his sister-in-law there was little love. The spirited Duchess had never concealed her dislike for his Majesty's character, or her contempt for his associates of both sexes, and she had also managed to make an enemy of the ill-natured Duke of Cumberland, whom the King feared for his cutting tongue. The Duke sought to embitter his brother's mind against the Duchess of Kent, and when the death of the Duke of Clarence's two children, in 1820 and 1821, had made it pretty certain that Princess Victoria would become Queen, the Duchess felt that the King might possibly obtain the support of his Ministers if he insisted that the future Sovereign should be brought up under masters and mistresses designated by himself. The little Princess could not have received a better education than that which was given her under Prince Leopold's direction, and which tended to make her simply an accomplished lady. Her uncle considered that she ought to be kept as long as possible from the knowledge of her position, which might raise a large growth of pride or vanity in her and make her unmanageable; so Victoria was twelve years old before she knew that she was to wear a crown.

The Princess was zealously watched. Until she became Queen she never slept a night away from her mother's room, and she was not allowed to converse with any grown-up person, friend, tutor, or servant without the Duchess of Kent or the Baroness Lehzen, her private governess, being present. Miss Lehzen, a native of Coburg, had come to England as governess to the Princess Feodore of Leiningen, the Duchess of Kent's daughter by her first husband, and she became teacher to the Princess Victoria when the latter was five years old. George IV. afterwards made her a baroness of Hanover. The little Princess Drina, as she was called till her ninth year, at first took all her lessons in German, and she learnt to speak her native tongue with such a Teutonic accent that she made her uncles laugh by saying "Goot mornink." But this peculiarity wore off when in her tenth year she was placed under English masters. The Rev. George Davys, afterwards Bishop of Peterborough, taught her Latin; Mr J. B. Sale, music; Mr Westall, history; and Mr Thomas Steward, the writing master of Westminster School, gave her instruction in penmanship, and often amused her by relating the pranks played by the King's scholars on Edward the Confessor's foundation. In all her studies the Princess was diligent, but she exhibited a special aptitude for modern languages, music, and drawing. She grew up to be a good linguist, she sketched cleverly, and she sang with a pretty voice and a correctness which in later years drew a surprised compliment from Mendelssohn.

George IV. complained that he did not see enough of his niece, and in 1829 he insisted that she should be present at a children's party which he gave in honour of Donna Maria da Gloria, the little Queen of Portugal, who was then aged ten, having been born in the same year as Victoria. Her small Majesty was a pretty child, but she got a fall in dancing, turned cross, and went away; the English Princess, on the other hand, though observed to be "a short, plain child," won good opinions from everybody by her sweetness of temper.

Reign of William IV.

In 1830 George IV. died, and William IV. having ascended the throne, the Princess Victoria became his heir. A Regency Bill was introduced into Parliament by Lord Lyndhurst, Chancellor in the Duke of Wellington's Administration, and it was judged that the Princess ought now to be told of her proper place in the order of succession. One day the Baroness Lehzen put a genealogical table into her pupil's English history. What followed is mentioned in Sir Theodore Martin's *Life of the Prince Consort*:—

> "The Princess opened the book, and perceiving the additional paper, said, 'I never saw that before.' 'It was not thought necessary that you should, madam,' answered her governess. 'I see I am nearer the throne than I thought,' continued the Princess, and after some moments resumed: 'Now, many a child would boast, but they don't know the difficulty. There is much splendour, but there is more responsibility.' The Princess, having lifted up the forefinger of her right hand while she spoke, gave the Baroness her little hand, repeating, 'I will be good. I understand now why you urged me so much to read even Latin. My aunts, Mary and Augusta, never did; but you told me Latin is the foundation of English grammar and of all elegant expressions, and I learned it as you wished it, but I understand all better now,' and the Princess gave her hand, repeating, 'I will be good.' The governess then said, 'But your Aunt Adelaide is still young and may have children, and of course they would ascend the throne after their father, William IV., and not you, Princess.' The Princess answered, 'And if it were so I should not be disappointed, for I know by the love Aunt Adelaide bears me how fond she is of children.'"

Queen Adelaide was a very good woman. When the second of her children died she had written to the Duchess of Kent: "My children are dead, but your child lives and she is mine too." Kind old William IV. also cherished affectionate feelings towards his niece; unfortunately he took offence at the Duchess of Kent for declining to let her child come and live at his Court for several months in each year, and through the whole of his reign there was strife between the two; and Prince Leopold who, after refusing the crown of Greece, had been induced to open a new career for himself as King of the Belgians, was no longer in England to act as peacemaker.

On 24th February 1831, the Princess Victoria for the first time attended a Drawing Room, and the King was angry because the Duchess of Kent behaved coldly to him, and, as he declared, "made little Victoria look at him stonily." Soon afterwards there was trouble because the Duchess received royal salutes from the ships at Portsmouth when she went to the Isle of Wight. The King was much incensed at this, and negotiations were opened with the Duchess of Kent to make her forego these honours; but she stood on her rights, whereupon the King somewhat ungallantly ordered that no more gunpowder should be burned for her pleasure. Much time and temper was consumed over quarrels of this sort. Emissaries journeyed between Windsor and Kensington, long letters were written, the Duke of Wellington was referred to as arbiter, and as fast as the fire was extinguished in one direction it broke out in another. The Duchess had settled at Kensington Palace, and the King was displeased at her appropriating a suite of seventeen rooms without his permission. In 1835, when the Princess Victoria was confirmed in the chapel of St James's Palace by the Archbishop of Canterbury, his Majesty felt hurt because the Duchess did not seize this opportunity of confessing her imputed wrongs and suing for a reconciliation. To make matters worse, the Duchess and her daughter spent a great part of 1834 and 1835 in rounds of visits to the country houses of the nobility, and certain mischievous busybodies persuaded the King that the object of these expeditions was to undermine his popularity. As a matter of fact, the Duchess of Kent had too much tact ever to speak of the King with disrespect, and her visits to Belvoir, Holkham, Burghley, Chatsworth, Alton Towers, Walmer, and other places were undertaken because it seemed good that the Princess should become acquainted with the leading members of the aristocracy. It was equally desirable that the foremost among the King's subjects should see for themselves that their future Queen had been properly educated, that she was no German mispronouncing her native tongue, that she had no domineering spirit or unorthodox religious opinions, and, above all—a matter about which contemporary opinion was very sensitive—that she evinced no disposition to marry a Roman Catholic prince.

William IV.'s resentment against the Duchess of Kent only increased as the Princess grew older, and it found vent at last in a very violent and undignified attack on the Duchess at his own table. In 1836 the Princess Victoria had failed to attend two Drawing Rooms, and the Duchess had refused an invitation to spend a few days at Windsor on the occasion of Queen Adelaide's birthday. But she and her daughter were present at a banquet given on the 20th August; and there the King, returning thanks for the drinking of his health, made a lachrymose speech, in which he railed at his sister-in-law for being his enemy. "I hope," he continued with growing excitement, "that I may live at least nine months longer, until my dear niece is of age, so that there may be no Regency. A person near me [the Duchess] is surrounded by evil counsellors, and is unfit to exercise the duties of her station."

In May 1837, the Duchess received an address from the City of London, congratulating her on the majority of her daughter, and in her reply she hinted that she had been friendless when she arrived in England, and had since that time met with kindness only from the nation, not from the Royal Family. Exasperated at this, the King vowed he would hold no more terms with the Duchess. The amount of the Princess's allowance was under discussion at the time, and the Duchess desired to be appointed trustee for her daughter; but the King declared that the Princess should have £10,000 a year for her own sole use uncontrolled, and he wrote her a private letter to this effect in fatherly terms. The Marquis of Conyngham, Lord Chamberlain, bore the missive to Kensington, and the Duchess of Kent held out her hand to receive it. "The King's commands are that I should deliver the letter to the Princess Victoria," said Lord Conyngham as coldly as possible, and he did this. The Princess had never before had an unopened letter put into her hands. Before breaking the seal she turned with an affectionate gesture towards her mother, as if to beg her permission; and eventually, by the Duchess's advice, a grateful answer was written, thanking the King for his intended kindness. But the allowance was never settled, since four weeks later William IV. died. The thoughts of his last hours dwelt often on his niece, and he repeatedly said that he was sure she would be "a good woman and a good Queen. It will touch every sailor's heart to have a girl Queen to fight for. They'll be tattooing her face on their arms, and I'll be bound they'll all think she was christened after Nelson's ship." He wanted much to see his niece at his bedside, and at twelve o'clock on Monday, the 19th, an express was sent to Kensington, commanding the Princess Victoria's immediate attendance. The Duchess of Kent chose to ignore this order, though she subsequently explained that the commands had not been brought to her in the King's name, and that she had not understood that his Majesty was at the point of death. It had been her intention to go to Windsor on the following day, but William IV. died in the night.

The Queen's accession.

The King died at about 2 A.M., and half-an-hour afterwards Dr Howley, Archbishop of Canterbury, and the Marquis of Conyngham, started in a landau with four horses for Kensington, which they reached at 5 o'clock. The sun broke from behind clouds and shed a glory over the old red brick Palace as they drove up to it, and the Archbishop noted this as a good omen. Lord Conyngham observed that the proclamation would take place on the morrow, the first day of summer and the longest day of the year, which was of happy augury too. For a long time, however, the two dignitaries who came to hail the girl-Queen could not rouse the porter at the gate. Their servants rang, knocked, and thumped; and when at last admittance was gained, the Primate and the Marquis were shown into a lower room and there left to wait. Presently a maid appeared and said that the Princess Victoria was "in a sweet sleep and could not be disturbed." Dr Howley, who was nothing if not pompous, and who, being attired in his rochet, was vexed that this garment had not obtained for him more respectful treatment, answered with some warmth that he had come on State business, to which everything, even sleep, must give place. The Princess was accordingly roused, and quickly came downstairs in a dressing-gown, her fair hair flowing loose over her shoulders. The Duchess of Kent accompanied her, likewise *en déshabillé*, and in a few minutes the ever-vigilant Baroness Lehzen entered upon the scene with a bottle of sal volatile and the words "Your Majesty" gushing from her lips. The young Queen shed tears on hearing the Archbishop's very solemn announcement, and for a few moments she stood weeping in silence, with her face resting on her mother's shoulder. "I felt no exultation, but something like fear," she wrote a few days later to her uncle Leopold. "I wished to ask the Archbishop to offer up a prayer. I had made up my mind to do this whenever the sad news should come, but I grew confused from hearing Mme von Lehzen address me by my new title and ask Lord Conyngham for details." The Queen's first care on regaining composure was to write a letter of condolence to Queen Adelaide, and she addressed this letter "To her Majesty the Queen." Somebody had the bad taste to suggest that the word "dowager" should be added. "I will not be the first to remind my aunt of the great loss she has sustained," answered the young Queen, thus evincing at the outset of her reign the kindly tact which ever distinguished her public and private conduct.

She was then in her nineteenth year, of pleasing countenance without being pretty, and of dignified deportment without constraint in her movements. She had blue eyes and a rosy complexion; she smiled readily, and had a gentle, wistful glance, which always seemed to solicit the approbation of those to whom she spoke, and turned quickly to astonishment or sadness if she met no genial response. Her dancing mistress, Mlle Bourdin, had taught her to walk, bow, and curtsey in the French fashion—that is, with gracious inclinations of the head and cheerful looks (which were contrary to the etiquette of German Courts, where everything used to be done with rigid gravity)—but the happy vivacity of the Princess's disposition prevented any of her gestures from appearing artificial. She was always natural, and waived etiquette whenever it interfered with a free display of her impulses towards anybody whom she loved or honoured. Her demeanour throughout the trying day when she succeeded to the throne excited general admiration.

The Privy Council assembled at Kensington at 11 o'clock; and the usual oaths were administered to the Queen by Lord Chancellor Cottenham, after which all present did homage. There was a touching incident when the Queen's uncles, the Dukes of Cumberland and Sussex, two old men, came forward to perform their obeisance. The Queen blushed to the brow, and descending from her throne, kissed them both, without allowing them to kneel. By the death of William IV., the Duke of Cumberland had become King of Hanover, and immediately after the ceremony he made haste to reach his kingdom. Within a fortnight of his arrival there he had revoked the Constitution of the country, and wrote to his friend the Duke of Buckingham boasting that he had "cut the wings of democracy." Had Queen Victoria died without issue, this Prince, who was arrogant, ill-tempered, and rash, would have become King of Great Britain; and, as nothing but mischief could have resulted from this, the young Queen's life became very precious in the sight of her people. She, of course, retained the late King's Ministers in their offices, and it was under Lord Melbourne's direction that the Privy Council drew up their declaration to the kingdom. This document described the Queen as Alexandrina Victoria, and all the peers who subscribed the roll in the House of Lords on 20th June swore allegiance to her under those names. It was not till the following day that the Sovereign's style was altered to Victoria simply, and this necessitated the issuing of a new declaration and a re-signing of the peers' roll.

The public proclamation of the Queen took place on the 21st at St James's Palace with great pomp, and it proved a severe ordeal for the nerves of a delicate girl still under her mother's care. Crowds lined the whole route from Kensington, which then stood quite in the suburbs; and from Hyde Park Corner, where the masses became more dense, the young Queen, in her open carriage, was greeted with cheers so loud and hearty that by the time she reached St James's she was trembling with emotion. She appeared at a window in the courtyard of the Palace, dressed in deep mourning, with a white tippet, white cuffs, and a border of white lace under her small black bonnet; and everybody noticed how pale she was. Sir Ralph Bigland, Garter King, made his proclamation, according to the quaint old forms, in presence of the Lord Mayor of London and Sheriffs, the great officers of State, and a cohort of heralds; and when his concluding words were followed by a blare of trumpets and the acclamations of a loyal crowd thronging all the approaches to the Palace, the Queen's fortitude for a moment forsook her. It was in allusion to this that Elizabeth Barrett Browning wrote her pretty lines about the child-Queen who "wept to wear a crown."

Lord Melbourne and the Queen.

At the time of the Queen's accession, Lord Melbourne's Ministry had been in office two years. The Cabinet nominally commanded a good majority in the House of Commons, but it was not popular with the country, and at the general election which took place in July 1837 (in pursuance of the constitutional law which then required that the death of a Sovereign should be followed by a dissolution of Parliament), the ministerial majority was reduced to fourteen. The true cause for the weakness of the Whigs lay in the towering personal ascendancy of the two Tory leaders—the Duke of Wellington and Sir Robert Peel. All things considered, it was more surprising that the Whigs should have remained in office so long than that they should have been feeble in their rule. So far as concerned Lord Melbourne personally, it was a positive disadvantage to him that from the first he ingratiated himself with the young Queen, and thereby exposed himself to unreasoning party jealousies. Lord Melbourne was an amiable, warm-hearted man. There was a double danger that a man of his winning character might either yield too much to the Court, or by the charm of his manner domineer over the Sovereign, and give her mind a bias towards his party. The Tories feared the latter contingency; Lord Brougham, Mr Roebuck, and all ardent Liberals expressed their misgivings as to the former.

The Queen opened her first Parliament in person, and in a well-written speech, which she read with much feeling, adverted to her youth and to the necessity which existed for her being guided by enlightened advisers. When both Houses had voted loyal addresses, the question of the Civil List was considered, and a week or two later a message was brought to Parliament requesting an increase of the grant formerly made to the Duchess of Kent. Government recommended an addition of £30,000 a year, and this led to an angry scene in the Lords between Brougham and Melbourne. Brougham alluded to the "Queen Mother," upon which Melbourne interrupted, saying, "Mother of the Queen," which is very different. "I confess I am but rude of speech," answered Brougham. "My noble friend is much more of a courtier; his tongue is better hung; he is well acquainted with the motions of those who gloze and fawn and bend the knee in Courts." Stung to the quick, Melbourne retorted that he knew "of no man in the country who could more gloze and flatter and bend the knee" than Brougham. The proposed addition was voted, and before the close of the year a Civil List Bill was passed, settling £385,000 a year on her Majesty, Mr Hume's motion for reducing that grant by £50,000 mustering only nineteen votes. The remainder of the session was engrossed by the affairs of Canada, which gave the Queen her first insight into some of the curious tactics of party warfare.

It had long been arranged between the Duchess of Kent and her brothers, King Leopold and the Duke of Coburg, that the Queen should marry her cousin, Prince Albert of Saxe-Coburg, and the Prince himself had been made acquainted with this plan from his earliest years. When he was three years old his nurse used to prattle to him about "the little May Flower," his destined bride in England. In 1836 Prince Albert, who was born in the same year as his future wife, had come on a visit to England with his father and with his brother, Prince Ernest, and his handsome face, gentle disposition, and playful humour had produced a favourable impression on the Princess, who, a few days after his departure, was frankly informed by King Leopold of the hopes which he cherished as to her marriage. The Princess's answer to her uncle (7th June 1836) left no doubt that her own heart was inclined to the scheme. "I have only now to beg you, my dearest uncle, to take care of the health of one now so dear to me, and to take him under your special protection. I hope and trust that all will go on prosperously as to this subject, which is now of such importance to me." The Duchess of Kent had communicated her projects to Lord Melbourne, and they were known to many other statesmen, and to persons in society; but the gossip of drawing-rooms during the years 1837–38 continually represented that the young Queen had fallen in love with Prince This or Lord That, and the more imaginative babblers hinted at post-chaises waiting outside Kensington Gardens in the night, private marriages, and so forth.

The Coronation.

The Coronation took place on 28th June 1838, and the event served to impress deeply on the minds of foreign princes—suitors or not—a notion of the British Sovereign's exalted and enviable position. No more touching ceremony of the kind had ever been performed in Westminster Abbey. Anne was a middle-aged, married woman at the time of her coronation; she waddled and wheezed, and made no majestic appearance upon her throne. Mary was odious to her Protestant subjects, Elizabeth to those of the unreformed religion, and both these Queens succeeded to the crown in times of general sadness; but the youthful Queen Victoria had no enemies except a few Chartists, and the land was peaceful and prosperous when she began to reign over it. The cost of George IV.'s coronation amounted to £240,000; that of William IV. had amounted to £50,000 only; and in asking £70,000 the Government had judged that things could be done with suitable luxury, but without waste. The traditional banquet in Westminster Hall, with the throwing down of the glove by the King's champion in armour, had been dispensed with at the coronation of William IV., and it was resolved not to revive it. On the other hand, it was arranged that the Sovereign's procession to the Abbey through the streets should be made a finer show than on previous occasions; and it drew to London 400,000 country visitors. Old-fashioned ceremonial and acts of humble obeisance seemed peculiarly befitting in the case of a young Queen. Lord Melbourne was perfect as he redeemed the sword of State with a hundred shillings. The Earl of Albemarle, Treasurer of the Household, knelt with a knightly grace to present the gold nugget of one-pound's weight, which the Queen was to put into the offertory plate; and afterwards it was with a lordly air that he scattered among the crowds in the aisles handfuls of commemorative medals in gold and silver. This item in the proceedings caused much turbulent scrimmaging. Her Majesty's Judges, in their robes of scarlet and ermine, stretched forth their hands with decorous languor to try to seize some of the flying mementoes, but of course disdained to stoop and pick up anything from the floor; the Aldermen of London, less proud, sprawled over the flags in their furred gowns, and grabbed one another by the sleeves in their rude scramble for the pieces. The culminating point of the ceremony occurred when, the Primate having placed the crown on the Queen's brow, the orb and sceptre in her two hands, all the peers and peeresses donned their coronets, and a deafening acclamation of "God save the Queen" arose, to be repeated again and again, while the organ pealed forth the National Anthem. When the tumult had subsided, trains of peers ascended the steps of the throne to do their homage—first touching the crown with the right hand, then bending the knee and kissing the Queen's hand. At former coronations the peers had kissed the Sovereign's cheek, but it had been thought right to spare a young lady such salutes from 500 gentlemen. Only one incident, for a moment, marred the ceremony. Lord Rolle, a large, infirm old man, was held up by two peers, and had nearly reached the royal footstool when he slipped through the hands of his supporters, and rolled over and over down the steps, lying at the bottom coiled up in his robes. His disaster sent a shock through the assemblage. He was instantly lifted up, and he tried again and again to ascend the steps amid shouts of admiration at his valour. The Queen, having whispered to Lord Melbourne, rose, leaned forward and held out her hand to the old man, dispensing with his touching the crown. Three ambassadors for different reasons became objects of great interest at the coronation. Marshal Soult, Wellington's old foe, received a hearty popular welcome as a military hero; Prince Esterhazy, who represented Austria, dazzled society by his Magyar uniform, which was encrusted all over, even to the boots, with pearls and diamonds; while the Turkish ambassador, Sarim Effendi, caused much diversion by his bewilderment at the magnificence of the spectacle presented to his gaze. He was so wonder-struck that he could not walk to his place, but stood as if he had lost his senses, and kept muttering, "All this for a woman!" The glories of the Coronation were brought to an appropriate ending by all sorts of popular rejoicings, the most novel of which was a fair in Hyde Park, where the fun was kept up fast, furious, and noisy, during four days and nights.

The "Bedchamber Plot."

Within a year of the Coronation the Court was brought into sudden disfavour with the country by two events of unequal importance, but both exciting. The first was the case of Lady Flora Hastings. In February 1839 this young lady, a daughter of the Marquis of Hastings, and a Maid of Honour to the Duchess of Kent, was accused by certain Ladies of the Bedchamber of immoral conduct. The charge having been laid before Lord Melbourne, he communicated it to Sir James Clark, the Queen's physician, and the result was that Lady Flora was subjected to the indignity of a medical examination, which, while it cleared her character, seriously affected her health. In fact, she died in the following July, and it was then discovered that the physical appearances which first provoked suspicion against her had been due to enlargement of the liver. The Queen's conduct towards Lady Flora was kind and sisterly from the beginning to the end of this painful business; but the scandal was made public through some indignant letters which the Marchioness of Hastings addressed to Lord Melbourne praying for the punishment of her daughter's traducers, and the general opinion was that Lady Flora had been grossly treated at the instigation of some private Court enemies. While the agitation about the affair was yet unappeased, the political crisis known as the "Bedchamber Plot" occurred. The Whig Ministry had introduced a Bill suspending the Constitution of Jamaica because the Assembly in that colony had refused to adopt the Prisons Act passed by the Imperial Legislature. Sir Robert Peel moved an amendment, which, on a division (6th May), was defeated by a majority of five only in a House of 583, and Ministers thereupon resigned. The Duke of Wellington was first sent for, but he advised that the task of forming an Administration should be entrusted to Sir Robert Peel. Sir Robert was ready to form a Cabinet in which the Duke of Wellington, Lords Lyndhurst, Aberdeen, and Stanley, and Sir James Graham would have served; but he stipulated that the Mistress of the Robes and the Ladies of the Bedchamber appointed by the Whig administration should be removed, and to this the Queen would not consent. On 10th May she wrote curtly that the course proposed by Sir Robert Peel was contrary to usage and repugnant to her feelings; the Tory leader then had to inform the House of Commons that, having failed to obtain the proof which he desired of her Majesty's confidence, it was impossible for him to accept office. The Ladies of the Bedchamber were so unpopular in consequence of their behaviour to Lady Flora Hastings that the public took alarm at the notion that the Queen had fallen into the hands of an intriguing coterie; and Lord Melbourne, who was accused of wishing to rule on the strength of Court favour, resumed office with diminished prestige.

There can be no doubt that the Queen was badly advised in this emergency. Sir Robert Peel could not be expected to govern while the Queen kept about her person ladies who were related to his political opponents. One of the Bedchamber ladies was wife of Lord Normanby, the Colonial Secretary, another was sister to Lord Morpeth, the Chief Secretary for Ireland, and the warm friendship which the Queen proclaimed for these ladies was not a reassuring thing, constitutionally speaking. The Tories thus felt aggrieved; and the Chartists also were so prompt to make political capital out of the affair that large numbers were added to their ranks. On

14th June Mr Attwood, M.P. for Birmingham, presented to the House of Commons a Chartist petition alleged to have been signed by 1,280,000 people. It was a cylinder of parchment of about the diameter of a coach-wheel, and was literally rolled up the floor of the House. On the day after this curious document had furnished both amusement and uneasiness to the Commons, a woman, describing herself as Sophia Elizabeth Guelph Sims, made application at the Mansion House for advice and assistance to prove herself the lawful child of George IV. and Mrs Fitzherbert; and this incident, trumpery as it was, added fuel to the disloyal flame then raging.

The year 1839 was one of the most trying through which the Queen passed. Going in state to Ascot she was hissed by some ladies as her carriage drove on to the course, and two peeresses, one of them a Tory duchess, were openly accused of this unseemly act. Meanwhile some monster Chartist demonstrations were being organized, and they commenced on 4th July with riots at Birmingham. It was an untoward coincidence that Lady Flora Hastings died on 5th July, for though she repeated on her deathbed, and wished it to be published, that the Queen had taken no part whatever in the proceedings which had shortened her life, it was remarked that the ladies who were believed to have persecuted her still retained the Sovereign's favour. The riots at Birmingham lasted ten days, and had to be put down by armed force. They were followed by others at Newcastle, Manchester, Bolton, Chester, and Macclesfield.

The Queen's marriage.

These troublous events had the effect of hastening the Queen's marriage. There prevailed a feeling that the Court was too much under the control of women, and Ministers were anxious to be relieved of the delicate responsibility of guiding the young Queen in domestic matters. Their position towards the Duchess of Kent was one of daily embarrassment. The Duchess had no officially recognized power, but so long as her daughter remained unmarried her will in the royal household was paramount, and there were occasions — as in the Bedchamber affair — when domestic matters trenched to a dangerous extent on politics. Lord Melbourne, who had publicly borne the odium of the "Bedchamber Plot," was in reality very loth to be rated as a Court favourite, and his paternal attachment to the Queen had made him view with concern the occurrences which had caused her name to be too freely bandied about. Accordingly, when he had ascertained that the Queen's dispositions towards her cousin, Prince Albert, were unchanged, he advised King Leopold, through M. Van der Weyer, the Belgian Minister, that the Prince should come to England and press his suit. The Prince arrived with his brother on a visit to Windsor on 10th October 1839; but he had no idea that a speedy marriage was to result from this journey. A few weeks previously the Queen had written to her uncle, and said emphatically that she could entertain no project of matrimony for at least four years, and this having been reported to Prince Albert, he was under the impression that the Queen meant to break off their engagement, and that he had been summoned in order that a communication to this effect might be made to him in the most considerate manner possible. In the course of three days, however, he made such good use of his opportunities, that he carried his lady's heart by storm.

He had much improved since his last visit in 1836. He was no longer boyish, but tall and handsome, with a look of high intelligence in his clear, blue eyes and expansive forehead. On the evening of his arrival the Queen wrote, with significant emotion, to King Leopold: "Albert's beauty is most striking, and he is most amiable and unaffected—in short, very fascinating." After this it is not surprising that on the 14th her Majesty should have informed Lord Melbourne that she had made up her mind. "I am very glad of it," answered the Premier with fatherly enthusiasm; "the news will be very well received, for I hear that there is great anxiety now that his thing should be; and you will be much more comfortable, for a woman cannot stand alone, whatever her position may be." It was not till the following day that Prince Albert himself was apprised of the Queen's intentions. The proposal had to come from her, and maiden modesty being in conflict with royal etiquette, there was a natural timidity in her manner of approaching the moment which was to settle her life's course. The Prince had been hunting in the morning, and when he returned at noon he was summoned to the Queen's sitting-room, where he found her alone. She began by talking on different subjects to gain time. M. Daguerre's invention for taking pictures by sunlight—not yet called "photography"—was then a new thing, and some daguerreotypes which had been exhibited to the Queen that morning lay on the table. Having shown these, she spoke of the great tournament which had lately been held at Eglinton Castle and of Lady Seymour, the "Queen of Beauty"; then suddenly, after a pause, she said in German, with tears in her eyes, "Could you forsake your country for me?" The Prince's answer was to take her in his arms, and all ended so happily, that, once more writing to her uncle an hour or two later, the Queen could say: "I love him more than I can tell, and I shall do everything in my power to render this sacrifice (for such in my opinion it is) as small as I can. I think —and Albert approves—that we ought to be married very soon after Parliament meets, at the beginning of February."

The Prince, whose influence over the Queen was to be exercised in the most beneficial manner during a cloudless married life of twenty-two years, was a man whose worth was never fully known until after his death. He seemed to have been created on purpose for the position to which he was called; he was certainly educated in view of it, and this with the most watchful care under the superintendence of a German diplomatist who knew England well—Baron Friedrich von Stockmar. Lord Palmerston, who never much liked Stockmar, was obliged to confess of him: "He is the only absolutely disinterested man I have ever known." Stockmar was a native of Coburg, born in 1787, and had entered the service of Prince Leopold as private physician in 1816, when the Prince married the Princess Charlotte. The Princess died with her hand clasped in his, and it was owing to his skilful treatment that the Prince was enabled to bear the shock of a bereavement which seemed likely to crush him. Until the Prince became King of the Belgians Stockmar remained his private secretary, controller of his household, and his agent in all political negotiations. He was thus brought into contact with the leading statesmen of Europe, and their unanimous opinion of him was that he had no superior among diplomatists for penetration and tact. In 1831 he retired to his home at Coburg, being too shrewd to excite Belgian jealousies by residing at his master's court in the capacity of confidential adviser; but Leopold continued to ask his opinion by letter on all matters of importance, and he did so as regards Prince Albert's training.

The bulletins which Stockmar drew up to describe the young Prince's character are examples of psychological diagnosis pushed almost to vivisection. Very few young princes' characters could have borne such treatment. But Stockmar, knowing what were King Leopold's wishes, was anxious that Prince Albert should play the part which Leopold himself would have played had Princess Charlotte lived. Being aware, also, of how difficult the position of a Queen's Consort would be in England, no indication as to the Prince's habits seemed to his German mind too slight to be made a note of. Therefore he used to write that Prince Albert was sweet-tempered but listless, chivalrous and clever but lazy in studying politics. He did not care for newspapers: "He says that the *Augsburg Gazette* is enough for any man's wants, but he does not read even that." Then the Prince was indifferent to the society of ladies. "At parties he sits talking on art and war with old men, and takes no notice of the fair who are pining to dance with him." Extracts from these letters used to be shown to the Queen, and it is not certain that Prince Albert's callousness to the fascinations of German ladies constituted a blemish in her opinion. But she was sorry that he had no inclination towards politics; and about a year before her betrothal she had hailed it as a piece of good news that the Prince had at last begun to read his *Augsburg Gazette* with proper assiduity.

Baron Stockmar was sent to England in January 1840, as representative of Prince Albert, to settle the treaty of marriage, and to make arrangements for the Prince's future household. But now the Court's quarrel with the Tories in 1839 brought disagreeable consequences. The Queen's announcement of her betrothal was read by her in the House of Lords on 16th January, and was, of course, enthusiastically received. Yet, when the Government proposed that Prince Albert should receive an annuity of £50,000, amendments were moved for reducing that sum, and the Tories unexpectedly revealed themselves as rigid economists. The fault of this lay with Lord Melbourne. The proposals of his Government were in accordance with precedent, for in the cases of the last three Queens-Consort, and in that of Prince Leopold, the allowance had been £50,000, but the Opposition leaders should have been judiciously approached before the motion for the grant was publicly made. Lord Melbourne had neglected to consult them, and he gave offence to the Tories by not describing Prince Albert as a Protestant Prince. The Duke of Wellington denounced this omission, reviving the old charge that the Ministry were bidding for the Irish Catholic vote; and once more, the suspicion about Popery getting abroad, Lord Palmerston was obliged to ask Stockmar for assurance that Prince Albert did not belong to any sect of Protestants whose rules might prevent him from taking the Sacrament according to the ritual of the English Church. He got an answer couched in somewhat ironical terms to the effect that Protestantism owed its existence in a measure to the House of Saxony, from which the Prince descended, seeing that this House and that of the Landgrave of Hesse had stood quite alone against Europe in upholding Luther and his cause. Even this was not considered satisfactory, for certain High Churchmen held that a Lutheran was a "dissenter," and that the Prince should be asked to subscribe to the Thirty-Nine Articles. Other uneasy people doubted whether the Queen could constitutionally swear at the altar to "obey" a foreign prince, and wanted to have a special form of marriage service composed for her.

Much needless pain was given to the Queen by the angry temper shown in these discussions on the Prince's religion and his budget, and more especially on those concerning his future status as an Englishman. It was out of the question that the Prince should receive the title of King Consort; but the Queen naturally desired that her husband should be placed by Act of Parliament in a position which would secure to him precedence, not only in England, but in foreign Courts. Lord Melbourne sought to effect this by a clause introduced in a Naturalization Bill; but, having mismanaged every detail of the business, he found himself obliged to drop the clause on the understanding that the Queen should confer what precedence she pleased by letters patent. This was a lame way out of the difficulty, for the Queen could only confer precedence within her own realms, whereas an Act of Parliament bestowing the title of Prince Consort would have made the Prince's right to rank above all royal imperial highnesses quite clear, and would have left no room for such disputes as afterwards occurred when foreign princes chose to treat Prince Albert as having mere courtesy rank in his wife's kingdom. On the Prince's Annuity Bill the Government sustained a severe defeat. An amendment moved by Mr Hume for reducing the allowance to £21,000 was negatived; but the amendment of Colonel Sibthorp—a politician of no great repute—for making the annuity £30,000, was carried against Ministers by 262 votes to 158, the Tories and Radicals going into the same lobby, and many Ministerialists taking no part in the division. All this mortified Prince Albert exceedingly, and gave him a poor idea of the welcome that awaited him in England. His misgivings increased and were mingled with irritation when he learned that he was not to be allowed to appoint his own secretary, but must accept the services of Mr Anson, who had formerly been Lord Melbourne's secretary. He was destined to get on very well with this gentleman, but at first he considered it an affront that a stranger should be forced upon him, and it required nothing less than the heartiness of the public greeting vouchsafed when he landed at Dover four days before the wedding to cheer him again about his prospects. Lord Melbourne assured him that what had happened was "only the result of high party feeling, and must not be taken as a mark of personal antipathy"; and the Duke of Wellington strove to atone for Tory ungraciousness by agreeing, and, indeed, advising that the Prince should be appointed a field-marshal: "He must wear a red coat at his wedding," said the Duke, "otherwise the people won't believe he's English."

The Queen's marriage was solemnized on 10th February 1840, in the Chapel Royal, St James's. The Queen was dressed entirely in articles of British manufacture. Her dress was of Spitalfields silk; her veil of Honiton lace; her ribbons came from Coventry; even her gloves had been made in London of English kid—a novel thing in days when the French had a monopoly in the finer kinds of gloves.

Public affairs.

From the time of her marriage the Queen began to take a really active part in the affairs of State. Previously, her Ministers had tried to spare her all disagreeable and fatiguing business. Death warrants were not submitted for her signature, and though she spent an hour or two every morning writing her name on public documents, these were seldom read to her, nor did she ask to be informed of their contents. Lord Melbourne saw her every day, whether she was in London or at Windsor, and he used to explain all current business in a benevolent, chatty manner, which offered a pleasant contrast to the style of his two principal colleagues, Lord John Russell and Lord Palmerston. Lord John was never a lady's man. His natural kindliness was concealed under a somewhat sour air; the tone of his voice was piping and dictatorial. He was always in earnest about trifles. Lord Palmerston was a *persifleur*. Handsome, affable, well dressed, and cool, there was a point of irony in his tone as if he felt he were playing a comedy in talking to the Queen about serious things which a girl of her age could not be expected to understand, and in asking her for an approval which she could not refuse. Lord Melbourne always guarded himself against the presumption of seeming to expect approval as a matter of course. The words, "Your Majesty," sounded on his lips much like "My dear," but when the Queen had given assent to his proposals he showed the same kind of pleasure as a fond guardian who is glad to find his ward in harmony with him. Lord Melbourne failed as a party leader, but not as a Queen's Minister, and it may be questioned whether a statesman of firmer mould would have succeeded so well as he did in making rough places smooth for Prince Albert. Lord John Russell and Lord Palmerston were jealous of the Prince's interference—and of King Leopold's and Baron Stockmar's exercised through him—in State affairs; but Lord Melbourne took the common-sense view that a husband will control his wife whether people wish it or not. He did not object to the Prince being present when he opened his despatch-box before the Queen; and, knowing what soreness existed in her Majesty's mind against the Tories, he strove to mollify the Prince's feelings towards a party who might soon come to office. In this he behaved admirably, and he displayed wisdom, though the royal pair hardly appreciated it at the time, in desiring that the Queen should retain the Baroness Lehzen as her private secretary. The Duchess of Kent, after her daughter's marriage, retired to Ingestre House, Belgrave Square, and the Queen gave the Baroness some hints that she might retire too on a pension, resigning her secretaryship to Prince Albert. Lord Melbourne thought, however, that the office of private secretary held by a prince would seem to the public too much like a secretaryship of State, and would in any case bring the Queen's Consort into relations neither dignified nor agreeable with all sorts of people. A great part of a secretary's business consists in writing refusals to importunate requests. To confer on Prince Albert every honour that the Crown could bestow, and to let him make his way gradually into public favour by his own tact, was the advice which Lord Melbourne gave; and the Prince acted upon it so well, avoiding every appearance of intrusion, and treating men of all parties and degrees with urbanity, that within five months of his marriage he obtained a signal mark of the public confidence. In expectation of the Queen becoming a mother a Bill was passed through Parliament providing for the appointment of Prince Albert as sole Regent in case the Queen, after giving birth to a child, died before her son or daughter came of age.

Attempts on the Queen's life.

The Regency Bill had been hurried on in consequence of the attempt of a crazy pot-boy, Edward Oxford, to take the Queen's life. On 10th June 1840, the Queen and Prince Albert were driving up Constitution Hill in an open carriage, when Oxford fired two pistols, the bullets from which flew, it is said, close by the Prince's head. He was arrested on the spot, and when his lodgings were searched a quantity of powder and shot was found, with the rules of a secret society, called "Young England," whose members were pledged to meet, "carrying swords and pistols and wearing crape masks." These discoveries raised the surmise that Oxford was the tool of a widespread Chartist conspiracy—or, as the Irish pretended, of a conspiracy of Orangemen to set the Duke of Cumberland on the throne—and while these delusions were fresh, they threw well-disposed persons into a paroxysm of loyalty. Even the London street dogs, as Sydney Smith said, joined with O'Connell in barking "God save the Queen." For several days, whenever the Queen and the Prince drove out, they were escorted by hundreds of ladies and gentlemen on horseback, who served as a bodyguard, while large and sympathizing crowds in the streets cheered uproariously. Oxford seems to have been craving for notoriety; but it may be doubted whether the jury who tried him did right to pronounce his acquittal on the ground of insanity. He feigned madness at his trial, but during the forty years of his subsequent confinement at Bedlam he talked and acted like a rational being, and when he was at length released and sent to Australia he earned his living there as a house painter, and used to declare that he had never been mad at all. His acquittal was to be deprecated as establishing a dangerous precedent in regard to outrages on the Sovereign. It was always Prince Albert's opinion that if Oxford had been flogged the attempt of Francis on the Queen in 1842, and of Bean in the same year, would never have been perpetrated. After the attempt of Bean—who was a hunchback, really insane—Parliament passed a Bill empowering judges to order whipping as a punishment for those who molested the Queen; but somehow this salutary Act was never enforced. In 1850 a half-pay officer, named Pate, assaulted the Queen by striking her with a stick, and crushing her bonnet; he was sentenced to seven years' transportation; but the judge, Baron Alderson, excused him the flogging. In 1869 an Irish lad, O'Connor, was sentenced to eighteen months' imprisonment and a whipping for presenting a pistol at the Queen, with a petition, in St James's Park, but this time it was the Queen herself who privately remitted the corporal punishment, and she even pushed clemency to the length of sending her aggressor to Australia at her own expense. The series of attempts on the Queen was closed in 1882 by Maclean, who fired a pistol at her Majesty as she was leaving the Great Western Railway Station at Windsor. He, like Bean, was a genuine madman, and was relegated to Broadmoor.

Birth of the Princess Royal.

The birth of the Princess Royal, on 21st November 1840, removing King Ernest of Hanover from the position of heir-presumptive to the British Crown, was a subject of loud congratulations to the people; and nothing happened after the confinement to give the nation a moment's uneasiness as to the mother's health or the baby's. A scare was occasioned at Buckingham Palace, however, when the little Princess was a fortnight old, owing to the intrusion of the celebrated "Boy Jones," who was found concealed under a bed in the royal nursery. This disagreeable lad, at first suspected of a design to kidnap the Queen's baby, was examined before the Privy Council, but as it appeared that he had no evil intent, he was handed over to a magistrate to be imprisoned for three months as a vagabond. Jones had a mania for palace-breaking. Three times he effected a clandestine entry into the Queen's residence, and twice he managed to spend several days there. By day he concealed himself in cupboards or under furniture, and by night he groped his way into the royal kitchen to eat whatever he could find. After his third capture, in March 1841, he coolly boasted that he had lain under a sofa, and listened to a private conversation between the Queen and Prince Albert. This third time he was not punished, but sent to sea, and turned out very well. Indirectly the Boy Jones was the means of doing some good, for he called public attention to the careless attendance, untidiness, and waste that prevailed in the royal household. This strengthened Prince Albert's hands in trying to carry out sundry domestic reforms, which were being stoutly resisted by vested interests. The royal residences and grounds used to be under the control of four different officials—the Lord Chamberlain, the Lord Steward, the Master of the Horse, and the Commissioners of Woods and Forests. Baron Stockmar, describing the confusion fostered by this state of things, said :—

> "The Lord Steward finds the fuel and lays the fire ; the Lord Chamberlain lights it. The Lord Chamberlain provides the lamps ; the Lord Steward must clean, trim, and light them. The inside cleaning of windows belongs to the Lord Chamberlain's department, but the outer parts must be attended to by the Office of Woods and Forests, so that windows remain dirty unless the two departments can come to an understanding."

The Boy Jones had found his way into Buckingham Palace because there was no responsible authority to which all servants looked for orders ; and if he had been a little bolder he might have billeted himself upon some mess in the Palace without anybody being qualified to ask him what his business was. Ample as the Queen's income looked in figures, it hardly sufficed to cover expenditure when no disbursements could be properly checked. Prince Albert, going over the Lord Steward's accounts, once found an item of thirty-five shillings a week for "Red Room wine." After a patient investigation, sulkily hindered at every step, he ascertained that a certain chamber at Windsor had been temporarily used during George III.'s reign as a guard-room, and five shillings a day had been allowed to provide wine for the officer on guard. The chamber had long ceased to be a guard-room, but the item for wine still figured in the cellarage accounts, and formed one of the perquisites of a half-pay officer, who enjoyed the sinecure of under-butler. This officer was much shocked when he was offered the alternative of renouncing his wine money or doing duty as butler ; and, of course, the sympathies of other sinecurists were all on his side. Even after Jones's freak had set all the world laughing at the misrule of the Palace, it took Prince Albert four years of firmness and diplomacy to bring the Queen's home under the efficient control of a Master of the Household. This was finally done according to a plan of Baron Stockmar's in 1845, while Sir Robert Peel was Premier ; and the Queen's Palaces were always from that time such models of good management that several foreign monarchs took pattern by them in reorganizing their own households.

Sir Robert Peel's ministry.

At the general election of 1841 the Whigs returned in a minority of seventy-six, and, being at once worsted in a division on the Address, Lord Melbourne resigned. The Queen was affected to tears at parting with him. She had experienced nothing but kindness at his hands ; and she naturally felt some antipathy towards Sir Robert Peel who succeeded him. When the Queen got to understand Peel's mannerisms, and saw how excellent and genial a man he was in the main, she liked him much ; but to have him as an adviser after the courtly Melbourne was, at first, like exchanging an indulgent guardian for a prosy tutor. Peel, on his side, was far from comfortable about the reception he was likely to get from Prince Albert. He and his Tory friends had begun privately to repent of the support they had given to Colonel Sibthorp's motion for reducing the Prince's annuity, for it had placed them in a position repugnant to the traditions of their party. Coming to power in triumph they met with no Bedchamber difficulties. The Whig ladies who had held high appointments at Court resigned, and their places were filled by others connected with Tory families ; but these others did not feel very proud of Colonel Sibthorp, all the less so as this gentleman had taken to singularizing himself by the most eccentric kinds of motions in Parliament. Prince Albert, perceiving there was embarrassment all round, set himself to allay it by exquisite good humour. He received Peel in a way that charmed the latter ; and his magnanimity met with instant reward, for one of the Tory Premier's first acts was to propose that a Royal Commission should be appointed to consider the best means for promoting art and science in the kingdom, and he nominated Prince Albert as President. This graceful proceeding was fully appreciated, and it had its importance, as marking out for the Prince a set of non-political duties, which he ably discharged to the end of his life. He was a born artist, whose taste for painting and sculpture embraced everything that was well done, without predilection for any particular school ; he was an accomplished musician, too, and took an interest in all branches of science. The International Exhibition of 1851, the creation of the Museum and Science and Art Department at South Kensington, the founding of art schools and picture galleries all over the country, the spread of musical taste, and the fostering of technical education, may be attributed, more or less directly, to the Commission of distinguished men which began its labours under Prince Albert's auspices.

Birth of the Prince of Wales.

The Queen's second child, the Prince of Wales (see EDWARD VII.), was born on 9th November 1841. He was baptized in water brought from the Jordan. King Frederick William of Prussia came to England to be his sponsor, and his birth "filled the measure of the Queen's domestic happiness," as she said in her speech from the throne at the opening of the session of 1842.

The Court and the country.

It is unnecessary from this point onwards to go seriatim through the domestic history of the reign, which is given in the article ENGLISH HISTORY. At this time there was much political unrest at home, and serious difficulties abroad. As regards internal politics, it may be remarked that the Queen and Prince Albert were much relieved when Peel adopted Free Trade and repealed the Corn Laws, for it closed a dangerous agitation which gave them much anxiety. When the country was in distress, when there were bread riots and bankruptcies, alarms among landholders and levelling menaces in every demagogue's mouth, the Queen felt a womanly repugnance for festivities ; and yet it was undesirable that the Court should incur the reproach of living meanly to save money. There was a conversation between the Queen and Sir Robert Peel on this subject in the early days of the Tory Administration, and the Queen talked of reducing her establishment in order that she might give away larger sums in charities. "I am afraid the people would only say that your Majesty was returning them change for their pounds in halfpence," answered Peel. "Your Majesty is not perhaps aware that the most unpopular person in the parish is the relieving officer, and if the Queen were to constitute herself a relieving officer for all the parishes in the kingdom, she would find her money go a very little way, and she would provoke more grumbling than thanks." Peel added that a Sovereign must do all things in order, not seeking praise for doing one particular thing well, but striving to be an example in all respects, even in dinner-giving. To a Queen of twenty-two, with a husband of the same age, both of whom read the newspapers, and wondered whether the vast changes which steam and electric wires were working in the world were not going to modify all ancient notions as to royal duties, such advice was not inopportune.

Meanwhile the year 1842 was ushered in by splendid fêtes in honour of the King of Prussia, who held the Prince of Wales at the font. In the spring there was a

The Queen's first railway journey.

fancy-dress ball at Buckingham Palace, which remained memorable owing to the offence which it gave in France. Prince Albert was costumed as Edward III., the Queen as Queen Philippa, and all the gentlemen of the Court as Knights of Poitiers. The French chose to view this as an unfriendly demonstration, and there was some talk of getting up a counter-ball in Paris, the Duke of Orleans to figure as William the Conqueror. In June the Queen took her first railway journey, travelling from Windsor to Paddington on the Great Western line. The Master of the Horse, whose business it was to provide for the Queen's ordinary journeys by road, was much put out by this innovation. He marched into the station several hours before the start to inspect the engine, as he would have examined a steed; but greater merriment was occasioned by the Queen's coachman, who insisted that, as a matter of form, he ought to make-believe to drive the engine. After some dispute, he was told that he might climb on to the pilot engine which was to precede the Royal train, but his scarlet livery, white gloves, and wig suffered so much from soot and sparks that he made no more fuss about his rights in after trips. The run to Paddington was successfully accomplished, and the motion of the train was found to be so pleasant that the Queen readily trusted herself to the railway for a longer journey a few weeks later, when she paid her first visit to Scotland. There the noble scenery and warm-hearted people pleased the Queen so well that her resolution of buying an estate was formed before she returned to England, and Sir James Clark was instructed to make inquiries concerning the localities which were most healthy. His report led to the Queen's visiting Balmoral in 1848, and to the purchase of the Balmoral estate in 1852, and the Queen's diary of her journeys in Scotland shows what constant enjoyment she derived from her Highland home. Seven years before this the estate of Osborne had been purchased in the Isle of Wight, in order that the Queen might have a home of her own. Windsor she considered too stately, and the Pavilion at Brighton too uncomfortable. The first stone of Osborne House was laid in 1845, and the Royal Family entered into possession in September 1846.

Relations with foreign sovereigns.

In August 1843 the Queen and Prince Albert paid a visit to King Louis Philippe at the Château d'Eu. They sailed from Southampton for Tréport in a yacht, and, as it happened to be raining hard when they embarked, the loyal members of the Southampton Corporation remembered Raleigh, and spread their robes on the ground for the Queen to walk over. In 1844 Louis Philippe returned the visit by coming to Windsor. It was the first visit ever paid by a King of France to a Sovereign of England, and Louis Philippe was much pleased at receiving the Order of the Garter. He said that he did not feel that he belonged to the "Club" of European Sovereigns until he received this decoration. The Tsar Nicholas also visited Windsor in 1844 (the year in which Prince Alfred, who was to marry the Tsar's granddaughter, was born). The Queen was not much struck by the handsome Russian autocrat. She wrote that she did not think him clever, as politics and military concerns were the only things in which he took an interest.

In 1846 the affair of the "Spanish Marriages" seriously troubled the relations between the United Kingdom and France. Louis Philippe and M. Guizot had planned the marriage of the Duke of Montpensier with the Infanta Louisa of Spain, younger sister of Queen Isabella, who, it was thought at the time, was not likely ever to have children. The intrigue was therefore one for placing a son of the French King on the Spanish throne. Lord Normanby, British Ambassador in Paris, was instructed to deliver to M. Guizot a formal protest based on the Treaty of Utrecht and on formal assurances given by M. Guizot to Lord Aberdeen; at the same time the Queen wrote privately to the Queen of the French, Marie Amélie, urging the many objections to the marriage. This letter caused Louis Philippe to write to his daughter Marie, Queen of the Belgians, as follows:—

> "I am inclined to think that the good little Queen was as sorry to write the letter as I was to read it. But she now sees things only through the spectacles of Lord Palmerston, and these distort the truth too often. The difference between Palmerston and Aberdeen is that the latter wishes to be well with his friends, while the former seeks to quarrel with them."

The marriage took place, but did not yield the political results contemplated, for Queen Isabella had children, and the Duke of Montpensier wholly failed to win popularity or influence in Spain. But as to Queen Victoria's intervention on this question and on others, these words, written by Gladstone in 1875, may be quoted:—

> "Although the admirable arrangements of the Constitution have now shielded the Sovereign from personal responsibility, they have left ample scope for the exercise of direct and personal influence in the whole work of government. . . . The Sovereign as compared with her Ministers has, because she is the Sovereign, the advantage of long experience, wide survey, elevated position, and entire disconnexion from the bias of party. Further, personal and domestic relations with the ruling families abroad give openings in delicate cases for saying more, and saying it at once more gently and more efficaciously than could be ventured in the formal correspondence and rude contacts of Government. We know with how much truth, fulness, and decision, and with how much tact and delicacy, the Queen, aided by Prince Albert, took a principal part on behalf of the nation in the painful question of the Spanish Marriages."

The year 1848, which shook so many Continental thrones, left that of the United Kingdom unhurt. Revolutions broke out in Paris, Vienna, Berlin, Madrid, Rome, Naples, Venice, Munich, Dresden, and Budapest. The Queen and Prince Albert were affected in many private ways by the events abroad. Panic-stricken princes wrote to them for political assistance or pecuniary aid. Louis Philippe came to the shores of England almost destitute, and the Queen employed Sir Robert Peel as her intermediary for providing him with money to meet his immediate wants. Subsequently Claremont was assigned to the exiled Royal Family of France as a residence. During a few weeks of 1848 Prince William of Prussia (afterwards German Emperor) found an asylum in England.

Irish trip, 1849.

In August 1849 the Queen and Prince Albert accompanied by the little Princess Royal and the Prince of Wales paid a visit to Ireland, landing at the Cove of Cork, which from that day was renamed Queenstown. The reception was enthusiastic, and so was that at Dublin. "Such a day of jubilee," wrote *The Times*, "such a night of rejoicing, has never been beheld in the ancient capital of Ireland since first it arose on the banks of the Liffey." The Queen was greatly pleased and touched. She said in her diary: "It was a wonderful and striking scene, such masses of human beings, so enthusiastic, so excited, and yet such perfect order maintained—a never-to-be-forgotten scene when one reflected how lately the country had been in open revolt and under martial law." The project of establishing a royal residence in Ireland was often mooted at this time, but the Queen's advisers never urged it with sufficient warmth. There was no repugnance to the idea on the Queen's part, but Sir Robert Peel thought unfavourably of it as an "empirical" plan, and the question of expense was always mooted as a serious consideration. Lastly, it had to be borne in mind that the Queen, becoming an

Irish landowner, would have to do as other landowners did—that is, exact fair rents—and submit to the consequent odium of ordering evictions when rents were not paid. The scheme was never exactly rejected, but it was again and again shelved. There is no doubt that the absence of a royal residence in Ireland was felt as a slur upon the Irish people in certain circles.

During these years the Queen's family was rapidly becoming larger. Princess Alice (afterwards Grand Duchess of Hesse) was born on 25th April 1843; Prince Alfred (afterwards Duke of Edinburgh and Duke of Saxe-Coburg and Gotha) on 6th August 1844; Princess Helena (Princess Christian) on 25th May 1846; Princess Louise (Duchess of Argyll) on 18th March 1848; and Prince Arthur (Duke of Connaught) on 1st May 1850. It was in this same month, and while the Queen was still in delicate health, that—as we have mentioned—the lunatic Pate assaulted her Majesty. This event made the Queen ill, and was the indirect cause of Sir Robert Peel's death. Returning from Buckingham Palace, where he had called to inquire after the Queen's health, his horse stumbled on Constitution Hill, threw him heavily, and fell upon him (29th June). Peel died on 2nd July, and the Queen was for a time inconsolable. Baron Bunsen wrote: "The Queen's grief is excessive. She is in a constant flood of tears, and with the greatest difficulty could be prevailed upon to hold the Levée, which, having been fixed for this day [3rd July], could not be put off."

The Great Exhibition of 1851.

The idea in which the Exhibition of 1851 originated was in keeping with the religious tolerance and with the large-minded views of human progress which Prince Albert always evinced. The idea was his own, but he had to work for its realization against an extraordinary outburst of angry expostulations. Every stage in his project was combated. In the House of Peers, Lord Brougham denied the right of the Crown to hold the Exhibition in Hyde Park; in the Commons, Colonel Sibthorp prophesied that England would be overrun with foreign rogues and revolutionists, who would subvert the morals of the people, filch their trade secrets from them, and destroy their faith and loyalty towards their religion and their Sovereign. Prince Albert was President of the Exhibition Commission, and every post brought him abusive letters, accusing him, as a foreigner, of being intent upon the corruption of England. He was not the man to be balked by talk of this kind, but quietly persevered, looking always to the probability that the manufacturing power of Great Britain would be quickened by bringing the best manufactured products of foreign countries under the eyes of the mechanics and artisans. The artistic sense was at this time almost wholly wanting among the English people. One day the Prince had a conversation with a great manufacturer of crockery, and sought to convert him to the idea of issuing something better than the eternal willow-pattern in white with gold, red, or blue, which formed the staple of middle and lower class domestic china. The manufacturer held out that new shapes and designs would not be saleable; but he was induced to try, and he did so with such a rapid success that a revolution in the china cupboards of England was accomplished from that time. A great difficulty in regard to the architecture and cost of the proposed Exhibition building was most happily overcome when Mr Joseph Paxton, head gardener on the Duke of Devonshire's estate at Chatsworth, suggested that the building should be made throughout of glass and iron on the model of a conservatory. The first column was set up on 26th September 1850, and the Exhibition was opened by the Queen on 1st May 1851. The Exhibition proved in every way a colossal success. It remained open 138 days, and was visited by 6,007,944 persons, an average of 43,536 each day. The surplus, after all expenses had been paid, amounted to £150,000, and this sum was spent on establishing and endowing the Museum at South Kensington, and on the purchase of land in the neighbourhood.

The Queen and Lord Palmerston.

In 1852 occurred the incident of Lord Palmerston's dismissal from the office of Foreign Secretary. On 2nd December 1851, Prince Louis Napoleon struck his *coup d'état* which destroyed the French Republic. Lord Palmerston expressed his approval of the Prince's action, taking a very shrewd view of the condition to which France had been reduced by the conflict of Pretenders and parties, and he was dismissed from his post as Foreign Secretary in consequence. The circumstances, which have been told in detail in Sir Theodore Martin's *Life of the Prince Consort*, are of extreme interest for the light they throw on the Queen's very proper estimate of her constitutional position and authority. At this date, and earlier, Lord Palmerston was not *persona grata* at Court. His Anglo-Irish nature was not sympathetic with the somewhat formal character and German training of Prince Albert; and his views of Ministerial independence were not at all in accord with those of the Queen and her husband. Already in 1849, *à propos* of the Hungarian crisis, the Queen had to remind her Foreign Secretary that his despatches must pass through the hands of the Prime Minister, Lord John Russell, and Palmerston assented, and promptly and repeatedly disobeyed. A year later, on 12th August 1850, the Queen wrote to Lord John Russell the following important memorandum, which was communicated to the Foreign Secretary at the time, and, after his dismissal, was read by the Prime Minister in the House of Commons (3rd February 1852):—

> "OSBORNE, 12*th August* 1850.
>
> "With reference to the conversation about Lord Palmerston which the Queen had with Lord John Russell the other day, and Lord Palmerston's disavowal that he ever intended any disrespect to her by the various neglects of which she has had so long and so often to complain, she thinks it right, in order to avoid any mistakes for the future, to explain what it is she expects from the Foreign Secretary.
>
> "She requires—
>
> "1. That he will distinctly state what he proposes in a given case, in order that the Queen may know as distinctly to what she has given her royal sanction.
>
> "2. Having given her sanction to a measure, that it be not arbitrarily altered or modified by the Minister. Such an act she must regard as failing in sincerity to the Crown, and justly to be visited by the exercise of her constitutional right of dismissing that Minister. She expects to be kept informed of what passes between him and the Foreign Ministers, before important decisions are taken, based upon that intercourse; to receive the foreign despatches in good time, and to have the drafts for her approval sent her in sufficient time to make herself acquainted with their contents before they must be sent off. The Queen thinks it best that Lord John Russell should show this letter to Lord Palmerston."

The offence of the Foreign Secretary at the time of the *coup d'état* was that he had, of his own initiative, given assurances to Napoleon's Ambassador, Count Walewski, which were not in accord with the views of the Cabinet and with the "neutrality which had been enjoined" by the Queen. The Prime Minister was justifiably annoyed, the Queen was rightly angry, and Lord Palmerston left the Foreign Office in disgrace—only, however, to come back as Prime Minister three years later.

The death of the Duke of Wellington in 1852 deeply affected the Queen. The Duke had acquired a position above parties, and was the trusted adviser of all statesmen

Death of the Duke of Wellington: Prince Albert's position.

and of the Court in emergencies. The Queen sadly needed such a counsellor, for Prince Albert's position was one full of difficulty, and party malignity was continually putting wrong constructions upon the advice which he gave, and imputing to him advice which he did not give. During the Corn Law agitation offence was taken at his having attended a debate in the House of Commons, the Tories declaring that he had gone down to overawe the House in favour of Peel's measures. After Palmerston's enforced resignation, there was a new and more absurd hubbub. Napoleon's destruction of the Republic, and his proscription of all the leading statesmen, generals, and writers of France, seemed an odious act to the British people, and yet they were ready to clamour against Prince Albert for having recommended the punishment of the British Minister who had given his sanction to this act. Finally, when the difficulties with Russia arose which led to the Crimean war, the Prince was accused by the peace party of wanting war, and by the war party of plotting surrender; and it came to be publicly rumoured that the Queen's husband had been found conspiring against the State, and had been committed to the Tower. Some said that the Queen had been arrested too, and the Prince wrote to Stockmar: "Thousands of people surrounded the Tower to see the Queen and me brought to it." This gave infinite pain to the Queen, and at length she wrote to Lord Aberdeen on the subject. Eventually, on 31st January 1854, Lord John Russell took occasion to deny most emphatically that Prince Albert interfered unduly with foreign affairs, and in both Houses the statesmen of the two parties delivered feeling panegyrics of the Prince, asserting at the same time his entire constitutional right to give private advice to the Sovereign on matters of State. From this time it may be said that Prince Albert's position was established on a secure footing. He had declined (1850) to accept the post of Commander-in-Chief at the Duke of Wellington's suggestion, and he always refused to let himself be placed in any situation which would have modified ever so slightly his proper relations with the Queen. The Queen was very anxious that he should receive the title of "King Consort," and that the crown should be jointly borne as it was by William III. and Mary; but he himself never spoke a word for this arrangement. It was only to please the Queen that he consented (1859) to change his title to that of Prince Consort, and he only did this when it was manifest that statesmen of all parties approved the change.

The Crimean war.

For the Queen and Royal Family the Crimean war time was a very busy and exciting one. Her Majesty personally superintended the committees of ladies who organized relief for the wounded; she helped Miss Florence Nightingale in raising bands of trained nurses; she visited the crippled soldiers in the hospitals, and it was through her resolute complaints of the utter insufficiency of the hospital accommodation that Netley Hospital was built. The distribution of medals to the soldiers and the institution of the Victoria Cross (February 1857) as a reward for individual instances of merit and valour must also be noted among the incidents which occupied the Queen's time and thoughts. In 1855 the Emperor and Empress of the French visited the Queen at Windsor Castle, and the same year her Majesty and the Prince Consort paid a visit to Paris. An International Exhibition had been opened in the French capital, although the times were not very propitious for such a thing. The Queen was splendidly received; the fortifications of Paris on the side where she entered were masked with flowers, and the historical Château of Versailles was refurnished for her residence.

The Queen and her family.

The Queen's family life was a most happy one. Two more children had been born to the royal pair since Prince Arthur's (the Duke of Connaught's) birth in 1850, Prince Leopold (Duke of Albany) on 7th April 1853, and on 14th April 1857 their last child, the Princess Beatrice (Princess Henry of Battenberg), bringing the Royal Family up to nine—four sons and five daughters. Less than a year after Princess Beatrice's birth her Majesty's eldest daughter, the Princess Royal, was married to Prince Frederick William of Prussia, who was destined to reign too short a time over the German empire as Emperor Frederick. Of this marriage, as of the others in the Royal Family, it may be said that the first consideration which the Queen always took into view was the domestic welfare of her children. Although the circle of choice was restricted to Protestant—or, at least, non-Catholic—houses there were princes and princesses enough in Europe whose alliance could have been recommended as offering solid political advantages; but to the honour of the statesmen who advised the Crown, they did not attempt to thwart the Queen's inclinations, or those of her children, by adducing reasons of State for or against such and such a marriage. As one royal betrothal after another came to be announced in Parliament, it was always enough for the Minister of the day to say that the young people loved each other. The Queen's children all had an excellent, if strict, bringing-up. Their masters and governesses were chosen with care, and their father himself superintended their education with an unceasing vigilance. At Balmoral and Windsor the Court lived in virtual privacy, and the Queen and the Prince Consort saw much of their children. Countless entries in the Queen's diaries testify to the anxious affection with which the progress of each little member of the household was watched.

Royal marriages.

The next marriage after the Princess Royal's was that of the Princess Alice to Prince Louis (afterwards Grand Duke) of Hesse-Darmstadt in 1862. In 1863 the Prince of Wales married the Princess Alexandra of Denmark. In 1866 the Princess Helena became the wife of Prince Christian of Schleswig-Holstein; and in 1871 the Princess Louise was wedded to the Marquis of Lorne, eldest son of the Duke of Argyll. In 1874 Prince Alfred, Duke of Edinburgh, married Princess Marie Alexandrovna, only daughter of the Tsar Alexander II. The Duke of Connaught married in 1879 the Princess Louise of Prussia, daughter of the soldier-prince Frederick Charles; and in 1882 Prince Leopold, Duke of Albany, wedded the Princess Helen of Waldeck-Pyrmont. Finally came the marriage of Princess Beatrice in 1885 with Prince Henry of Battenberg.

On the occasion of the coming of age of the Queen's sons and the marriages of her daughters Parliament made provision. The Prince of Wales, in addition to the revenues of the Duchy of Cornwall, had £40,000 a year, the Princess £10,000, and an addition of £36,000 a year for their children was granted by Parliament in 1889. The Princess Royal received a dowry of £40,000 and £8000 a year for life, the younger daughters £30,000 and £6000 a year each. The Dukes of Edinburgh, Connaught, and Albany were each voted an income of £15,000 and £10,000 on marrying. All these grants were voted under the conditions of the general financial settlement accepted by Parliament at the beginning of the Queen's reign, and according to which certain Crown lands were transferred to the nation. In providing for the Queen's children Parliament simply fulfilled a contract.

The American Civil War.

The dispute with the United States concerning the *Trent* affair of 1861 will always be memorable for the part played in its settlement by the Queen and the Prince Consort. In 1861 the accession of Abraham Lincoln to the Presidency of the United States of America caused the Southern States of the Union to revolt, and the sanguinary War of Secession began. The sympathies of the United Kingdom would have gone naturally with the Northern against the slave-holding States, but various reasons induced Great Britain to look coldly on the struggle. Among the upper classes indeed a very bitter feeling towards America had been engendered by the reckless praises which demagogues bestowed on republican institutions, and this feeling blazed out furiously when in November 1861 the British West India steamer *Trent* was boarded by a vessel of the Federal Navy, the *San Jacinto*, and Messrs Slidell and Mason, Commissioners for the Confederate States, who were on their way to England, were seized. The British Government were on the point of demanding reparation for this act in a peremptory manner which could hardly have meant anything but war, but the Queen and her husband insisted on drafting a despatch which gave the American Government an opportunity to concede the surrender of the prisoners without humiliation.

Death of the Prince Consort.

The year 1861 was the saddest in the Queen's life. On 16th March her mother, the Duchess of Kent, died, and on 14th December, while the dispute with America about the *Trent* affair was yet unsettled, the Prince Consort breathed his last at Windsor. Nobody could have suspected that he was so near his end. He was in the flower of manhood, he seemed to be strong and full of animal spirits. But in the autumn his constitution suddenly gave way, and he caught a cold which he could not shake off. One of his last journeys was to Cambridge to see the Prince of Wales, and his last actual appearance in public was when he reviewed the Eton College Rifle Corps in the Home Park at Windsor in the last week of November. On the Sunday before his death, while the Royal Family were at church, he lay at home on a sofa while the Princess Alice sang hymns to him. He closed his eyes with a serene expression, and after some minutes of silence said, "I am full of happy thoughts." In the course of the week symptoms of gastric fever declared themselves, and he died on 14th December.

His death left a void in the Queen's life which nothing could ever fill. She kept the memory of her wedded life and the lost Prince ever before her. She built at Frogmore a magnificent mausoleum where he and she might be buried. The anniversary of the Prince's death was regularly kept as a day of prayer. Statues and memorials sprang up on all sides. Of these the most conspicuous were the Albert Hall (1867) and the Albert Memorial in Hyde Park (1876). The Albert Medal also (1866) was established as a decoration in reward for gallantry in saving life.

The new decorations instituted during the Queen's reign may here be noted: The Victoria Cross (1856), Order of the Star of India (1861), Royal Order of Victoria and Albert (1862), Imperial Order of Crown of India (1878), Order of the Indian Empire (1878), Royal Red Cross (1883), Distinguished Service Order (1886), and the Royal Victorian Order (1896).

A new epoch in the constitutional history of the United Kingdom was opened with the Prince Consort's death. When he died the controlling power of the Crown fell temporarily into comparative abeyance. The Queen in her deep affliction retired for several years into almost complete privacy. Never again during her reign did the Queen live in London, and Buckingham Palace was only used for occasional visits of a few days. For a time she was naturally diffident of exercising her full authority in State affairs, though as the years passed her personal influence became more felt, and for the last ten years of her reign she was recognized as the most experienced statesman in Europe. So long as Lord Palmerston lived the inconveniences of the Queen's temporary withdrawal were not much felt, but Palmerston himself foresaw that mischief might some day arise if party conflicts should come to be fought out without the restraints which constitutional monarchy is intended to impose. At the time of the Prince's death the Prince of Wales was in his twenty-first year. He had spent several terms at each of the two Universities of Oxford and Cambridge, and he had already travelled much, having visited most of Europe, Egypt, and the United States. His marriage was solemnized at Windsor on 10th March 1863. The Queen witnessed the wedding from the private pew or box of St George's Chapel, Windsor, but she wore the deep mourning which she was never wholly to put off to the end of her life, and she took no part in the festivities of the wedding. In January 1864 a son was born to the Prince of Wales, and was christened Albert Victor after both his grandparents.

Marriage of the Prince of Wales.

Austro-Prussian War.

In 1866 the Austro-Prussian war broke out, and many short-sighted people were tempted to side with France when, in 1867, Napoleon III. sought to obtain a "moral compensation" by laying a claim to the Duchy of Luxemburg. A conference met in London, and the difficulty was settled by neutralizing the Duchy and ordering the evacuation of the Prussian troops who kept garrison there. But this solution, which averted an imminent war, was only arrived at through Queen Victoria's personal intercession. In the words of a French writer:—

> "The Queen wrote both to the King of Prussia and to the Emperor Napoleon. Her letter to the emperor, pervaded with the religious and almost mystic sentiments which predominate in the Queen's mind, particularly since the death of Prince Albert, seems to have made a deep impression on the Sovereign who, amid the struggles of politics, had never completely repudiated the philanthropic theories of his youth, and who, on the battlefield of Solferino, covered with the dead and wounded, was seized with an unspeakable horror of war."

Disraeli and Gladstone.

During Disraeli's two Premierships (1868; 1874–80) it has been said with some justice that the parts of Sovereign and Minister became often inverted, that Disraeli reigned and the Queen governed. Disraeli, at all events, rightly thought that the Queen ought to be a power in the State. His notion of duty—at once a loyal and chivalrous one—was that he was obliged to give the Queen the best of his advice, but that the final decision in any course lay with her, and that once she had decided he was bound, whatever might be his own opinion, to stand up for her decision in public. The Queen, not unnaturally, came to trust Disraeli implicitly, and she frequently showed her friendship for him. At his death she paid an exceptional tribute to his "dear and honoured memory" from his "grateful and affectionate Sovereign and friend." To something like this position Lord Salisbury after 1886 succeeded. A somewhat different conception of the Sovereign's functions was that of Disraeli's great rival, Gladstone, who, though his respect for the person and office of the Sovereign was unbounded, not only expected all people, the Queen included, to agree with him when he changed his mind, but to become suddenly enthusiastic about his new ideas. The Queen consequently never felt safe with him. Nor did she like his manner—he spoke to her (she is believed to have said) as if she was a public meeting. The Queen was opposed to the Disestablishment of the Irish Church (1869)—the question which brought Gladstone to be Premier, and though she yielded with good grace, Gladstone was fretful and astonished because she would not pretend to give a hearty assent to the measure. It happens that this matter of Irish Disestablishment is one of the few political questions in the second half of the Queen's reign in regard to which we have a definite published record of her opinions and actions. The *Life of Archbishop Tait* contains a deeply interesting correspondence between the Queen and the Primate on the line to be taken with regard to the second reading, in the House of Lords, of the Government Bill; a correspondence which it is impossible to read without renewed admiration for the political wisdom, as well as the high religious character, of the Sovereign. The Bill had passed the House of Commons; it seemed certain that the House of Lords would reject it, and the Queen, like the Archbishop, was deeply desirous that a conflict between the two Houses, resulting in a long and bitter agitation in the country, should not take place upon a religious question. Her Majesty commanded the Archbishop to confer with Gladstone, with a view to coming to some agreement as to the limits of disendowment; and then, after a meeting of peers had decided (Lord Salisbury dissenting) to oppose the second reading of the Bill, she endeavoured, through the Archbishop, to modify this decision, and to persuade the Lords to be content with improving the Bill in Committee. Through her secretary, General Grey, the Queen pointed out that she had not concealed from Gladstone "how deeply she deplored" his having felt himself under the necessity of raising the question, and how apprehensive she was of the possible consequences of the measure; but, when a general election had pronounced on the principle, when the Bill had been carried through the House of Commons by unvarying majorities, she did not see what good could be gained by rejecting it in the Lords. Later, when through the skilful diplomacy of the Primate the Lords had passed the second reading by a small but sufficient majority (179 to 146), and after various amendments had been adopted, the Queen herself wrote:—

> "The Queen . . . is very sensible of the prudence and, at the same time, the anxiety for the welfare of the Irish Establishment which the Archbishop has manifested during the course of the debates, and she will be very glad if the amendments which have been adopted at his suggestion lead to a settlement of the question; but to effect this, concessions, the Queen believes, will have to be made on *both* sides. The Queen must say that she cannot view without alarm possible consequences of another year of agitation on the Irish Church, and she would ask the Archbishop seriously to consider, in case the concessions to which the Government may agree should not go so far as he may himself wish, whether the postponement of the settlement for another year may not be likely to result in worse rather than in better terms for the Church. The Queen trusts, therefore, that the Archbishop will himself consider, and, as far as he can, endeavour to induce the others to consider, any concessions that may be offered by the House of Commons in the most conciliatory spirit."

The correspondence of which this letter forms a part is one of the few published witnesses to the Queen's careful and active interest in home politics during the latter half of her reign; but it is enough to prove how wise, how moderate, and how steeped in the spirit of the Constitution she was; how she disliked the premature raising of vital issues, and how at the same time she recognized the truth that, when the country had definitely declared its will at a general election, it would be the height of unwisdom not to give effect to that decision. Another instance is that of the County Franchise and Redistribution Bills of 1884–85. There, again, a conflict between the two Houses was imminent, and the Queen's wish for a settlement had considerable weight in bringing about the curious but effective conference of the two parties, of which the first suggestion, it is believed, was due to Lord Randolph Churchill.

Prince of Wales's illness.

Towards the end of 1871 the shadow of a great misfortune hung threateningly over the country and the Queen. In November the Prince of Wales was attacked with typhoid fever; on 8th December, after making good progress, he had a severe relapse, and for many days his life was in imminent danger. The blackest moment was just before 14th December, the tenth anniversary of the Prince Consort's death; but that day the improvement began, and his Royal Highness's recovery was assured. The intense excitement and sympathy of the whole people greatly touched the Queen, who gave full expression to her gratitude in a letter to her subjects, written on 26th December. "Their sympathy," she wrote, "has made a deep and lasting impression on her heart which can never be effaced. It is, indeed, nothing new to her, for the Queen had met with just the same sympathy when, just ten years ago, a similar illness removed from her side the mainstay of her life, the best, wisest, and kindest of husbands." The sympathy thus nobly recognized found extraordinary expression two months later, on 27th February 1872, when the Queen and the Royal Family went in state to St Paul's to return thanks for the Prince's recovery.

"Empress of India."

In 1876 a Bill was introduced into Parliament for conferring on the Queen the title of "Empress of India." It met with much opposition, and Disraeli was accused of ministering simply to a whim of the Sovereign, whereas, in fact, the title was intended to impress the idea of British suzerainty forcibly upon the minds of the native Princes, and upon the population of Hindustan. The Prince of Wales's voyage to India in the winter of 1875–76 had brought the heir to the throne into personal relationship with the great Indian vassals of the British Crown, and it was felt that a further demonstration of the Queen's interest in her magnificent dependency would confirm their loyalty in face of the many insidious attempts made to subvert it.

Private life.

The Queen's private life during the decade 1870–80 was one of quiet, broken only by one great sorrow when the Princess Alice died in 1878. In 1867 her Majesty had started in authorship by publishing *The Early Days of the Prince Consort*, compiled by General Grey; in 1869 she gave to the world her interesting and simply-written diary entitled *Leaves from the Journal of our Life in the Highlands*, and in 1874 appeared the first volume of *The Life and Letters of the Prince Consort* (2nd vol. in 1880) edited by Sir Theodore Martin. A second instalment of the Highland journal appeared in 1885. These literary occupations solaced the hours of a life which was mostly spent in privacy, although the Queen regularly transacted all the State business incumbent on her, and on occasions appeared in public ceremonies or inaugurated institutions of public usefulness. A few trips to the Continent, in which the Queen was always accompanied by her youngest daughter, the Princess Beatrice, brought a little variety into the home-life, and aided much in keeping up the good health which the Queen enjoyed almost uninterruptedly. So far as public ceremonies were concerned, the Prince and Princess of Wales were now coming forward more and more to represent the Royal Family. People noticed meanwhile that the Queen had taken a great affection for her Scottish manservant, John Brown, who had been in her service since 1849; she made him her constant personal attendant, and looked on him more as a friend than as servant. When he died in 1883 the Queen's grief was intense.

The Jubilee.

From 1880 onwards Ireland almost monopolized the field of domestic politics. The Queen felt great personal reluctance to sanction Gladstone's Home Rule policy; but she observed in public a constitutional reticence on the subject. In the year, however, of the Crimes Act, 1887, an event took place which was of more intimate personal concern to the Queen, and of more attractive import to the country and the Empire at large. June 20th was the fiftieth anniversary of her Majesty's accession to the throne, and on the following day, for the second time in English history, a great Jubilee celebration was held to commemorate so happy an event. Relieved from the danger of a break-up of the United Kingdom, favoured by a summer of the most exceptional brilliancy and beauty, encouraged by the state of general peace which prevailed over the world, the country threw itself into the celebration with unchecked enthusiasm; large sums of money were everywhere subscribed; in every city, town, and village something was done both in the way of rejoicing and in the way of establishing some permanent memorial of the event. In London the day itself was kept by a solemn service in Westminster Abbey, to which the Queen went in state, surrounded by the most brilliant, royal, and princely escort that had ever accompanied a British Sovereign, and cheered on her way by the applause of hundreds of thousands of her subjects. Around her carriage rode her sons and sons-in-law, and some of her grandsons, conspicuous among them being the noble figure of the ill-fated Crown Prince, afterwards the Emperor Frederick, with his son, afterwards the Emperor William II. Waiting to receive her Majesty in the Abbey were the ambassadors and ministers of all nations, the peers and the peeresses, the members of the House of Commons, the judges, the most distinguished officers of both services, and a multitude of all that was eminent in every branch of the national life, while grouped together and gazed upon by every eye stood a representative body of the Indian princes. In one of those touching letters to the nation which she wrote so naturally and so well the Queen three days afterwards addressed the Home Secretary :—

> "WINDSOR CASTLE, 24*th June*.
>
> "I am anxious to express to my people my warm thanks for the kind, and more than kind, reception I met with on going to, and returning from, Westminster Abbey, with all my children and grandchildren. The enthusiastic reception I met with then, as well as on all these eventful days, in London as well as in Windsor, on the occasion of my Jubilee, has touched me most deeply. It has shown that the labour and anxiety of fifty long years, twenty-two of which I spent in unclouded happiness shared and cheered by my beloved husband, while an equal number were full of sorrows and trials, borne without his sheltering arm and wise help, have been appreciated by my people. This feeling and the sense of duty towards my dear country and subjects, who are so inseparably bound up with my life, will encourage me in my task, often a very difficult and arduous one, during the remainder of my life. The wonderful order preserved on this occasion and the good behaviour of the enormous multitudes assembled merits my highest admiration. That God may protect and abundantly bless my country is my fervent prayer. VICTORIA, R. AND I."

The public ceremonials connected with the Jubilee were not, of course, confined to the Thanksgiving Service, nor did her Majesty limit her personal exertions to this one public appearance and to the entertainment of her Royal guests at Buckingham Palace and Windsor. The Queen had already paid a memorable visit to the East End, when she opened the People's Palace on 14th May. On 2nd July she reviewed at Buckingham Palace some 28,000 Volunteers of London and the home counties. On 4th July she laid the foundation stone of the Imperial Institute, the building at Kensington to which, at the instance of the Prince of Wales, it had been determined to devote the large sum of money collected as a Jubilee offering, and which was opened by the Queen in 1893. On 9th July her Majesty reviewed 60,000 men at Aldershot; and, last and chief of all, on 23rd July, one of the most brilliant days of a brilliant summer, she reviewed the Fleet at Spithead. Altogether 135 vessels of war were gathered together, including 26 armoured and 9 unarmoured ships, 38 first-class torpedo boats, the same number of gunboats, and 12 troopships, while outside the lines were moored innumerable merchant steamers, yachts, and other vessels of all sorts and sizes, thronged with proud and cheering spectators.

The Queen and Bismarck.

The year 1888 witnessed two events which greatly affected European history, and in a minor, though still marked, degree the life of the English Court. On 9th March the Emperor William I. died at Berlin. He was succeeded by his son, the Emperor Frederick III., known to all the world as the Crown Prince Fritz, and regarded with special affection in England as the husband of the Princess Royal. But at the time he was suffering from a malignant disease of the throat, and he died on 15th June, being succeeded by his eldest son, the Emperor William II., the grandson of the Queen. Meanwhile Queen Victoria spent some weeks at Florence at the Villa Palmieri, and returned home by Darmstadt and Berlin. In spite of the illness of the Emperor Frederick a certain number of Court festivities were held in her honour, and she had long conversations with Prince Bismarck, who was deeply impressed by her Majesty's personality. Just before, the Prince, who was still Chancellor, had taken a very strong line with regard to a royal marriage in which the Queen was keenly interested—the proposal that Prince Alexander of Battenberg, lately ruler of Bulgaria, and brother of the Queen's son-in-law, Prince Henry, should marry Princess Victoria, the eldest daughter of the Emperor Frederick. Prince Bismarck, who had been anti-Battenberg from the beginning, vehemently opposed this marriage, on the ground that for reasons of State policy it would never do for a daughter of the German Emperor to marry a prince who was personally disliked by the Tsar. This affair caused no little agitation in royal circles, but in the end State reasons were allowed to prevail and the Chancellor had his way.

1888–1889.

The Queen had borne so well the fatigue of the Jubilee that during the succeeding years she was encouraged to make somewhat more frequent appearances among her subjects. In May 1888 she attended a performance of Sir Arthur Sullivan's *Golden Legend* at the Albert Hall, and in August she visited Glasgow to open the magnificent new municipal buildings, remaining for a couple of nights at Blythswood, the seat of Sir Archibald Campbell. Early in 1889 she received at Windsor a special embassy, which, though it attracted comparatively little attention at the time, was the beginning of a memorable chapter of English history: two Matabele chiefs were sent by King Lobengula to present his respects to the "great White Queen," as to whose very existence, it was said, he had up till that time been sceptical. Soon afterwards her Majesty went to Biarritz, and the occasion was made memorable by a visit which she paid to the Queen-Regent of Spain at San Sebastian, the only visit that an English reigning Sovereign has ever paid to the Peninsula. On her return home the Queen paid a visit to Sandringham, where Henry Irving and the

Lyceum Company performed before her; several Jubilee statues were unveiled during this summer by the Prince of Wales; her Majesty, for the first time for very many years, went to see the procession of boats at Eton on the Fourth of June, and herself distributed the medals at the Royal Agricultural Show which was held shortly afterwards in Windsor Park. In August she received the visit of her grandson, the new German Emperor, who came, accompanied by his fleet, to the Solent. It was on this occasion that her Majesty appointed William II. an Admiral of the Fleet, and in return was made by her grandson Honorary Colonel of the 1st Dragoon Guards, which were thenceforward to be known as the "Queen of England's Own."

Parliamentary grant to the Prince of Wales's children.

The relations between the Court and the country formed matter in 1889 for a somewhat sharp discussion in Parliament and in the press. A Royal message was brought by Mr W. H. Smith on 2nd July, expressing, on the one hand, the Queen's desire to provide for Prince Albert Victor of Wales, and, on the other, informing the House of the intended marriage of the Prince of Wales's daughter, the Princess Louise, to the Earl (afterwards Duke) of Fife. On the proposal of Mr Smith, seconded by Gladstone, a Select Committee was appointed to consider these messages and to report to the House as to the existing practice and as to the principles to be adopted for the future. The evidence laid before the Committee explained to the country for the first time the actual state of the royal income, and on the proposal of Gladstone, amending the proposal of the Government, it was proposed to grant a fixed addition of £36,000 per annum to the Prince of Wales, out of which he should be expected to provide for his children without further application to the country. The interesting point in this affair was the divergence of opinion manifested between Gladstone and some of his followers. The ex-Premier, with an experience of nearly sixty years of public life, came forward as a strong advocate for granting an ample, though not extravagant, allowance to the Royal Family, whereas not only Mr Bradlaugh and Mr Labouchere, but even Mr Morley, who moved an amendment to Mr Smith's resolution for payment of the proposed sum, took a distinctly opposite view. The amendment was rejected by 355 to 134, and effect was given to it in a Bill called "The Prince of Wales's Children's Bill," which was carried in spite of the persistent opposition of a small group of Radical members.

1890-1891.

In the spring of 1890 the Queen visited Aix-les-Bains in the hope that the waters of that health resort might alleviate the rheumatism from which she was now frequently suffering. She returned as usual by way of Darmstadt, and shortly after her arrival at Windsor paid a visit to Baron Ferdinand Rothschild at Waddesdon Manor. The following year was one of great personal activity on the part of the Queen. In February she launched the battleship *Royal Sovereign* at Portsmouth; a week later she visited the Horse Show at Islington. Her annual spring visit to the South was this year paid to the little town of Grasse, which lies a few miles inland, to the left of the railway between Toulon and Cannes. Returning much benefited, the Queen, for the first time since the death of the Prince Consort, commanded a dramatic performance at Windsor Castle, and *The Gondoliers* was played in the Waterloo Gallery, the first of many similar performances at Windsor and Balmoral. A short time afterwards her Majesty paid a state visit to Derby, and opened a new hospital there.

Death of the Duke of Clarence.

At the beginning of 1892 a heavy blow fell upon the Queen, the Royal Family, and the country in the death of Prince Albert Victor, Duke of Clarence and Avondale. The eldest son of the Prince and Princess of Wales had never been of a robust constitution, and when he was attacked by influenza, at that time so prevalent, he made little resistance, pneumonia supervened, and after a little more than a week's illness he died at Sandringham. The Queen (whose motherly private letters to one sorrowing subject or another at various times endeared her more and more to all) addressed her people through the Home Secretary in a touching letter, expressing the feelings of profound grief which the loss of the young and amiable Prince had caused to her. Only a short time before it had been announced that the Prince was about to marry his second cousin, Princess May, daughter of the Duke and Duchess of Teck; and the pathos of the Prince's loss was increased by the thought of the ruin of this new hope:—

> "OSBORNE, 26*th January* 1892.
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> "I must once again give expression to my deep sense of the loyalty and affectionate sympathy evinced by my subjects in every part of my Empire on an occasion more sad and tragical than any but one which has befallen me and mine as well as the nation. The overwhelming misfortune of my dearly-loved grandson having been thus suddenly cut off in the flower of his age, full of promise for the future, amiable and gentle, and endearing himself to all, renders it hard for his sorely-stricken parents, his dear young bride, and his fond grandmother to bow in submission to the inscrutable decrees of Providence. The sympathy of millions, which has been so touchingly and visibly expressed, is deeply gratifying at such a time, and I wish, both in my own name and that of my children, to express, from my heart, my warm gratitude to all. These testimonies of sympathy with us, and appreciation of my dear grandson, whom I loved as a son, and whose devotion to me was as great as that of a son, will be a help and consolation to me and mine in our affliction. My bereavements during the last thirty years of my reign have indeed been heavy. Though the labours, anxieties, and responsibilities inseparable from my position have been great, yet it is my earnest prayer that God may continue to give me health and strength to work for the good and happiness of my dear country and Empire while life lasts. VICTORIA, R.I."

The death of the young Prince threw a gloom over the country, and caused the Royal Family to spend the year in such retirement as was possible. Her Majesty had already begun to pay annual visits to a warmer clime; this year it was Costebelle, a suburb of Hyères, in the south of France, that was her choice. In this sunny region she passed some quiet weeks and returned refreshed to take up her life of unobtrusive work.

1893.

In 1893 the country, on the expiration of the royal mourning, began to take a more than usual interest in the affairs of the Royal Family. On 19th February the Queen left home for a first visit to Florence, and spent many delightful weeks in the Villa Palmieri. She was able to display remarkable energy in visiting the sights of this famous city, and even went as far afield as San Gimignano; and her visit had a notable effect in strengthening the bonds of friendship between the United Kingdom and the Italian people. On 28th April her Majesty arrived home, and a few days later the Duke of York, who by his brother's death had been left in the direct line of succession to the throne, was betrothed to the Princess May, the marriage being celebrated on 6th July in the Chapel Royal of St James's Palace.

1894.

In 1894 the Queen stayed for some weeks at Florence, and on her return she stopped at Coburg to witness the marriage between two of her grandchildren, the Grand Duke of Hesse and the Princess Victoria Melita of Coburg. On the next day the Emperor William officially announced the betrothal of the Cesarevitch (afterwards the Tsar Nicolas II.) to the Grand Duchess Alix of Hesse, a granddaughter whom her Majesty had always regarded with special affection. After a few weeks in London her Majesty went northwards and stopped at Manchester, where she opened the Ship Canal. Two days afterwards she celebrated her seventy-fifth birthday in quiet at Balmoral. A month later (June 23) took place the birth of a son to the Duke and Duchess of York, the child receiving the thoroughly English name of Edward.

Death of Prince Henry of Battenberg.

In 1895 the Queen lost her faithful and most efficient private secretary, General Sir Henry Ponsonby, who for many years had helped her in the management of her most private affairs and had acted as an intermediary between her and her Ministers with singular ability and success. His successor was Sir Arthur Bigge. The following year, 1896, was marked by a loss which touched the Queen even more nearly and more personally. At his own urgent request Prince Henry of Battenberg, the Queen's son-in-law, who belonged to a fighting family, and who had a natural desire to see some form of life a little more adventurous than what can be afforded by the luxurious monotony of a Court, was permitted to join the Ashanti expedition, and early in January the Prince was struck down with fever. He was brought to the coast and put on board her Majesty's ship *Blonde*, where, on the 20th, he died. The news came as a terrible shock to the Queen and to the Princess Beatrice; and, writing to the Home Secretary a few weeks later, her Majesty expressed her sense of loss in terms of touching sincerity. "This new sorrow," she wrote, "is overwhelming, and to me is a double one, for I lose a dearly-loved and helpful son, whose presence was like bright sunshine in my home, and my dear daughter loses a noble, devoted husband, to whom she was united by the closest affection."

The Diamond Jubilee.

In September 1896 the Queen's reign had reached a point at which it exceeded in length that of any other English sovereign; but by her special request all public celebrations of the fact were deferred until the following June, which marked the completion of sixty years from her accession. As the time drew on it was obvious that the celebrations of this Diamond Jubilee, as it was popularly called, would exceed in magnificence those of the Jubilee of 1887. Mr Chamberlain, the Secretary for the Colonies, induced his colleagues to seize the opportunity of making the Jubilee a festival of the British empire. Accordingly, the Prime Ministers of all the self-governing colonies, with their families, were invited to come to London as the guests of the country to take part in the Jubilee procession; and drafts of the troops from every British colony and dependency were brought home for the same purpose. The procession was, in the strictest sense of the term, unique. Here was a display, not only of Englishmen, Scotsmen, Irishmen, Welshmen, but of Mounted Rifles from Victoria and New South Wales, from the Cape and from Natal, and from the Dominion of Canada. Here were Hausas from the Niger and the Gold Coast, coloured men from the West India regiments, zaptiehs from Cyprus, Chinamen from Hong Kong, and Dyaks—now civilized into military police—from British North Borneo. Here, most brilliant sight of all, were the Imperial Service troops, sent by the native Princes of India; while the detachments of Sikhs who marched earlier in the procession received their full meed of admiration and applause. The route taken was from Buckingham Palace, along Constitution Hill, Piccadilly, St James's Street, Pall Mall, and the Strand to St Paul's Cathedral, where the procession halted while a short service was held on the steps, the Queen not leaving her carriage on account of her lameness. Thence her Majesty proceeded to the Mansion House, where she received an address, and then —the great novelty of the day—crossed London Bridge, traversed South London amid crowds as great and enthusiastic as those which thronged the West End, and returned home by way of Westminster Bridge and St James's Park. Altogether the Queen was in her carriage for more than four hours, in itself an extraordinary physical feat for a woman of seventy-eight. Her own feelings were shown by the simple but significant message she sent to her people throughout the world: "From my heart I thank my beloved people. May God bless them." Some time later her Majesty gave a garden party at Buckingham Palace, and held numerous receptions at Windsor, including that of the Colonial troops and that of the members of the House of Commons and their wives. The illuminations in London and the great provincial towns were magnificent, and all the hills from Ben Nevis to the South Downs were crowned with bonfires. The Queen herself held a great review at Aldershot; but a much more significant display was the review by the Prince of Wales of the Fleet at Spithead on Saturday, 26th June. No less than 165 vessels of all classes were drawn up in four lines, extending altogether to a length of 30 miles; opposite were arrayed representative war-vessels from many foreign States, while a line of merchant steamers and scores of other steamers and yachts, crowded with guests, gave colour and at times movement to the scene. People learned, with something like amazement, that the vast fleet of modern vessels there assembled was drawn from home waters only; and that with no difficulty it had been manned with 40,000 officers and men, only a very few of whom were drawn from the Naval Reserve.

The two years that followed the Diamond Jubilee were, as regards the Queen, comparatively uneventful. Her health remained good, and her visit to Cimiez in the spring of 1898 was as enjoyable and as beneficial as before. In May 1899, after another strengthening visit to the Riviera, her Majesty performed what proved to be her last ceremonial function in London; she proceeded in "semi-state" to South Kensington, and laid the foundation stone of the new buildings completing the Museum—henceforth to be called the Victoria and Albert Museum —which had been planned more than forty years before by the Prince Consort.

The Queen's last year.

Griefs and anxieties encompassed the Queen during the last year of her life. But if the South African war proved more serious than had been anticipated, it did more to weld the empire together than years of peaceful progress might have accomplished. The Queen's frequent messages of thanks and greeting to her colonies and to the troops sent by them, and her reception of the latter at Windsor, gave evidence of the heartfelt joy with which she saw the sons of the empire giving their lives for the defence of its integrity; and the satisfaction which she showed in the Federation of the Australian colonies was no less keen. The reverses of the first part of the Boer campaign, together with the loss of so many of her officers and soldiers, caused no small part of that "great strain" of which the *Court Circular* spoke in the ominous words which first told her Majesty's subjects that she was seriously ill. But the Queen faced the new situation with her usual courage, devotion, and strength of will. She reviewed the departing regiments; she entertained the wives and children of the Windsor soldiers who had gone to the war; she showed by frequent messages her watchful interest in the course of the campaign and in the efforts which were being made throughout the whole empire; and her Christmas gift of a box of chocolate to every soldier in South Africa was a touching proof of her sympathy and interest. She relinquished her annual holiday on the Riviera, feeling that at such a time she ought not to leave her country. Entirely on her own initiative, and moved by admiration for the fine achievements of "her brave Irish" during the war, the Queen announced her intention of paying a long visit to Dublin; and there, accordingly, she went for the month of April 1889, staying in the Viceregal Lodge, receiving many of the leaders of Irish society, inspecting some 50,000 school children from all parts of Ireland, and taking many a drive amid the charming scenery of the neighbourhood of Dublin. She went even further than this attempt to conciliate Irish feeling, and to show her recognition of the gallantry of the Irish soldiers she issued an order for them to wear the shamrock on St Patrick's Day, and for a new regiment of Irish Guards to be constituted.

In the previous November the Queen had had the pleasure of receiving, on a private visit, her grandson, the German Emperor, who came accompanied by the Empress and by two of their sons. His Foreign Minister, Count von Bülow, was with him; there were long interviews with Mr Balfour and Mr Chamberlain; and there was a rapid visit to Sandringham, where Bishop Creighton preached a strong sermon on the need of a good understanding between the United Kingdom and Germany; to which the Emperor replied, "You are preaching a doctrine which I am endeavouring with all my strength to impress upon my people." This visit of her grandson cheered the Queen, and the successes of the army which followed the arrival of Lord Roberts in Africa occasioned great joy to her, as she testified by many published messages. But independently of the public anxieties of the war, and of those aroused by the violent and unexpected outbreak of fanaticism in China, the year brought deep private griefs to the Queen. In 1899 her grandson, the Hereditary Prince of Coburg, had succumbed to phthisis, and in 1900 his father, the Duke of Coburg, the Queen's second son, previously known as the Duke of Edinburgh, also died (July 30). Then Prince Christian Victor, the Queen's grandson, fell a victim to enteric fever at Pretoria; and during the autumn it came to be known that the Empress Frederick, the Queen's eldest daughter, was very seriously ill. Moreover, just at the end of the year a loss which greatly shocked and grieved the Queen was experienced in the sudden death, at Windsor Castle, of the Dowager Lady Churchill, one of her Majesty's oldest and most intimate friends. These losses told upon the Queen at her advanced age. Throughout her life she had enjoyed excellent health, and even in the last few years the only marks of age were rheumatic stiffness of the joints, which prevented walking, and a diminished power of eyesight. In the autumn of 1900, however, her health began definitely to fail, and though arrangements were made for another holiday in the South, it was plain that her strength was seriously affected. Still she continued the ordinary routine of her duties and occupations. Before Christmas she made her usual journey to Osborne, and there on 2nd January she received Lord Roberts on his return from South Africa and handed to him the insignia of the Garter. A fortnight later she commanded a second visit from the Field-Marshal; she continued to transact business, and until a week before her death she still took her daily drive. A sudden loss of power then supervened, and on Friday evening, 18th January, the *Court Circular* published an authoritative announcement of her illness. On Tuesday, 22nd January 1901, she died.

Death of the Queen.

Queen Victoria was a ruler of a new type. When she ascended the throne the popular faith in kings and queens was on the decline. She revived that faith; she consolidated her throne; she not only captivated the affections of the multitude, but won the respect of thoughtful men; and all this she achieved by methods which to her predecessors would have seemed impracticable—methods which it required no less shrewdness to discover than force of character and honesty of heart to adopt steadfastly. The Queen was no woman of placid temperament who could remain indifferent to public affairs so long as her domestic concerns were not interfered with. To imagine that she divested herself of all responsibilities and secured to herself a peaceful life by doing, without reflection, whatever her Ministers advised, would be absolutely to misunderstand her intelligent, sensitive nature, and to ascribe grand results to very petty causes. Whilst all who approached the Queen bore witness to her candour and reasonableness in relation to her Ministers, all likewise proclaimed how anxiously she considered advice that was submitted to her before letting herself be persuaded that she must accept it for the good of her people. By thus acting she put statesmen on their mettle, raised the level of public morality, and laid down the lines of action for a modern constitutional ruler.

Though richly endowed with saving common-sense, the Queen was not specially remarkable for high development of any specialized intellectual force. Her whole life, public and private, was an abiding lesson in the paramount importance of character. John Bright said of her that what specially struck him was her absolute truthfulness. For nearly sixty-four years she watched, at first diffidently, later with ever-maturing experience, but always with insight, sympathy, and genuine patriotism, over the developments of national policy. The condition of Europe when she ascended the throne was one of extreme instability. A few years later it became one of turmoil and confusion, in which dynasties were overthrown and high potentates had to flee their countries for asylum elsewhere. That the British throne came through that troublous time unscathed, and even with added prestige, must be ascribed in no small measure to the character of its occupant. The extent of her family connexions, and the correspondence she maintained with foreign sovereigns, together with the confidence inspired by her personal character, often enabled her to smooth the rugged places of international relations; and she gradually became in later years the Mother of her people, and the link between all parts of a democratic empire, the citizens of which felt a passionate loyalty for their venerable Queen.

By her long reign and unblemished record her name had become associated inseparably with British institutions and British solidarity. Her own life was by choice, and as far as her position would admit, one of almost austere simplicity and homeliness; and her subjects were proud of a Royalty which involved none of the mischiefs of caprice or ostentation, but set an example alike of motherly sympathy and of queenly dignity. She was mourned at her death not by her own country only, nor even by all English-speaking people, but by the whole world. The funeral in London on 1st and 2nd February, including first the passage of the coffin from the Isle of Wight to Gosport between lines of warships, and secondly a military procession from London to Windsor, was a memorable solemnity; from beginning to end there was no false note, but a simple and serious realization that the greatest of English sovereigns, whose name would in history mark an age, had gone to her rest.

There is a good bibliographical note at the end of Mr Sidney Lee's article in the *National Dictionary of Biography*. See also the full biography published by *The Times*, from which the above has been condensed, modified, and adapted.

Victoria, a state of the Commonwealth of Australia. The first discoverer of Victoria was Captain Cook, in command of H.M.S. *Endeavour*, who sighted Cape Everard, about half-way between Cape Howe and the

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mouth of the Snowy river, on 19th April 1770, a few days prior to his arrival at Botany Bay. The first persons to land in Victoria were the supercargo and a portion of the crew of the merchant ship *Sydney Cove* which was wrecked at the Furneaux Islands in Bass Strait on 9th February 1797. In the same year, Mr Bass, a surgeon in the navy, discovered the strait which bears his name and separates Victoria from Tasmania. Lieutenant Grant in the *Lady Nelson* surveyed the south coast in 1800, and in 1801 Port Phillip was for the first time entered by Lieutenant Murray. In 1802 that harbour was surveyed by Captain Flinders, and in the same year Mr Grimes, the surveyor-general of New South Wales, explored the country in the neighbourhood of the present site of Melbourne. In 1804 Lieutenant-colonel Collins, who had been sent from England, formed a penal settlement on the shores of Port Phillip, but after remaining a little more than three months near Indented Head, he removed his party to Van Diemen Land. Victoria was visited in 1824 by two sheep farmers named Hume and Hovell, who rode overland from Lake George, New South Wales, to the shores of Corio Bay. In 1826 a convict establishment was attempted by the Government of New South Wales at Settlement Point, near French Island, Western Port Bay, but it was abandoned shortly afterwards. In 1834 Messrs Edward and Francis Henty, who had taken part in the original expedition to Swan River, West Australia, and afterwards migrated to Van Diemen Land, crossed Bass Strait, established a shore whaling station at Portland Bay, and formed sheep and cattle stations on the river Wannon and Wando rivulet, near the site of the present towns of Merino, Casterton, and Coleraine. In 1835 a number of flock owners in Van Diemen Land purchased through Batman from the aborigines, a tract of 700,000 acres on the shores of Port Phillip. The sale was repudiated by the British Government, which regarded all unoccupied land in any part of Australia as the property of the Crown, and did not recognize the title of the aborigines. Batman, however, remained at Port Phillip, and commenced farming within the boundaries of the present city of Melbourne. He was followed by John Pascoe Fawkner and other settlers from Van Diemen Land, who occupied the fertile plains of the new territory. In 1836 Captain Lonsdale was sent to Melbourne by the Government of New South Wales to act as resident magistrate in Port Phillip. The first census taken in 1838 showed that the population was 3511, of whom 3080 were males and 431 females. In 1839 Mr Latrobe was appointed superintendent of Port Phillip, and a resident judge was nominated for Melbourne, with jurisdiction over the territory which now forms the state of Victoria. The years 1840 and 1841 were periods of depression owing to the decline in the value of all descriptions of live stock, for which the first settlers had paid high prices, but there was a steady immigration from Great Britain of men with means, attracted by the profits of sheep-farming, and of labourers and artisans who obtained free passages under the provisions of the Wakefield system, under which half the proceeds from the sale and occupation of Crown lands were expended upon the introduction of workers. The whole district was occupied by sheep and cattle graziers, and in 1841 the population had increased to 11,738. Melbourne was incorporated as a town in 1842, and was raised to the dignity of a city in 1847. In that same year the first Anglican was ordained, and in 1848 the first Roman Catholic bishop. The third census (taken in 1846) showed a population of 32,870.

The elective element was introduced into the Legislative Council of South Wales in 1842, in the proportion of twenty-four members to twelve nominated by the Crown, and the district of Port Phillip, including Melbourne, returned six members. But the colonists were not satisfied with government from and by Sydney; an agitation in favour of separation commenced, and in 1851 Victoria was formed into a separate colony with an Executive Council appointed by the Crown, and a Legislative Council, partly elective and partly nominated, on the same lines as that of New South Wales. The population at that date was 77,435. Gold was discovered a few weeks after the colony had entered upon its separate existence, and a large number of persons were attracted to the mines, first from the neighbouring colonies—some of which, such as South Australia, Van Diemen Land, and West Australia, were almost denuded of able-bodied men and women—and subsequently from Europe and America. Notwithstanding the difficulties with which the local government had to contend, the task of maintaining law and order was fairly grappled with; the foundations of a liberal system of primary, secondary, and university education were laid; roads, bridges, and telegraphs were constructed, and Melbourne was provided with an excellent supply of water.

Local self-government.

Local self-government was introduced in 1853, and the Legislature found time to discuss a new Constitution, which not only eliminated the nominee element from the Legislature, but made the executive government responsible to the people. The administration of the gold-fields was not popular, and the miners were dissatisfied at the amount charged for permission to mine for gold, and at there being no representation for the gold-fields in the local Legislature. The discontent culminated at Ballarat in December 1854, in riots in which there was a considerable loss of life both amongst the miners and the troops. Eventually, an export duty on gold was substituted for the licence fee, but every miner had to take out a right which enabled him to occupy a limited area of land for mining, and also for residence. The census taken in 1854 showed a population of 236,778. The new Constitution was proclaimed in 1855, and the old Executive Council was gazetted as the first responsible ministry. It held office for about sixteen months, and was succeeded by an administration formed from the popular party. Several changes were made in the direction of democratizing the Government, and vote by ballot, manhood suffrage, and the abolition of the property qualification followed each other in rapid succession. To several of these changes there was strenuous opposition, not so much in the Assembly which represented the manhood, as in the Council in which the property of the colony was supreme. The Crown lands were occupied by graziers, termed locally "squatters," who held them under a licence renewable annually at a low rental. These licences were very valuable, and the goodwill of a grazing farm or "run" commanded a high price. Persons who desired to acquire freeholds for the purpose of tillage could only do so by purchasing the land at auction, and the local squatters, unwilling to be deprived of any portion of a valuable property, were generally willing to pay a price per acre with which no person of small means desirous of embarking upon agricultural pursuits could compete. The result was that although the population had increased in 1861 to 540,322, the area of land under crop had not grown proportionately, and Victoria was dependent upon the neighbouring colonies and even more distant countries for a considerable portion of its food. A series of Land Acts was passed, the first in 1860, with the view of encouraging a class of small freeholders. The principle underlying all these laws was that residence by landowners on their farms, and their cultivation, were more important to the state than the sum realized by the sale of the land. The policy was only partially successful, and by a number of ingenious evasions, a large proportion of the best land in the colony passed into the possession of the original squatters. But a sufficient proportion was purchased by small farmers to convert Victoria into a great agricultural country, and to enable it to export large quantities of farm and dairy produce.

The greater portion of the revenue was raised by the taxation through the customs of a small number of products, such as spirits, tobacco, wine, tea, coffee, &c. But an agitation arose in favour of such an adjustment of the import duties as would protect the manufactures which at that time were being commenced. A determined opposition to this policy was made by a large minority in the Assembly, and by a large majority in the Council, but by degrees the democratic party triumphed. The victory was not gained without a number of political crises which shook the whole fabric of society to its foundations. The Assembly tacked the tariff to the Appropriation Bill, and the Council threw out both. The result was that there was no legal means of paying either the civil servants or the contractors, and the Government had recourse to an ingenious though questionable system by which advances were made by a bank which was recouped through the Crown "confessing" that it owed the money, whereupon the Governor issued his warrant for its payment without any recourse to Parliament. Similar opposition was made by the Council to payment of members, and to a grant made to Lady Darling, the wife of Governor Sir Charles Darling, who had been recalled by the Secretary of State on the charge of having shown partiality to the democratic party. Indeed on one occasion the dispute between the Government and the Council was so violent, that the former dismissed all the police, magistrates, county court judges, and other high officials, on the ground that no provision had been made by the Council, which had thrown out the Appropriation Bill, for the payment of salaries.

Notwithstanding these political struggles the population of the colony steadily increased, and the Legislature found time to pass some measures which affected the social life and the commercial position of the colonies. State aid to religion was abolished and divorce was made comparatively easy. A system of free, compulsory, and secular primary education was introduced. The import duties were increased and the transfer of land was simplified. In 1880 a fortnightly mail service *viâ* Suez between England and Melbourne was introduced, and in 1880 the first International Exhibition ever held in Victoria was opened. In the following year the census showed a population of 862,346, of whom 452,083 were males, and 410,263 females. During the same year the lengthy dispute between the two Houses of Parliament, which had caused so much inconvenience, so many heartburnings, and so many political crises, was brought to an end by the passage of an Act which reduced the qualifications for members and the election of the Legislative Council, shortened the tenure of their seats, increased the number of provinces to fourteen, and the number of members to forty-two. In 1883 a coalition Government, in which the Liberal or protectionist, and the Conservative or free-trade party were represented, took office, and with some changes remained in power for seven years. During this political truce several important changes were made in the Constitution. An Act for giving greater facilities for divorce was passed, and with some difficulty obtained the royal assent. The Victorian railways were handed over to the control of three commissioners, who to a considerable extent were made independent of the Government, and the civil service was placed under the supervision of an independent board. In 1887 the representatives of Victoria met those of the other British colonies and of the United Kingdom in London, under the presidency of Lord Knutsford, in order to discuss the questions of defence, postal and telegraphic communication, and the contribution of Australia to the Imperial navy. In 1888 a weekly mail service was established *viâ* Suez by the steamers of the P. & O. and the Orient Company, and the second Victorian International Exhibition was opened. In 1890 all the Australian colonies, including New South Wales and New Zealand, sent representatives to a conference at Melbourne, at which resolutions were passed in favour of the establishment of a National Australian Convention empowered to consider and report upon an adequate scheme for the Federal Constitution. This Convention met in Sydney in 1891 and took the first step towards federation (see AUSTRALIA).

In 1891 the coalition Government resigned and a Liberal administration was formed. An Act passed in that year placed the railways again under the control of the Government. Measures of a democratic and collectivist tendency have since obtained the assent of the Legislature. The franchise of property-holders not resident in an electorate was abolished and the principle of "one man one vote" was established. Acts have been passed sanctioning Old Age Pensions; prohibiting shops, except those selling perishable goods, from keeping open more than eight hours; compelling the proprietors to give their assistants one half-holiday every six days; preventing persons from working more than forty-eight hours a week; and appointing for each trade a tribunal composed of an equal number of employers and employed to fix a minimum wage.

Victoria enjoyed a large measure of prosperity during the later 'eighties and earlier 'nineties, and its financial prosperity enabled the Government to expend large sums in extending railway communication to almost every locality and to commence a system of irrigation. The soil of Victoria is on the whole more fertile than in any other colony on the mainland of Australia, and in no portion of the continent is there any locality equal in fertility to the western district and some parts of Gippsland. The rainfall is more equable than in any portion of Australia, but the northern and north-western districts, which are the most remote from the sea and the Dividing Range, are subject to droughts which, although not so severe or so frequent as in the interior of the continent, are sufficiently disastrous in their effects. The results of the expenditure upon irrigation have not been so successful as was hoped. Victoria has no mountains covered with snow, which in Italy and South America supply with water the rivers at the season of the year when the land needs irrigation, and it was necessary to construct large and expensive reservoirs. The cost of water is therefore greater than the ordinary agriculturist who grows grain or breeds and fattens stock can afford to pay, although the price may not be too high for orchardists and vine-growers. In 1892 the prosperity of the colony was checked by a great strike which for some months affected production, but speculation in land continued for some time longer, especially in Melbourne, which at that time contained nearly half the population, 500,000 out of a total of 1,140,105. There does not seem to have been any other reasons for this increase in land values for there was no immigration, and the value of every description of produce had fallen—except that the working-classes were prosperous and well paid, and

Crisis of 1892.

that the purchase of small allotments in the suburbs was a popular mode of investment. In 1893 there was a collapse. The value of land declined enormously, hundreds of persons believed to be wealthy were ruined, and there was a financial panic which caused the suspension of all the banks, with the exception of the Australasia, the Union of Australia, and the New South Wales. Most of them resumed payment, but three went into liquidation. It was some years before the normal condition of prosperity was restored, but the great resources of the colony and the energy of its people discovered new markets, and new products for them, and enabled them materially to increase the export trade.

Government.—The Constitution of Victoria was established by an Act passed by the Legislature of the colony in 1854, in pursuance of the power granted by the original Act of the Imperial Parliament. The Legislative authority is vested in a Parliament of two Chambers—the Legislative Council, composed of 48 members, and the Legislative Assembly, composed of 95 members. According to an Act which came into force in 1881, members of Council must be in possession of an estate of the annual value of £100, and electors must be in possession or occupancy of property of the rateable value of £10 per annum, if derived from freehold, or of £25 if derived from leasehold, or the occupation of rented property. No electoral property qualification is required from graduates of British universities, matriculated students of the Melbourne University, ministers of religion of any denomination, certificated schoolmasters, lawyers, medical practitioners, and officers of the army and navy. One-third of the members of Council must retire every two years. The members of the Assembly are elected by universal suffrage, no persons being allowed to exercise more than one vote, for the term of three years, but can be dissolved at any time by the Governor in Council. Members of the Legislative Assembly are paid £300 a year. Clergymen of any religious denomination cannot hold seats in the Council or Assembly. (G. C. L.)

Population.

As regards population, Victoria maintained the leading position among the Australasian colonies until the end of the year 1891, when New South Wales overtook it. The population at the opening of 1902 was 1,208,700, the proportion of the sexes being nearly equal. In 1860 the population numbered 537,847; in 1870, 726,599; in 1880, 860,067; and in 1890, 1,133,266. The state has gained little, if anything, by immigration during these forty years, for the excess of immigration over emigration from 1861 to 1870, and from 1881 to 1890, was counterbalanced by the excess of departures during the period 1871 to 1880, and from 1891 to 1902. The births in 1901 numbered 31,008, and the deaths 15,904, representing respectively 25·78, and 13·22 per 1000 of the population. The birth-rate has fallen markedly since 1875, as the following statement of the averages arranged in quinquennial periods shows:—

Period.	Births per 1000 of Population.	Period.	Births per 1000 of Population.
1861–65	43·30	1881–85	30·76
1866–70	39·27	1886–90	32·72
1871–75	35·69	1891–95	31·08
1876–80	31·43	1896–1901	26·20

The number of illegitimate births, calculated for a period of ten years, 1892–1901, represents 5·53 of the total births, the number of illegitimate children born in 1901 being 1729, and the total births in that year 31,008. The death-rate has greatly improved, and now stands a little higher than 13 per 1000. Arranged in quinquennial periods the death-rates were:—

Period.	Deaths per 1000 of Population.	Period.	Deaths per 1000 of Population.
1861–65	17·36	1881–85	14·65
1866–70	16·52	1887–90	16·07
1871–75	15·64	1891–95	14·10
1876–80	14·92	1896–1901	13·67

The marriages in 1901 numbered 8406, which represents a rate of 6·99 per 1000 persons, and 13·98 persons married. In the five years, 1871–75, the marriage-rate stood at 6·38 per 1000; in 1876–80, 6·02; in 1881–85, 7·37; in 1886–90, 8·13. Since the period last named, the average has varied between 6·3 and 6·9 per 1000.

The aborigines number only 643, of whom a large proportion are half-castes and quadroons. Most of them reside in farms called Aboriginal Reserves, set apart in various localities. The chief cities and towns are Melbourne and suburbs, population, 459,500 (1901); Ballarat (43,823), Bendigo (30,774), Geelong (18,289), Warrnambool (6404), Castlemaine (5703), Maryborough (5622), and Stawell (5318).

Religion.

The Church of England had 421,723 adherents in 1901; the Roman Catholic Church, 261,187; Presbyterians, 175,373; Wesleyan and other Methodists, 155,954; Congregationalists, 23,220; Baptists, 29,291; Lutherans, 16,322; Jews, 6786; and the Salvation Army is strongly represented in the state, its Australian headquarters being in Melbourne.

Instruction.

There are 1948 state schools, in which there are 243,667 children enrolled and 4562 teachers. There are also a large number of private schools (884 schools and 2652 teachers in 1901) and about 17 per cent. of the children are taught therein. The total children enrolled in the various schools is 291,817, and the daily attendance is 182,877. The majority of the private schools are connected with one or other of the principal religious denominations, the Roman Catholic Church alone supporting more than 190 schools, with an enrolment of 25,000 children. The Melbourne University maintains its high position as a teaching body. In 1900 the number of matriculants was 108, of whom 21 were women; and the graduates were 134, including 15 women. There are 407 public libraries, with about 1,150,000 books. The public library at Melbourne contains about 545,000 volumes. The proportion of men who sign the marriage register with a mark is now not more than 7 per 1000, while the proportion of women is even less. Crime is decreasing, and Victoria ranks with South Australia as having the smallest proportion of offenders. In 1900 there were 27,568 persons arrested, which represents about 23 arrests per 1000 inhabitants. The arrests for drunkenness numbered 15,878. Serious offences have very greatly diminished, as the committals for trials clearly show. In 1881 the number of arrests was 25,346, the summary convictions 16,448, and the committals for trial 591; in 1891 the arrests were 37,309, summary convictions 23,307, and committals 873; in 1900 the arrests were 27,568, summary convictions 18,384, and committals 575. The population between 1881 and 1900 increased by over one-third, so that the latest figures show a large reduction in crime both trivial and serious.

Finance.

Victoria has a complete system of local government, and the finances are not burthened with the cost of local works. The public revenue has not expanded of late years with the population, a circumstance due partly to the operation of high customs duties, and partly to the effect which the fall in prices has had upon the value of imports; the value of imports being greatly reduced, the *ad valorem* duties levied thereon showing a corresponding reduction. The public revenue in five-yearly periods since 1880 was: 1880, £4,621,282; 1885, £6,290,361; 1890, £8,519,159; 1895, £6,712,512; and 1901, £7,722,397. The sum last mentioned represents £6 10s. 3d. per inhabitant. The present sources of public revenue are: import and excise duties, £1,257,540; other taxes, £493,220; railway receipts, £3,302,200; posts and telegraphs, £625,761; public lands, £332,700; fees and fines £637,440; other revenue, £1,642,035. Included in this amount is a sum of £1,177,740 representing Commonwealth Balances returned by the Federal Treasurer. The main items of expenditure are working expenses: railways, £1,955,487; posts and telegraphs, £305,787; public instruction, £624,187; interest and charges on public debt, £1,955,173; and other services, £2,802,444. On 30th June 1901 the public debt stood at £55,406,118, equal to £46 5s. 1d. per inhabitant. The great bulk of the proceeds of loans was applied to the construction of revenue-yielding works, only about three millions sterling being otherwise used. The state has alienated a little over 23,369,000 acres of the public domain, and has about 9 million acres under lease; the area neither alienated nor leased amounts to 23,500,000 acres. The self-governing districts number 208, and control an area of 87,322 square miles out of 87,884 square miles, the estimated area of the state. The capital value of properties as returned by the municipalities in 1900, was nearly £169,912,000, and the annual value £10,283,500. These figures are substantially less than in some preceding years. In 1884 the values were 104 millions and £8,099,000, and in 1891, 203 millions and £13,734,000; the year last mentioned marked the highest point of inflation in land values, and during the following years there was a vast reduction, both in capital and in annual values, the lowest point touched being in 1895; since 1895 a gradual improvement has taken place, and there is every evidence that this improvement will continue. The revenues of municipalities are derived chiefly from rates, but the rates are largely supplemented by fees and licences, and contributions for services rendered. Excluding Government endowments and special grants, which at present amount to about £100,000, the revenues of the municipalities in the years named were: 1880, £616,132; 1885, £789,429; 1890, £1,273,855; 1895, £1,038,720; and 1900, £1,036,497. In addition to the municipalities there were other local bodies empowered to levy rates; these and their revenues were in 1900: Melbourne Harbour Trust, £143,362; Melbourne and Metropolitan Board of Works, £269,213; and Fire Boards, £18,516. The Board of Works is the authority administering the metropolitan water and sewerage works. Excluding revenue from services rendered, the amount of taxation levied in Victoria amounted in 1900 to £3,965,699, of which the Government levied £2,984,592, the municipalities £853,322, and the Melbourne Harbour Trust £127,785.

Defence.

The defence force numbers about 7000 men, of whom 400 are paid and devote their whole time to the services of defence, 3500 partially paid, and 2900 unpaid volunteers. Besides these, there are some 300 naval artillery, a force capable of being employed either as a light artillery land force or on board the local war vessels. For harbour defence there are the armoured turret ship, *Cerberus*, 3480 tons, two first-class, two second-class, and three wooden torpedo boats. Victoria contributes £33,000 towards the maintenance of an auxiliary fleet stationed by the Imperial Government in Australian waters. This fleet consists of five fast cruisers and two torpedo gunboats, and is attached to the command of the admiral of the Australian Naval Station. The total expenditure in 1900 for purposes of defence, was £201,611 from ordinary revenue, and £229 from loan votes, or in all £201,840, equal to about three shillings per inhabitant.

Production and industry.

Minerals.—About 32,000 persons find employment in the goldfields, and the quantity of gold won in 1900 was 807,407 oz., valued at £3,190,940, as against 854,500 oz., valued at £3,353,000 in 1899. The yield has increased considerably of late years, and the return for 1899 was only once exceeded during the preceding twenty-three years. Up to the close of 1900 the total value of gold won from the first discovery in 1851 was £256,984,830. No other metallic minerals are systematically worked, although many valuable deposits are known to exist. Brown coal, or lignite, occurs extensively, and attempts have frequently been made to use the mineral for ordinary fuel purposes, but without much success. Black coal is now being raised in increasingly large quantities, and is superseding the New South Wales coal to a certain extent, the exports of which to Victoria having fallen from 954,277 tons in 1894 to 866,895 tons in 1900. The principal collieries are the Outtrim Howitt, the Coal Creek Proprietary, the Jumbunna, and the Korumburra, all in the Gippsland district. The annual production of coal exceeds 260,000 tons, nearly all of which is locally consumed.

Agriculture.—Judged by the area under tillage, Victoria ranks first among the states of the Australian group. The area under crop in 1901 was 3,810,413 acres, compared with 2,116,000 acres in 1891, and 1,435,000 acres in 1881. Wheat-growing claims the chief attention, 1,754,417 acres being under that cereal in 1901, the area of land devoted to other crops being as follows: maize, 10,020 acres; oats, 329,150 acres; other cereals, 41,548 acres; hay, 659,239 acres; potatoes, 40,058 acres; vines, 28,592 acres; orchards and gardens, 58,807 acres; and other crops, 888,582 acres, of which 681,816 acres were in fallow when the returns were collected. The hay crops are chiefly wheat and oats. Victorian wheat is of exceptionally fine quality, and usually commands a high price in the London market. The average yield per acre is about 8½ bushels. The yield of oats is about 20½ bushels per acre, and of barley about 19 bushels, and of potatoes 3½ tons. Great progress has been made in the cultivation of the grape vine, and Victoria now produces about one-third of the wine made in Australia.

Live Stock.—The number of sheep on the 31st March 1901 was 10,841,790. The quality of the sheep is steadily improving, and "Port Phillip" commands a higher price than any other Australian wool in the London market. Systematic attention to stock has brought about an improvement in the weight of the fleece, and careful observations show that between 1861 and 1871 the average weight of wool per sheep increased about one-third; between 1871 and 1881 about one pound was added to the weight per fleece, and there has been a further improvement since the year named. The following were the number of sheep depastured at the dates named: 1861, 6,240,000; 1871, 10,002,000; 1881, 10,267,000; 1891, 12,928,000; and 1901, 10,841,790. The horses number 392,237, the swine 350,370, and the horned cattle 1,602,384; of these last 521,612 are dairy cows. Butter-making has greatly increased since 1890, and a fairly large export trade has arisen. In 1900 over 55½ million ℔ of butter were made, 4,284,000 ℔ of cheese, and over 13 million ℔ of bacon and hams. Victorian dairy produce is of excellent quality.

Manufactures.—There has been a good deal of fluctuation in the amount of employment afforded by the factories, as the following figures show: hands employed, 1885, 49,297; 1890, 56,639; 1893, 39,473; 1895, 46,095; and 1900, 64,207. Of the hands last named, 45,794 were males, and 18,413 females. The total number of establishments was 3097, and the horse-power of machinery was 43,659, of which 33,410 horse-power was actually used. The value of machinery was returned at £4,711,000, and of land and buildings, £7,184,000. The majority of establishments are small, but there are, nevertheless, some of large size. There were in 1900 153 employing from 50 to 100 hands, and 107 over one hundred hands.

Trade.

Excluding the coastal trade, the tonnage of vessels entering Victorian ports in 1900 was 2,929,389, or about 2½ tons per inhabitant. The imports in the same year were valued at £18,301,811, and the exports at £17,442,552. These figures represent £15 6s. 8d. and £14 12s. per inhabitant respectively. According to the customs returns the domestic produce exported was valued in 1900 at £13,918,556; in 1891 the value was £13,026,426, and in 1881 £12,480,567. The comparatively small increase over the period named is due mainly to the large fall in prices of the staple articles of local production. There has, however, been some loss of trade due to the action of the New South Wales Government in extending its railways into districts formerly supplied from Melbourne. The principal articles of local production exported during 1900, with their value, were as follows: butter, £1,489,548; gold (coined and bullion), £4,122,061; wheat, £700,814; frozen mutton, £107,747; frozen and preserved rabbits and hares, £183,929; sheepskins, £99,735; wool, £3,422,704; horses, £250,385; tallow, £172,397; oats, £257,899; flour, £196,899; hay and chaff, £316,352; leather, £311,239. As the total value of gold won during 1900 was only £3,190,940, part of the gold included in the amount stated in the foregoing list was not of local production, although classified as such. The customs returns show that the value of Victorian produce and manufacture exported in 1900 was £13,918,556, and the re-export trade £3,503,996. It is probable, however, the re-export trade was larger than the figures seem to indicate. The bulk of the trade passes through Melbourne, the imports in 1900 at that port being £15,351,819, and the exports £16,188,595.

Communications.

Railways.—The railways have a total length of 3238 miles, and the cost of their construction and equipment, up to 30th June 1901, was £40,145,404; this sum was obtained by raising loans, mostly in London, on the security of the general revenues of the state. In 1901 the gross railway earnings were £3,337,797, and the working expenses £1,984,796, so that the net earnings amounted to £1,353,001, which sum represents a little over 3 per cent. on the capital cost. The gross earnings per train mile were 6s. and the working expenses 3s. 7d. The management of the railways is in the hands of a single commissioner, and, as in New South Wales, all proposals to construct new lines are submitted to a committee selected from both Houses of Parliament. This committee takes evidence as to the suitability of the route proposed for any new line, the probable cost of its construction, and its financial prospects, and according to the weight of the evidence advises Parliament to adopt or reject the scheme proposed.

Posts and Telegraphs.—Victoria had a length of 6772 miles of telegraph line in operation in 1900; there were about 830 stations, and the business done was represented by 1,993,000 telegraphs. The post offices, properly so called, were over 1600 in number, and 66½ million letters and postcards, 21 million newspapers, and 11 million packets passed through them. The postal service is carried on at a slight profit, as the revenue in 1900 was £625,761, and the expenditure £608,875. Telephones are widely used; in January 1901 the length of telephone wire in use was 16,750 miles, and the number of telephones 5136, bringing in a revenue of £53,300 per annum.

Banking.

Melbourne is the headquarters of several of the principal banking companies operating in Australia, and was until recent years, if it be not so still, the financial centre of the colonies. At the end of 1900 the banks of issue had liabilities to the extent of £31,895,571, and assets of £41,755,928. The capital employed by them in their business was, therefore, £9,860,357. The principal items amongst the liabilities were: notes in circulation, £963,447; deposits bearing interest, £18,373,300; and deposits not bearing interest, £12,264,985. The chief assets were: coin, £7,352,135; bullion, £425,721; landed property, £2,800,419; notes and bills of other banks, £328,006; balances due from other banks, £237,114; and advances, discounts, and other debts due to the banks, £30,612,533. The money in deposit in the savings banks amounted to £9,110,793, to the credit of 375,070 depositors. The total sum on deposit in the state was, therefore, £39,749,078.

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(T. A. C.)

Victoria, the capital of the province of British Columbia, Canada, situated near the south-east corner of Vancouver Island. Its estimated population is 24,000, comprising a great variety of nationalities, including a large number of Chinese, and a small but increasing proportion of Japanese. With the exception of the handsome legislative buildings (opened 1899) and the post office, the city has few buildings of architectural pretensions. The city owns its waterworks and street-lighting plant. There are two hospitals, one managed by the nuns of the Roman Catholic church, a city isolation hospital, and a marine hospital, supported by the Canadian Government. On one of the islands of the Strait of Georgia is a leper hospital, the inmates of which are at present exclusively Chinese. There are churches of all denominations in the city, and a number of graded schools. The Japan and China steamers, and those of the Australian line, call at Victoria, and the headquarters of the British Pacific squadron is at Esquimalt, a fine harbour about 3 miles west of Victoria, and connected with it by an electric railway. This harbour, though spacious, is not much used by merchant vessels, being almost entirely a naval port. It is provided with a large dry-dock, and is defended by fortifications of modern type. There is a naval hospital and barrack for the garrison. There are daily steamers carrying passengers, mails, &c., between Victoria and the city of Vancouver as well as a daily service to ports on Puget Sound, in the State of Washingson, and a fortnightly steamer to San Francisco. A large part of the goods destined for points in the Yukon Territory, the Atlin district of British Columbia, the northern fishing and mining districts, and the sparsely settled islands in the Strait are shipped at Victoria. Until recently only ships drawing about 17 feet of water could call, but by the construction of a wharf at the entrance of the harbour, the port has been made available to the largest vessels. A large part of the wholesale business of the province is done in Victoria, and nearly all the principal banks of Canada have branches in the city.

Victoria Land. See North-West Territories.

Victoria Nyanza, the largest lake in Africa, lying between about 0° 25′ N. to 3° S. and 31° 5′ to 34° 52′ E. It is the second in size of the fresh-water lakes of the world, and has probably an area of 25,000 to 26,000 square miles, but as the outline is still imperfectly mapped, no near estimate is yet possible. The most important alteration of its contours is due to the discovery by Stanley in 1889 of a large gulf to the south-west, since named Emin Pasha Gulf, the existence of which had been before masked by the large islands which lie across its mouth. Beyond these it extends some 35 miles to the south. As now delineated the lake has roughly the form of a parallelogram, of which the length is about 200 miles and the average breadth 130 miles, the longer axis running from south-south-west to north-north-east. It is thus found to be somewhat longer and considerably narrower than had been first supposed, the whole eastern coast having been shifted some 20 miles to the west as compared with Stanley's delineation in 1875. A modification on a point of detail was introduced by the discovery in 1892 of an unsuspected bay on this coast in 2° N. It was made by Dr O. Baumann, whose name it has since borne. In the north-east a survey has more recently been carried out by Commander Whitehouse, which has for the first time revealed the true contours of the nearly land-locked Kavirondo Bay, formerly known as Ugowe Bay, the latter name being found to apply more correctly to a smaller bay to the north. The extreme west and east points are now placed in 31° 50′ and 34° 52′ E. respectively. According to the trigonometrical survey of Captain G. E. Smith, R.E., the altitude of the lake is 3775 feet.

Coasts.

Victoria Nyanza fills a wide depression in the extensive series of crystalline formations which occupy a large area between the central and eastern rift valleys. The shores are still imperfectly known, especially on the east. The irregular northern coasts with the associated islands have been surveyed more or less accurately by officials of the Uganda protectorate, and those to the south (in part) and west (south of 1° S.) by various German officers and missionaries, especially Captain Herrmann. This officer well describes the general structure of the country bordering the west coast, which is intimately connected with the form of the coast-line, here running in an unusually straight line from north-north-east to south-south-west. The whole region is formed by a succession of elongated blocks (separated by depressions), composed of clay slates and quartzites elevated to a considerable height above the granite and gneiss found farther south. The actual coast-line may once have formed a chain of islands at a time when the depression to the west was occupied by the lake water; while the present line of islands, running parallel to the coast, would eventually form the coast-line were the retreat of the water to be continued. A survey of the island of Ukerewe, which has somewhat modified its outline, has also been made by Captain Herrmann. The island is 25 miles long with a maximum breadth of about 12 miles, and its whole interior consists of a wooded, hilly country, quite uninhabited, rising to a height of 650 feet above the lake. The Sesse archipelago, at the opposite corner of the lake, was in part explored in 1893 by Father Brard, who found that the western half is formed of a single, narrow island of very irregular shape, almost cut in two near the middle at a spot where canoes can be dragged from one shore to the other. The island, like most of the group, has a number of villages, and has for some time been the site of a Catholic mission station, while a Government station (Fort Stanley) has been more recently established. Bukasa, the largest island in the east of the group, has a station of the Church Missionary Society.

The lake and the Nile system.

The exact part played by Victoria Nyanza in the economy of the Nile is still a matter of discussion, some holding that the lake itself can alone be regarded as the source of the river, while others seek this in one or other of the head-streams of the Kagera, which enters from the west, in 0° 58′ S. The Kagera is by far the largest feeder of the lake, and the mountainous region from which it comes has a much heavier rainfall than the rest of the catchment area, with the exception of a small district to the north-east, near Mount Elgon. The amount of precipitation over its basin is thus probably greater than that over the whole surface of the lake, which is, besides, counterbalanced by the evaporation from the same. The streams which enter on the south and south-east have been found to be quite insignificant except at the height of the rains, but those from the north-east are of more consequence, the principal being the Mori, which rises in the forests of the Mau plateau, and in its lower course is a copious stream 300 paces wide; and the Nzoia, which derives its water-supply from the Guas

Ngishu and Nandi plateaux and the southern slopes of Mount Elgon.

Fluctuations of level.

A considerable amount of information has been obtained of late years regarding the fluctuations of the lake level, which seem to be of three if not four distinct kinds. Any secular shrinking of the lake[1] in common with the lakes of Central Africa generally must be so gradual as to have no practical importance, but a periodic variation with phases recurring at intervals of eighteen to twenty-five years has been considered probable by some travellers, and would seem to be attributable to variations of rainfall. About 1878–81 the water seems to have been at its highest, but soon afterwards a fall set in which had, however, given place to a renewed rise in 1892. Since this date the movements have been irregular and of no great extent, a low level in 1900 having been followed by a comparatively high one in 1901. The extent of the fluctuation has been variously estimated at from 5 to 10 feet. Besides this, an annual and even a daily fluctuation has been noticed, and observations by which the former of these may in time be elucidated were inaugurated in 1896 at stations on the north shore of the lake.[2] They do not show an entire agreement with variations of rainfall in the districts bordering the lake, nor do the periods of highest and lowest level fall at the same portions of different years. The rainfall at the sources of the tributary streams of course exercises an influence, as also does the régime of the winds which tend to pile up the water at different parts of the lake. The extreme yearly range observed down to the end of 1900, disregarding one influenced by local causes, was 18·5 inches, and the greatest difference between the highest and lowest months, 16·4 inches. But between November 1900 and June 1901 a difference of 42 inches was recorded. The winds may also be the cause of the daily variations of level, which on Speke Gulf have been found to reach 20 inches; but this may also partake of the character of a "seiche." Currents setting towards the north or north-west have been observed in various parts of the lake.

Political, &c.

By the Anglo-German agreement of 1890 the shores of the lake were divided between Great Britain and Germany, the boundary cutting the lake on both sides in 1° S.; and stations have since been established at many points. A small steamer (the *Ruwenzori*) was launched on the lake by a Zanzibar firm in 1896, and has since done much service; while in 1900 a steamer (the *William Mackinnon*) built in Glasgow at the instance of Sir W. Mackinnon, and afterwards taken over by Government, made her first trip on the lake. There are also two small launches, one belonging to the German administration, the other to that of Uganda. The chief trade on the lake is, however, still done by dhows, which bring goods from German territory to Uganda across the lake.

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Vienna (German, *Wien*), the capital of Austria, or (to use the correct official title) "the kingdoms and countries represented in the Reichsrath," and the largest city of Austria-Hungary. By the removal of the second or outer girdle of fortifications, which formed the boundary for the city imposts, and the incorporation in 1891, either wholly or in part, of about fifty suburban districts, the area of Vienna was more than trebled (from 21⅓ to 69 English square miles) while over half a million was added to the population. The number of its wards was thus increased from ten to nineteen, which, in March 1900, was converted into twenty by the creation of a new district out of part of the old ward of Leopoldstadt. The new districts are: Simmering, Meidling, Hietzing, Rudolfsheim, Fünfhaus, Ottakring, Hernals, Währing, Döbling, and Brigittenau. In June 1902 preliminary arrangements were made for the further incorporation of the small manufacturing town of Floridsdorf (Vienna terminus of the projected Danube–Oder canal) and four adjoining communes on the left bank of the Danube. This new ward would increase the area of the city by about one-fifth and add nearly 50,000 to the population.

A distinguishing feature of the new city of Vienna is the unusually large proportion of woods, pastures, meadows, vineyards, and arable land within its bounds. These form 58½ per cent. of its total area, private gardens, parks, and open spaces occupying a further 13 per cent. It now extends along the right bank of the Danube from the historic and legendary Kahlenberg to the point where the Danube canal rejoins the main stream, being rounded off liberally on the other side by a considerable stretch of land which is rather rural than suburban in character. The object of these extensive annexations was to provide for the growth of the city in a symmetric and orderly fashion, by bringing the outlying districts within the scope of the regulations in force in the capital, both as regards the laying out of streets and the building of houses. While from the standpoint of population it takes the fourth place among European capitals, Vienna covers nearly three times as much ground as Berlin, which occupies the third place. But the bulk of the inhabitants being packed into a comparatively small portion of this area the working classes suffer greatly from overcrowding, and all sections of the community from high rents.

Population.—In 1800 the population of the old districts was 231,050; in 1840, 356,870; in 1857, 476,222 (or with suburbs, 587,235); in 1869, 607,514 (with suburbs, 842,951); in 1880, 704,756 (with suburbs, 1,090,119); in 1890, town and suburbs, 1,364,548; and in 1900, 1,662,269, including the garrison of 26,629 men. The marriage-rate (1898) was 10·17 per 1000; in 1887, 8·79 per 1000. The birth-rate, 34·84 per 1000, of which 33·05 per cent. were illegitimate (a diminishing ratio—in 1887, 42·7 per cent. of the births were illegitimate); and the death-rate was 20·35 per 1000, likewise diminishing. Some 4000 children are annually legitimized by the subsequent marriage of their parents. Owing to a series of sanitary reforms, including an important extension of the drainage system, and presumably also to a larger influx of persons in the prime of life, the mortality has undergone a steady diminution. Between 1830 and 1898 it sank from 46·6 to 20·35, or (excluding the deaths of strangers) to 19·63 per 1000. The decline in the death-rate from consumption, the most fatal disease of the Austrian capital, was equally satisfactory, falling from 63·76 per 10,000 of the population in 1878 to 37·7 in 1893. The permanent population (some 45·5 per cent. are born in the city) is recruited from all parts of Austria, and indeed of the entire monarchy. Previous to the loss of the Italian provinces, a considerable proportion came from Italy (30,000 in 1859), including artists, members of the learned professions, and artisans who left their mark on Viennese art and taste. The Italian colony now numbers about 2500 (chiefly navvies and masons), in addition to some 1400 Austrian subjects of that nationality. At present the largest and most regular contributions to the population of Vienna come from the Czech provinces of Bohemia and Moravia, next in importance being those from Lower Austria and Styria. This steady and increasing influx of Czechs is gradually infusing a large proportion of Slav blood in what Bismarck (in 1864) described as the German capital of a Slav empire. Formerly the Czech labourers, artisans, and domestic servants who came to Vienna were somewhat ashamed of their mother-tongue, and anxious to conceal that evidence of their origin as speedily as possible. The revival of the nationality agitation has produced a marked change in this respect. The Czech immigrants, attracted to Vienna as to other German towns by the growth of industry, are now too numerous for easy absorption, which is further retarded by their national organization, and the provision of separate institutions, churches, schools (thus far private), and places of resort. The consequence is that they take a pride in accentuating their national characteristics, a circumstance which threatens to develop into a new source of discord. In 1900 the population included 1,386,115 persons of German nationality, 102,974 Czechs and Slovaks, 4346 Poles, 805 Ruthenians, 1329 Slovenes, 271 Serbo-Croatians, and 1368 Italians, all Austrian subjects. To these should be added 133,144 Hungarians, 21,733 natives of Germany (3782 less than in 1890), 2506 natives of Italy, 1703 Russians, 1176 French, 1643 Swiss, &c. Of this heterogeneous population 1,461,891 were Roman Catholics, the Jews coming next in order with 146,926 (75,000 in 1880 and 118,495 in 1890). Protestants of the Augsburg and Helvetic Confessions numbered 54,364 (26,500 in 1880, 41,943 in 1890); members of the Church of England, 490 (531 in 1890); Old Catholics, 975 (1264 in 1890); members of the Greek Orthodox Church, 3674; Greek Catholics, 2521; and Mahommedans, 889. Several other creeds are represented by small numbers ranging from 5 to 100. Those returned as of no religion amounted to 2772, an increase of 638 in the decennial period.

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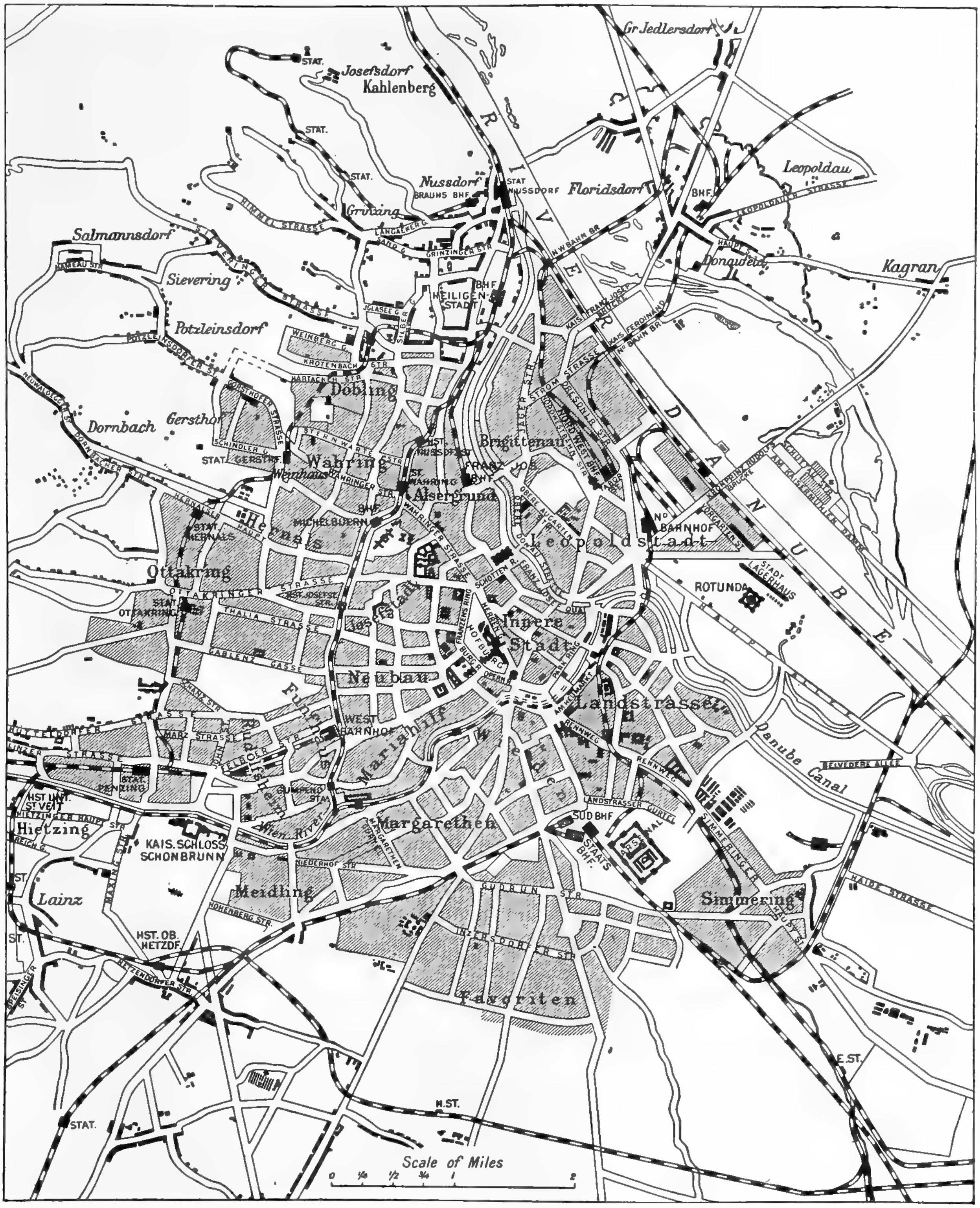
[1] Supposed by some to be indicated by the presence of recent fresh-water shells at some distance from the present shores, especially towards the south, but this might be accounted for by an elevation of the land.

[2] See British Association Reports on the Climatology of Africa, 1897–1901.



Plan of Vienna.

Vienna enjoys autonomy for communal affairs, but is under the control of the Governor and the Diet of Lower Austria, while the election of the Chief Burgomaster requires the sanction of the Sovereign, advised by the Prime Minister. The long struggle between the municipality and the Austrian Ministry arising out of the refusal to sanction the election of Dr Lueger, the anti-Semitic leader and champion, recalls in some respects the Wilkes incident in London. In this instance the ultimate success of the Corporation greatly strengthened the Obscurantist and reactionary element throughout Austria. In comparatively few years the anti-Semites, with Clerical and reactionary support and by means of vigorous agitation and obstruction, had routed the Liberals and converted an insignificant minority into a two-thirds majority. Since their accession to power their share in great public works has been in the main confined to the execution of the schemes of their predecessors, to the erection of new municipal gas works at an excessive cost, the introduction of electric traction on the tramway lines, and the building of a new theatre. The most important improvement of the last decade of the 19th century was the realization of the metropolitan railway scheme, eagerly advocated as long ago as 1867. In this great work two reforms have been combined. It had long been recognized as of urgent necessity, on sanitary and other grounds, to regulate the river Wien, which, at ordinary times little more than an ill-smelling brook at one side of an immense bed, was occasionally converted into a formidable and destructive torrent. Half the bed of the river is now walled off for the new railway, while the other half for the reception of the stream has been deepened, and a portion of it within the town has been arched over. A beginning has thus been made for a new and magnificent avenue. This great work, begun in February 1893, involved the construction of huge reservoirs and the solution of some difficult engineering problems. By the latter half of 1899 it had proceeded so far that the new railway enclosed the more densely populated parts of the town and formed a connexion between the various main lines. The completion in 1901 of the underground section along the Danube canal, which was carried out in conjunction with a further development of the main drainage system, closed the circle. Another public work of considerable immediate value and perhaps of still greater future possibilities is the conversion of the entire Danube canal into a harbour by the construction of a lock at its entrance. This gives the low-lying parts of the city (Leopoldstadt, Landstrasse, and Alsergrund) almost complete security from inundation, while the increased accommodation in the "winter harbour" at the other end of the canal would naturally promote trade in case the river navigation were to receive a much-needed impetus from the realization of the proposed Danube–March–Oder canal.

Relief of the congestion in the inner town has been obtained by the widening of the main arteries of traffic, a work which has also been vigorously pursued in the outer radial and cross streets.

There have been few additions to the number of important public buildings, excepting the completion (according to Fischer von Erlach's plans) of the façade of the Hofburg, and of one wing of the adjoining palace facing the Ring, which was intended for the late Crown Prince Rudolph. There has, however, been great activity in the construction of new streets, with the palatial tenements and business houses characteristic of Vienna. In this work of extension and reconstruction, as well as in the stations of the metropolitan railway, the architects of the so-called "Secessionist" school, and their more orthodox rivals who cultivate the traditional Vienna baroque style, have indulged in a liberal display of open-air mural decoration in relief, colour, and even gilding. The result is usually novel, frequently attractive, and at the worst escapes the deadly monotony which is one of the pitfalls of wholesale reconstruction elsewhere. There have also been erected several ecclesiastical structures, including a Russian church and a Hebrew temple, and mention should be made of a number of new bridges, theatres, baths, school-houses, parks, monuments, an extension of the water-supply, &c. There are now eleven theatres in all.

The cost of the transformation of Vienna, which has been in progress since 1858, cannot be said to have fallen heavily on the population. Great part of the burden has been borne throughout by the "City Extension Fund," realized from the utilization of the ground formerly occupied by the fortifications and glacis. The subsequent regulation of the former suburbs has to a large extent covered its own expenses through the acquisition by the town of the improved area. It must not be regarded as having contributed to the growth of Socialism in the capital, which is rather a consequence of the increase of factories, foreign influence, and the political confusion of recent years.

Austrian Socialism is of German origin. As a political party of any moment the Socialists are of recent date. Previous to 1889 (the first Congress of the party at Hainfield) the hesitating attempts at the organization of the working classes were numerically of little significance, and could scarcely be described as really Socialistic, such societies as existed being rather of the nature of mutual improvement associations and trade unions. A large number of these were subsequently converted to violent anarchism (1882–84) through the influence and teachings of the notorious Johann Most. The movement practically ceased for a few years in consequence of the severe repressive measures that followed a series of anarchist outrages in Vienna. On its revival the party adopted the tactics of German Socialism, and directed its energies mainly towards an extension of the suffrage. The only feature in the condition of Vienna specially calculated to promote Socialism is the high rents and the dearness of meat and certain other necessaries. This is attributed chiefly to inadequate communications and markets, and to the heavy taxation of house rents, averaging about 45 per cent. of the receipts. The nationality and anti-Semitic agitation of recent years has afforded the Vienna Socialists a great opportunity. They have made many converts among the routed remnants of the old Liberal party and the badgered Jewish community. The growing strength of the Socialist party is manifest in the better organization of the working classes, and the increasing importance of strikes in Vienna and elsewhere.

The municipal finance has on the whole been sound, and notwithstanding the extra burdens assumed on the incorporation of the suburbs, the equilibrium of the communal budget was maintained up to the fall of the Liberal administration. In spite of short-sighted parsimony in the matter of schools, &c., and increased resources through the allocation to the municipality of a certain percentage of new state and provincial taxation, their anti-Semitic successors have been unable to avoid a deficit, and have been obliged to increase the rates. But the direct damage done in this and other ways would seem to be less than that produced by the mistrust they inspired for a time among the propertied classes, and the consequent paralysing of enterprise. Their violent anti-Magyar attitude has driven away a certain amount of Hungarian custom, and helped to increase the political difficulties of the cis-Leithan Government. From 1887 to 1891, the last financial year prior to the incorporation of the suburbs, the total annual revenue, ordinary and extraordinary, varied from £1,748,118 to £1,800,968. There was a small surplus each year. In 1892 the revenue rose to £2,562,615, and left a surplus of over £50,000. In 1894, the last year of the Liberal administration, the ordinary receipts amounted, in round numbers, to £2,672,800 and the extraordinary to £881,200; the ordinary expenditure being £2,691,940 and the extraordinary £708,180. In 1897, the first complete financial year of the anti-Semitic administration, the ordinary receipts were £2,976,350 and the extraordinary £1,146,800. The ordinary expenditure was £2,770,930 and the extraordinary £1,281,440. In 1900 the ordinary receipts were £4,060,840 and the extraordinary £510,800. The ordinary expenditure amounted to £3,905,780 and the extraordinary to £828,420. This great increase within a few years is accounted for chiefly by a number of loans raised by the new administration (60,000,000 crowns in 1896, 30,000,000 in 1900, and 285,000,000 crowns in 1902, making a grand total of £15,625,000) for the erection of municipal gas works, the municipalization of the tramway system, and the introduction of electric traction, the establishment of electric works, an extension of the water-supply, and other purposes. The portion of these loans annually expended is included in the municipal balance sheet, which also comprise payments for older communal liabilities. It is too soon to form a final judgment on the soundness of these large investments and the general financial policy of the present municipal council.

During the decade 1890–1900 there was uninterrupted progress in all branches of education, including the highest; and a hopeful beginning has been made in that form of popular culture represented in England by university extension lectures and similar institutions. Significantly enough, this movement is opposed by the anti-Semites and their Clerical patrons. Women have been admitted to the University (March 1897), which is now attended by over 6600 students, of whom nearly a hundred are female. There has been a diminution in the number of Hungarian and foreign students, as also in the number of those attending the theological faculty. There is a large and steady increase in the attendance at the Polytechnic, which rose from 929 in 1892–93 to 1711 in 1898–99. The total attendance at the University and other high schools is about 10,000. There are now some fifty secondary schools and gymnasia, and 400 elementary schools (with 177,889 pupils), besides a large number of new establishments for special and technical education, including 150 (in addition to the celebrated Conservatory of Music and Dramatic Art) devoted to musical and theatrical training. In music Vienna more than maintains her traditional high position, and attracts students and amateurs from all parts of the world. There are 34 daily publications, and a total of about 1200 periodicals of all kinds, mostly in the German language. The press censorship confiscations vary from fifty to sixty per annum. The abolition of the newspaper stamp (December 1899) has not yet led to any great increase of journalistic enterprise.

Vienna is still the largest commercial and industrial centre in the monarchy. In 1890 it contained 5086 factories, employing 125,000 hands, in addition to 28,134 smaller concerns. The principal articles of commerce are: corn, flour, wine, seeds, cattle, coal, wood, iron, sugar, petroleum, oils, textiles, clothing, shoes, gloves and other leather goods, turnery, books and artistic publications. Its staple productions are steel, tin and bronze wares, machinery, musical and other instruments, pottery, bent and carved wood furniture, *objets d'art*, jewellery and articles in the precious metals, clothing, millinery, &c., and artistic products generally. Much of its recent prosperity is due to the State-fostered activity in the building trade.

The foregoing facts and figures tend to show that Vienna has become a healthier, handsomer, and more commodious town. Concurrently with these improvements, however, it has lost a great deal of its secular repute for being the gayest capital in Europe. Moreover, although there may not be an absolute decline in its prosperity, it has unquestionably failed to keep pace with its neighbours and rivals, the capitals of the German empire and of Hungary. From this standpoint it may be described as a Switzerland which has continued to develop all its domestic resources, material and moral, during a period marked by a steady diminution in the number of its wealthiest visitors. While Berlin and Budapest have made the most rapid progress of all European cities, having multiplied their population by nine in the period 1800–90, Vienna—even including the extensive annexations of 1891—has only increased its sevenfold. Many causes have conspired to this end, but most of them date from the years 1859, 1866, and 1867. The combined effect of these successive blows, aggravated by the long period of decentralizing policy from Taaffe to Badeni, is still felt in the Kaiserstadt. The gaiety of Vienna had for centuries depended on the brilliancy of its Court, recruited from all parts of Europe, including the nobility of the whole empire, and on its musical, light-hearted, and contented population. Even before it fell from its high estate as the social centre of the German-speaking world, it had suffered severely by the crushing defeats of 1859 and the consequent exodus of the Austrian nobles. These were held responsible for the misfortunes of the army, and to escape the atmosphere of popular odium retired to their country seats and the provincial capitals. They have never since made Vienna their home to the same extent as before. The change thus begun was confirmed by the exclusion of Austria from the German Confederation and the restoration of her constitution to Hungary, events which gave an immense impetus to the two rival capitals. Thus within eight years the range of territory from which Vienna drew its former throngs of wealthy pleasure-seeking visitors and more or less permanent inhabitants—Italian, German, and Hungarian—was enormously restricted, and it woke to find itself merely the capital of a reduced and circumscribed Austria, situated on its extreme eastern border. Since then Vienna has benefited largely by the enlightened efforts of its citizens and the exceptional opportunities afforded by the removal of the fortifications. But a decline of its importance, similar to that within the larger sphere which it influenced prior to 1859, has continued uninterruptedly within the Hapsburg dominions up to the present day. Its commercial classes constantly complain of the increasing competition of the provinces, and of the progressive industrial emancipation of Hungary. The efforts of the Hungarians to complete their social and economic, no less than their political, emancipation from Austria and Vienna have been unremittingly pursued. The formal recognition of Budapest as a royal residence and capital in 1892, and the appointment of independent Hungarian court functionaries in November 1893, mark new stages in its progress. It would no longer be correct to speak of Vienna as the capital of the dual monarchy. It merely shares that distinction with Budapest. The former Vienna residences of the Hungarian aristocracy are now let as tenement houses, the Magyar nobles having built themselves new palaces in their own capital, where they spend the most of their time. In a less degree the provincial capitals of Austria have likewise progressed at the expense of Vienna. The aristocracy and wealthy classes tend to spend more of their time at home and in foreign travel, Vienna no longer offering the special attractions they were accustomed to find there. Since 1890 there has been a further progressive decline in the number of aristocratic entertainments and of those public fêtes that depend for success upon the support of the upper classes.

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refusal to sanction the election of Dr Lueger, the anti-Semitic leader and champion, recalls in some respects the Wilkes incident in London. In this instance the ultimate success of the Corporation greatly strengthened the Obscurantist and reactionary element throughout Austria. In comparatively few years the anti-Semites, with Clerical and reactionary support and by means of vigorous agitation and obstruction, had routed the Liberals and converted an insignificant minority into a two-thirds majority. Since their accession to power their share in great public works has been in the main confined to the execution of the schemes of their predecessors, to the erection of new municipal gas works at an excessive cost, the introduction of electric traction on the tramway lines, and the building of a new theatre. The most important improvement of the last decade of the 19th century was the realization of the metropolitan railway scheme, eagerly advocated as long ago as 1867. In this great work two reforms have been combined. It had long been recognized as of urgent necessity, on sanitary and other grounds, to regulate the river Wien, which, at ordinary times little more than an ill-smelling brook at one side of an immense bed, was occasionally converted into a formidable and destructive torrent. Half the bed of the river is now walled off for the new railway, while the other half for the reception of the stream has been deepened, and a portion of it within the town has been arched over. A beginning has thus been made for a new and magnificent avenue. This great work, begun in February 1893, involved the construction of huge reservoirs and the solution of some difficult engineering problems. By the latter half of 1899 it had proceeded so far that the new railway enclosed the more densely populated parts of the town and formed a connexion between the various main lines. The completion in 1901 of the underground section along the Danube canal, which was carried out in conjunction with a further development of the main drainage system, closed the circle. Another public work of considerable immediate value and perhaps of still greater future possibilities is the conversion of the entire Danube canal into a harbour by the construction of a lock at its entrance. This gives the low-lying parts of the city (Leopoldstadt, Landstrasse, and Alsergrund) almost complete security from inundation, while the increased accommodation in the "winter harbour" at the other end of the canal would naturally promote trade in case the river navigation were to receive a much-needed impetus from the realization of the proposed Danube–March–Oder canal.

Relief of the congestion in the inner town has been obtained by the widening of the main arteries of traffic, a work which has also been vigorously pursued in the outer radial and cross streets.

There have been few additions to the number of important public buildings, excepting the completion (according to Fischer von Erlach's plans) of the façade of the Hofburg, and of one wing of the adjoining palace facing the Ring, which was intended for the late Crown Prince Rudolph. There has, however, been great activity in the construction of new streets, with the palatial tenements and business houses characteristic of Vienna. In this work of extension and reconstruction, as well as in the stations of the metropolitan railway, the architects of the so-called "Secessionist" school, and their more orthodox rivals who cultivate the traditional Vienna baroque style, have indulged in a liberal display of open-air mural decoration in relief, colour, and even gilding. The result is usually novel, frequently attractive, and at the worst escapes the deadly monotony which is one of the pitfalls of wholesale reconstruction elsewhere. There have also been erected several ecclesiastical structures, including a Russian church and a Hebrew temple, and mention should be made of a number of new bridges, theatres, baths, school-houses, parks, monuments, an extension of the water-supply, &c. There are now eleven theatres in all.

The cost of the transformation of Vienna, which has been in progress since 1858, cannot be said to have fallen heavily on the population. Great part of the burden has been borne throughout by the "City Extension Fund," realized from the utilization of the ground formerly occupied by the fortifications and glacis. The subsequent regulation of the former suburbs has to a large extent covered its own expenses through the acquisition by the town of the improved area. It must not be regarded as having contributed to the growth of Socialism in the capital, which is rather a consequence of the increase of factories, foreign influence, and the political confusion of recent years.

Austrian Socialism is of German origin. As a political party of any moment the Socialists are of recent date. Previous to 1889 (the first Congress of the party at Hainfield) the hesitating attempts at the organization of the working classes were numerically of little significance, and could scarcely be described as really Socialistic, such societies as existed being rather of the nature of mutual improvement associations and trade unions. A large number of these were subsequently converted to violent anarchism (1882–84) through the influence and teachings of the notorious Johann Most. The movement practically ceased for a few years in consequence of the severe repressive measures that followed a series of anarchist outrages in Vienna. On its revival the party adopted the tactics of German Socialism, and directed its energies mainly towards an extension of the suffrage. The only feature in the condition of Vienna specially calculated to promote Socialism is the high rents and the dearness of meat and certain other necessaries. This is attributed chiefly to inadequate communications and markets, and to the heavy taxation of house rents, averaging about 45 per cent. of the receipts. The nationality and anti-Semitic agitation of recent years has afforded the Vienna Socialists a great opportunity. They have made many converts among the routed remnants of the old Liberal party and the badgered Jewish community. The growing strength of the Socialist party is manifest in the better organization of the working classes, and the increasing importance of strikes in Vienna and elsewhere.

The municipal finance has on the whole been sound, and notwithstanding the extra burdens assumed on the incorporation of the suburbs, the equilibrium of the communal budget was maintained up to the fall of the Liberal administration. In spite of short-sighted parsimony in the matter of schools, &c., and increased resources through the allocation to the municipality of a certain percentage of new state and provincial taxation, their anti-Semitic successors have been unable to avoid a deficit, and have been obliged to increase the rates. But the direct damage done in this and other ways would seem to be less than that produced by the mistrust they inspired for a time among the propertied classes, and the consequent paralysing of enterprise. Their violent anti-Magyar attitude has driven away a certain amount of Hungarian custom, and helped to increase the political difficulties of the cis-Leithan Government. From 1887 to 1891, the last financial year prior to the incorporation of the suburbs, the total annual revenue, ordinary and extraordinary, varied from £1,748,118 to £1,800,968. There was a small surplus each year. In 1892 the revenue rose to £2,562,615, and left a surplus of over £50,000. In 1894, the last year of the Liberal administration, the ordinary receipts amounted, in round numbers, to £2,672,800 and the extraordinary to £881,200; the ordinary expenditure being £2,691,940 and the extraordinary £708,180. In 1897, the first complete financial year of the anti-Semitic administration, the ordinary receipts were £2,976,350 and the extraordinary £1,146,800. The ordinary expenditure was £2,770,930 and the extraordinary £1,281,440. In 1900 the ordinary receipts were £4,060,840 and the extraordinary £510,800. The ordinary expenditure amounted to £3,905,780 and the extraordinary to £828,420. This great increase within a few years is accounted for chiefly by a number of loans raised by the new administration (60,000,000 crowns in 1896, 30,000,000 in 1900, and 285,000,000 crowns in 1902, making a grand total of £15,625,000) for the erection of municipal gas works, the municipalization of the tramway system, and the introduction of electric traction, the establishment of electric works, an extension of the water-supply, and other purposes. The portion of these loans annually expended is included in the municipal balance sheet, which also comprise payments for older communal liabilities. It is too soon to form a final judgment on the soundness of these large investments and the general financial policy of the present municipal council.

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During the last quarter of the 19th century the number of textile establishments decreased from 120 to less than 30, but the production of fabrics doubled and the total value of the material, notwithstanding decline in price, rose from about £500,000 to over £750,000. The manufacture of woollen caps and gloves is carried on in several establishments, and gives employment to about 1000 persons. Population (1891), 21,033; (1901), 22,768.

Vienne, Haute-, a department of western France, watered by the river from which it is named.

Area, 2120 square miles. The population increased from 363,182 in 1886 to 374,212 in 1901. The births in 1899 were 9170, of which 532 were illegitimate; deaths, 7264; marriages, 3146. Though in 1896, 643 schools were attended by 58,000 pupils, more than 18 per cent. of the population was illiterate. The land under cultivation in 1896 amounted to 1,160,900 acres, of which only 701,480 acres were plough-land, the larger part of the rest being laid out in grass. The wheat grown in 1899 was valued at £521,100; rye, £578,450; buckwheat, £143,220; oats, £141,500; potatoes, £448,300; mangold-wurzel, £101,200; natural pastures and grass lands, nearly £903,000; hemp, £42,630; chestnuts, £47,760; apples, £28,000. The live-stock of 1899 included 8580 horses, 8652 asses, 241,200 cattle, 631,500 sheep—the second largest muster of sheep in France—194,800 pigs, and 12,700 goats. The principal mineral produced is kaolin, which supplies an important porcelain manufacture, having its seat at Limoges. There are also important paper-mills and nail factories. The population of Limoges, the capital, was (1901) 76,832.

Vierge, Daniel (1851-——), Spanish painter and draughtsman, was born in Madrid in 1851. He went to Paris in 1867 to seek his fortune, fired by the vivid energy of his national temperament. He became attached to the *Monde Illustré* in 1870, just before the Franco-Prussian war broke out, and, like other artists in the paper, came under the powerful influence of Edmond Morin, the first newspaper draughtsman in France who sought to impart to drawings for journals the character of a work of art. Vierge's earlier drawings, therefore, partake greatly of Morin's style; such are, "The Shooting in the Rue de la Paix," "The Place d'Armes at Versailles," "The Loan," "The Great School-fête of Lyons," "Anniversary of the Fight of Aydes," and "Souvenir of Coulmiers." Vierge lost no time in proving the extraordinary vigour and picturesqueness of his art. Apart from the contribution of his own original work, he was required by his paper to re-draw upon the wood, for the engraver, the sketches sent in by artist-correspondents, such as Luc Ollivier Merson in Rome and Samuel Urrabieta (Vierge's brother) in Spain. From 1871 to 1878 his individuality became more and more pronounced, and he produced, among his best-known drawings, "Christmas in Spain," "The Republican Meeting in Trafalgar Square," "Attack on a Train in Andalusia," "Feast of St Rosalia in Palermo," "In the Jardin d'Acclimatation," "The Burning of the Library of the Escurial, 1872," "Grasshoppers in Algiers," "Brigandage in Sicily," "Night Fête in Constantinople," "Episode of the Civil War in Spain," "Marriage of the King of Spain," and "The Bull Fight." About this time he illustrated with remarkable dash and skill Victor Hugo's *Année Terrible* (Michel Lévy, 1874, and Hugues, 1879), "1813" (Hugues, 1877), and *Les Misérables* (1882). His masterpiece of illustration is Michelet's *History of France* (1876), consisting of 26 volumes containing 1000 drawings. In 1879 he was drawing for *La Vie Moderne*, and then proceeded to illustrate *Pablo de Segovia.* While engaged upon this work he was attacked by paralysis in the right arm, but with characteristic energy and courage he set himself to acquire the necessary skill in drawing with the left, and calmly proceeded with the illustrations to the book. In 1891 he illustrated *L'Espagnole*, by Bergerat, and in 1895 *Le Cabaret des Trois Vertus.* In 1898 he held, at the Pelletan Gallery in Paris, an exhibition of his drawings for Chateaubriand's *Le Dernier Abencérage* ("The Last of the Abencerrages"), and in the following year a comprehensive exhibition of his work (including the illustrations to *Don Quixote*) at the Art Nouveau Gallery, also in Paris. In 1898 Vierge contributed to *L'Image*, a magazine devoted to the encouragement of engraving upon wood; and two years later, at the International Exhibition at Paris, he was awarded a Grand Prix. In 1902 he exhibited at the New Salon a scene from the Franco-Prussian war. The work of Vierge has also been seen in London, in an extensive exhibition held in the hall of Clifford's Inn.

See Roger Marx, *L'Image* (1898); Béraldi, *La Gravure au 19e siècle.*

Viersen, a town of Prussia, Rhine province, 11 miles by rail south-west from Crefeld, the seat of velvet, silk, plush, damask, cotton, and linen industries, dye-works, machine factories, tanneries, brickworks, &c. It has a 15th-century Roman Catholic parish church, and a new Evangelical church. Population (1885), 22,228; (1900), 24,797.

Vieuxtemps, Henri (1820-1881), Belgian violinist and composer, was born at Verviers, 20th February 1820. Until his seventh year he was a pupil of Lecloux, but when De Bériot heard him he adopted him as his pupil, taking him to appear in Paris in 1828. From 1833 onwards he spent the greater part of his life in concert tours, visiting all parts of the world with uniform success. He first appeared in London at a Philharmonic concert on 2nd June 1834, and in the following year studied composition with Reicha in Paris, and began the long series of works which are more highly appreciated by violinists than by any one else. From 1846 to 1852 he was solo violinist to the Tsar, and professor in the conservatorium in St Petersburg. From 1871 to 1873 he was teacher of the violin class in the Brussels Conservatoire, but was disabled by an attack of paralysis in the latter year, and from that time could only superintend the studies of favourite pupils. He died in Algiers, 6th June 1881. He had a perfect command of technique, faultless intonation, and a marvellous command of the bow; his staccato was famous all over the world, and his tone was exceptionally rich and full. In his playing and in his works there were occasional lapses from the ideal dignity of the highest art; but in his compositions there are often good ideas, as well as themes pleasing to the ear and passages of formidable difficulty.

(J. A. F. M.)

Vigan, the capital of the province of South Ilocos, Luzon, Philippine Islands, slightly north of the centre of the province, and a mile inland from its coast. Its people are industrious, and in addition to agriculture, devote themselves to fishing, brick-making, cabinet-making, and also to shipbuilding upon a small scale. Vigan is the residence of the bishop of Nueva Segovia, and its public buildings are among the finest to be seen in the Philippines outside of Manila. The language is Ilocano. Population, 19,000.

Vígfússon, Gúdbrandr (1828-1889), the foremost Scandinavian scholar of the 19th century, was born of a good and old Icelandic family in Breiðafjord in 1828. He was brought up, till he went to a tutor's, by his kinswoman Kristín Vígfussdottir, to whom, he records, he "owed not only that he became a man of letters, but almost everything." He was sent to the old and famous school at Bessastad and (when it removed thither) at Reykjavik; and in 1849, already a fair scholar, he came to Copenhagen University as a *bursarius* in the Regense College. He was, after his student course, appointed *stipendiarius* by the Arna-Magnæan trustees, and worked for fourteen years in the Arna-Magnæan Library till, as he said, he knew every scrap of old vellum and of Icelandic written paper in that whole collection. During his Danish life he twice revisited Iceland (last in 1858), and made short tours in Norway and South Germany with friends. In 1866, after some months in London, he settled down in Oxford, which he made his home for the rest of his life, only quitting it for visits to the great Scandinavian libraries or to London (to work during two or three long vacations with his fellow-labourer, F. Y. Powell), or for short trips to places such as the Isle of Man, the Orkneys and Shetlands, the old mootstead of the West Saxons at Downton, the Roman station at Pevensey, the burial-place of Bishop Brynjulf's ill-fated son at Yarmouth, and the like. He held the office of Reader in Scandinavian at the University of Oxford (a post created for him) from 1884 till his death. He was a Jubilee Doctor of Upsala, 1877, and received the Danish Order of the Dannebrog in 1885. He had many friends who valued his character and learning—as Professors Unger and Möbius; his distinguished fellow-countrymen Jón Sígurdson and Vilhelm Finnsen, and the Molièrist H. Larpent, the friend of his youth; and among Englishmen—Dean Liddell, "Bodley" Coxe, Dr Garth Wilkinson, Thomas and John Carlyle, Lord Sherbrooke, Lord Carnarvon, Sir Edmund Head, Sir G. W. Dasent, Arthur Lawrenson, James Sime, Bartholomew Price, the Dean of Durham, Mr G. Meredith, Dr Sweet, Mr James Bryce, Dr Rhys, Mr Gosse, Mr Moore, Professor Morfill, Dr Furnivall, Mr H. L. Ward, Professor Elton, Mr Sephton, and Mr H. M. Paget, who painted his portrait in 1888. Vígfússon died of cancer on 31st January 1889, after a short and painless illness, the first in his life, and was buried in St Sepulchre's Cemetery, Oxford, 3rd February. He was a spare but strong man, with a handsome and notable face; his hair was dark and curly, his eyes grey and full of light, his complexion healthy but almost colourless, his voice full. He was active of habit and enjoyed exercise (in youth, though a light-weight, he had been a skilled wrestler), exceedingly temperate, both in eating and drinking, a most energetic and conscientious worker, and a man of real distinction and influence, easy of access, modest and unpretentious to a rare degree, living a simple, earnest, cheerful life. He was an excellent judge of literature, reading most European languages well and being acquainted with their classics. His memory was remarkable, and if the whole of the Eddic poems had been lost, he could have written them down from memory; while to remember dates he had once read and references he had once made was no effort to him. He spoke English well and idiomatically, but with a strong Icelandic accent. He wrote a beautiful, distinctive, and clear hand, in spite of the thousands of lines of MS. copying he had done in his early life.

By his *Tímatál* (written between October 1854 and April 1855) he laid the foundations for the chronology of Icelandic history, in a series of conclusions that have not been displaced (save by his own additions and corrections), and that justly earned the praise of Jacob Grimm. His editions of Icelandic classics, 1858–68, *Biskopa Sögur*, *Bardar Saga*, *Forn Sögur* (with Möbius), *Eyrbyggia Saga*, and *Flateyar-bók* (with Unger) opened a new era of Icelandic scholarship, and can only fitly be compared to the Rolls Series editions of chronicles by Dr Stubbs for the interest and value of their prefaces and texts. Seven years of constant and severe toil, 1866–73, were given to the Oxford Icelandic-English Dictionary, incomparably the best guide to classic Icelandic, and a monumental example of single-handed work. His later series of editions, 1874–85, included *Orkneyinga* and *Hácονar Saga*, the great and complex mass of Icelandic historical sagas, known as *Sturlunga*, and the *Corpus Poeticum Boreale*, in which he edited the whole body of classic Scandinavian poetry. As an introduction to the *Sturlunga*, he wrote a complete though concise history of the classic Northern literature and its sources. In the introduction to the *Corpus*, he laid the foundations of a critical history of the Eddic poetry and Court poetry of the North in a series of brilliant, original, and well-supported theories that are gradually being accepted even by those who were at first inclined to reject them. His little Icelandic *Prose Reader* (with F. York Powell), 1879, furnishes the English student with a pleasant and trustworthy path to a sound knowledge of Icelandic. The *Grimm Centenary Papers* (1886) give good examples of the range of his historic work, while his Appendix on Icelandic currency to Sir G. W. Dasent's *Burnt Njal* is a model of methodical investigation into an intricate and somewhat important subject. As a writer in his own tongue he at once gained a high position by his excellent and delightful *Relations of Travel in Norway and South Germany*. In English, as his "Visit to Grimm" and his powerful letters to *The Times* show, he had attained no mean skill. His life is mainly a record of well-directed and efficient labour in Denmark and Oxford.

(F. Y. P.)

Vigo, seaport town of Spain, in the province of Pontevedra, connected by rail with Madrid, Portugal, and the north of Spain railway system. The most active industries are connected with the fisheries and the shipping interests, but there are also iron foundries, paper, flour, and saw mills, a petroleum refinery, distilleries, and some thirty sardine establishments. The town is acquiring a more modern aspect with large handsome streets, squares, fine buildings, schools, clubs or casinos, hotels, theatres, public gardens, quays, &c. In 1898, 1098 vessels of 104,940 tons entered, and 1593 vessels of 1,244,552 tons cleared. The exports in 1898 amounted to £128,658, the imports to £118,809. Population (1887), 15,044; (1897), 17,222

Villach, the chief town of a government district in Carinthia, on the river Drave, 22 miles west of Klagenfurt, in a broad, fertile basin at the foot of the Dobratsch or Villach Alp. The parish church is an interesting Gothic edifice of the 15th century. The industry of Villach is to a great extent dependent on the vicinity of the lead mines of Bleiberg, and consists in various applications of that metal. Machinery, cement, coffee substitutes, leather, paper and pasteboard, and beer are also manufactured; and marble is quarried in the neighbourhood. There is a considerable transit trade in and depôts for the sale of lead, iron, zinc, and steel, products of the mines and furnaces of the district. The warm sulphur springs of Warmbad-Villach are about 2 miles from the town. Population (1890), 6765; (1900), 9690, including garrison of 829 men.

Villa Concepción. See Concepción.

Villa del Pilar, an important city of Paraguay, about 104 miles from Asunción. Including its suburbs, it has a population of 5742. The city has a municipal board, military commander, justice of the peace, custom-house, port captain, national college, many public and private schools, a branch of the Agricultural Bank, and telegraph and post offices. Orange trees grow throughout the city, which is one of the largest orange-exporting towns in the republic, and has a fine harbour on the river Paraguay.

Villafranca, a town of the province of Verona, Lombardy, Italy, 11 miles S.S.W. of Verona, on the railway to Mantua. It has considerable silk industries. Here preliminaries of peace were signed between Napoleon III. and the Austrians in 1859 after the battle of Solferino. Population (1901), about 7500.

Villafranca de Los Barros, a town of Spain, province of Badajoz, on the railway from Merida to Séville. Population (1887), 9634; (1897), 9930. The surrounding country produces in abundance cereals of every kind, wine and oil, and is a noted district for the rearing of live stock. The town has modern houses and squares, a parish church of the 16th century, some old convents, a society, styled Tertulia Literaria, that has a remarkable archæological museum, with fine ceramics and ancient sepulchral stones and coins, almost all collected from the neighbourhood.

Villajoyosa, a town of Spain, on the Mediterranean coast, in the province of Alicante, opposite the island of Benidorm. Its municipal boundaries are extensive, and embrace much of the lovely and fertile *huerta* dotted with country houses and farms. The oldest part of the town, still showing some remains of the walls, is on the top of a hill, and is composed of narrow, crooked, steep streets, with a couple of parish churches. The more modern part, styled La Marina, or San Cristobal, is built at the foot of the hill, near the coast, and there is a suburb connected with it by a bridge across the little river Sella. The new town has broad, well-paved streets, a town hall, schools, asylum, and a fine chapel dedicated to Santa Marta, with a tower 29 metres high. The anchorage is not very good for large ships, but much frequented by coasting vessels. There is a lighthouse to the north-east of the town. The fisheries are important, and give employment to several hundred men with over a hundred boats. There is an active trade in agricultural products, and the industries include the making of rope, sails, nails, leather, shoes, hemp, esparto-grass rugs, almond pastes, and chocolate. Near Villajoyosa is a lunatic asylum and sanatorium founded by Dr Izquierdo, founder of the lunatic asylum of Madrid. Population (1887), 8763; (1897), 8981.

Villa Nova de Gaia, a town of Portugal, district of Oporto, a suburb of Oporto, on the left bank of the Douro, connected with Oporto by a couple of bridges. The manufactures include pottery, wine-casks, cottons, tobacco, glass, spirits, soap, corks, &c. Population (1890), 12,108; (1900), 14,754.

Villanueva de la Serena, a town of Spain, province of Badajoz, to the south of the river Guadiana, on the railway from Cuidad Real to Badajoz. The flat country produces wheat, hemp, fruit, and wine. Much live stock is reared in the neighbourhood. Villanueva has regular, well-paved streets, and among its public buildings are the town hall, parish church, several convents and hermitages, and the schools. Population (1887), 12,024; (1897), 11,731.

Villanueva y Geltru, a seaport town of Spain, province of Barcelona, with a station on the line from Madrid to Barcelona. Agricultural interests are important, and there are cotton, woollen, paper and linen manufactures, and iron foundries. The fisheries are active, giving employment to 900 men and boys with 310 boats. Most of the houses and public buildings are modern, well built, and the whole place has an air of ease and growing prosperity. The harbour affords safe and deep anchorage, and is chiefly frequented by coasting and small craft. San Cristobal Cape is a lifeboat station. The museum and library was founded and endowed by the eminent poet and academician, Victor Balaguer. It contains 40,000 volumes, valuable MSS. and paintings, with prehistoric and other collections. The collection of ceramics includes 2000 specimens, that of engravings 3000, the numismatic 6000; the antiquities from the Far East especially are unrivalled. Population (1887), 13,811; (1897), 11,839.

Villa Real, a town of Portugal, capital of the district of Villa Real, situated 10 miles N. of the Douro, and 47 E.N.E. of Oporto. Population (1890), 5920; (1900), 6736. The district of VILLA REAL has an area of 1717 square miles, and population (1890), 237,302; (1900), 243,584, giving 142 inhabitants to the square mile. There are alkaline waters and baths at Vidago (near Chaves) and at Pedras Salgadas (near Villa Ponca d'Aguiar). The district adjacent to the Douro is known *par excellence* as the wine country; in 1892 the vineyards covered 38,730 acres, and wine was produced to the extent of 8,827,170 gallons, and £448,670 in value. In 1898 the wine produced was 4,106,357 gallons. Cattle, sheep, and especially pig breeding are actively pursued, and hams are cured at Chaves and Murça.

Villa Rica, an important town of Paraguay, 90 miles east of Asunción, with about 25,000 inhabitants. It is situated in the interior of the country, in the midst of a rich agricultural region, with hills running east and west covered with fine timber. One of the national colleges is situated here, and there are public schools. It has a church, many modern edifices, commercial houses, and a branch of the Agricultural Bank.

Villari, Pasquale (1827-——), Italian historian, was born at Naples on 3rd October 1827. He studied under Basilio Puoti and Luigi La Vista, under whose auspices his first work, an attack upon the Bourbon régime in South Italy, appeared in 1847. Seeking refuge in Florence, Villari devoted himself to historical research in the archives of the Laurentian and Magliabecchi libraries, and produced in 1859 the first volume of his *Storia di Girolamo Savonarola e de suoi tempi*. A second volume followed in 1861, and the work, which was speedily recognized as an Italian classic, was translated into English, French, and German. It was followed in 1877 by a work of even greater critical value, *Niccolo Machiavelli e i suoi tempi*. In the meantime Villari had left his chair of history at Pisa to become professor of history at the Institute of Studi Superiori at Florence, and he was also appointed a member of the Council of Public Instruction, to which body in 1862, having served as a juror at the international exhibition of that year, he contributed an important monograph upon education in England and Scotland. In 1869 he was general secretary of public instruction, in 1884 he was made senator, and in 1891 he was minister of public instruction in the Rudini cabinet. In 1893–94 he collected a number of historical studies from the *Nuova Antologia*, under the title of *I primi due secoli della storia di Firenze*; and in 1901 he produced, in two volumes, *Le Invasioni barbariche in Italia*, a popular account of the dissolution of the empire, based largely upon the researches of Gibbon, Bury, Hartmann, and Hodgkin. All these works have been translated into English by the historian's wife, Linda Villari (*née* White), and all of them, especially the *Machiavelli*, are of great value to the student of Italian history. Of Villari's literary and especially his Dante studies, the most important are contained in *Saggi Critici* (1886). In *Lettere*

Meridionali he concerns himself mainly with social questions. The most influential by far of his political writings was a pamphlet, *Di chi e la colpa*, reprinted from the *Politecnico* in 1866, for the disasters of which year it courageously sought to find an explanation in national, moral, and political foibles and shortcomings. As a historian Villari is characterized by breadth of culture and sympathy rather than by profound insight. His sympathy with the aims of Savonarola led him to take what is probably a somewhat extravagant view of the moral and intellectual capacity of the reformer.

Villefranche, chief town of arrondissement, department of Rhône, France, 19 miles north by west of Lyons by rail. About twenty factories are engaged in the manufacture of cotton fabrics, of which the total value exceeds £1,000,000 a year. Establishments for dyeing and finishing goods give employment to about 1500 persons, and the manufacture of cotton thread and accessory branches of industry to 1000 or 1200 more. Population (1891), 11,581; (1901), 14,033.

Villiers de l'Isle-Adam, Auguste Philippe Mathias de (1838–1889), COUNT, French poet, was born at St Brieuc in Brittany, 28th November 1838. He may be said to have inaugurated the Symbolist movement, and *Axël*, the play on which he was engaged during so much of his life, though it was only published after his death, is the typical Symbolist drama. He began, at the age of twenty-one, with a volume of poems. This was followed by a wild romance of the supernatural, *Isis*, 1862, and by two plays, *Elën*, 1864, and *Morgane*, 1865. *La Révolte*, a play in which Ibsen's *Doll's House* seems to be anticipated, appeared in 1870; *Contes Cruels*, his finest volume of short stories, in 1880; *L'Eve Future*, an amazing piece of buffoonery satirizing the pretensions of science, in 1886; *Tribulat Bonhomet* in 1887; *Axël* in 1890. He died at Paris, under the care of the Frères Saint-Jean-de-Dieu, 19th August 1889. Villiers has left behind him a legend, probably not more fantastic than the truth. Sharing many of the opinions of Don Quixote, he shared also Don Quixote's life. He was the descendant of a Grand Master of the Knights of Malta, famous in history, and his pride as an aristocrat and as an idealist were equal. He hated mediocrity, science, progress, the present age, money, and "serious" people. In one division of his work he attacked all the things which he hated with a savage irony; in another division of his work he discovered at least some glimpses of the ideal world. He remains a remarkable poet and a remarkable satirist, imperfect as both. He improvised out of an abundant genius, but the greater part of his work was no more than improvisation. He was accustomed to talk his stories before he wrote them. Sometimes he talked them instead of writing them. But he has left, at all events, the *Contes Cruels*, in which may be found every classic quality of the French *conte*, together with many of the qualities of Poe and Hoffmann; and the drama of *Axël*, in which the stage takes a new splendour and a new subtlety of meaning. Villiers's influence on the younger French writers was considerable. It was always an exaltation. No one in his time followed a literary ideal more romantically. (A. SY.)

Villingen, a town of Germany, grand-duchy of Baden, 52 miles by rail north of Schaffhausen. It is the chief seat of the watch-making industry of the Black Forest. It is in part still surrounded by walls, with ancient gate towers. It also produces musical-boxes, glass, and silk; and has a Gothic church of the 13th century and another of the 11th, a 15th-century town hall, with a museum of antiquities, music, technical, and agricultural schools. Population (1885), 6140; (1900), 7819.

Vilna (properly WILNO), a Lithuanian government of West Russia, bordering on Poland, with an area of 16,421 square miles. It is chiefly built up of Lower Tertiary deposits, but in the north Devonian sandstones appear on the surface. The Tertiary deposits consist of Eocene clay, slates, sandstones, limestones, and chalk, with gypsum, and are partly of marine and partly of land origin. The whole is covered with thick layers of Glacial boulder clay and post-Glacial deposits, containing remains of the mammoth and other extinct mammals. Interesting discoveries of Neolithic implements, especially of polished stone, and of implements belonging to the Bronze Age and the early years of the Christian epoch, have been made in the province.

The population, which was 1,223,260 in 1883, numbered in 1897 1,591,912 (domiciled only), of whom 797,676 were women, and 201,447 lived in towns; nearly 400,000 of the inhabitants were Russians and 200,000 Jews, the remainder being Lithuanians and Poles. The province is divided into seven districts, the chief towns of which are Vilna, Vileika (3552 inhabitants), Disna (6739) Lida (8626), Oshmiany (6375), Sventsiany (6322), and Troki (3313). The standard of education is low; in 1898 there were only 1053 primary schools, attended by 30,107 boys and 8450 girls. Lignite, iron ore, and peat are the only minerals found in the province. Of the total area of 10½ million acres, 2,796,900 acres were in 1898 covered with forests. The soil varies greatly, from fertile black earth in the west to clay and sandy soil elsewhere, and the standard of agriculture is generally low, both on the peasants' lands (3,644,000 acres) and on the small estates. The total area under cereal crops in 1900 was 2,445,600 acres, and the average yield in 1895–99 was: rye, 5,456,000 cwt.; wheat, 253,000 cwt.; oats, 2,499,000 cwt.; barley, 1,032,000 cwt.; also 10,393,000 cwt. of potatoes, which are largely grown for distilleries. Flax, hemp, and beetroot for sugar are widely cultivated, and some tobacco is raised. There are a number of school-gardens in connexion with the village schools, and one at the normal school for teachers. Cattle-breeding is second in importance only to agriculture, there being in the province in 1897 222,400 horses, 561,200 horned cattle, 488,000 sheep, and 340,400 pigs. Industries are undeveloped, and the annual returns of all factories (chiefly distilleries, breweries, tobacco works, tanneries, paper-mills, flour-mills, and a few wire and nail works) only amounted to 11,323,000 roubles in 1898.

Vilna, the capital of the above province, on the river Viliya, 436 miles by rail south-west of St Petersburg, near the junction of three important lines running from Libau to Odessa and to the Don, and from St Petersburg to Warsaw. It is the headquarters of the Governor-General of the Lithuanian provinces, and has grown very rapidly; in 1897 its population was 159,568, as compared with 109,329 in 1889. It is an important centre for trade in timber and grain, which are exported both by rail and river. It has theological seminaries, both Orthodox and Catholic, a military school, a normal school for teachers, a number of lyceums, and a few professional schools. It is also the seat of many scientific societies (geographical, medical, and archæological), and has a good antiquarian museum and a public library.

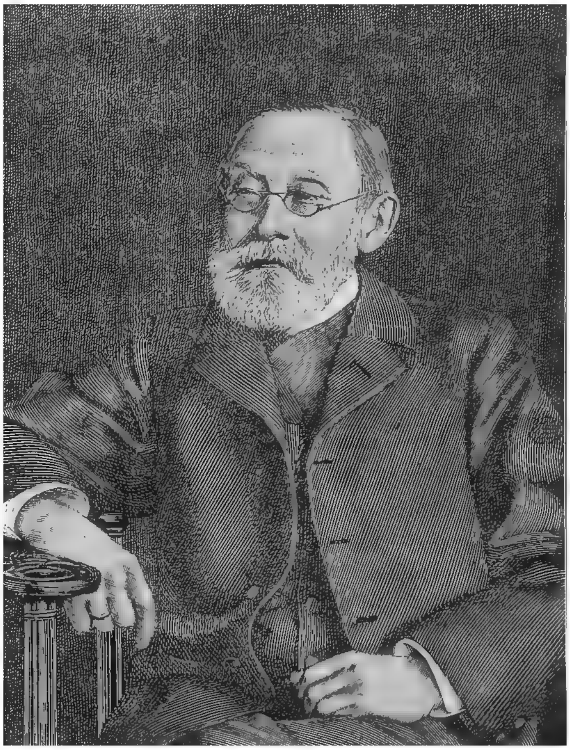
Vilvorde, a town of Belgium, in the province of Brabant, 9 miles north of Brussels by rail, on the river Senne. It manufactures, among other commodities, chemical manure, oil, and alimentary pastes. There are also breweries. Population (1890), 11,138; (1900), 12,992.

Vincennes, a city of Indiana, U.S.A., capital of Knox county, on the east bank of the Wabash river, in the south-western part of the state, at an altitude of 420 feet. Its site is level, the street plan regular, and it has water-supply and sewerage systems. Four railways —the Baltimore and Ohio South-Western; the Cleveland, Cincinnati, Chicago and St Louis; the Evansville and Terre Haute; and the Pittsburg, Cincinnati, Chicago and St Louis—intersect here, making it a railway centre of importance. The city contains repair and car works, and manufactures in great variety. Population (1890), 8853; (1900), 10,249, of whom 736 were foreign-born and 432 negroes.

Vinita, a town of the Cherokee nation, Indian Territory, U.S.A., in the northern part of the Territory, at the intersection of the St Louis and San Francisco, and the Missouri, Kansas and Texas railways, at an altitude of 700 feet. The lands of Indian Territory are, by United States law, the common property of the tribes, but in contravention of the law, the nation has granted this townsite to individuals, and upon such deeds the titles in the town rest. It is in an agricultural and pastoral region, for which it is a collecting and distributing point. It is peopled almost entirely by whites, the Indians remaining aloof from railways. Population (1890), 1200; (1900), 2339.

Virchow, Rudolf (1821–1902), German pathologist and politician, was born on 13th October at Schivelbein, in Pomerania, where his father was a small farmer and shop-keeper. As a boy he attended the *volksschule* of his native village, and at the age of seventeen, having passed through the gymnasium of Köslin, went to Berlin to study medicine. He took his doctor's degree in 1843, and almost immediately received an appointment as assistant-surgeon at the Charité Hospital, becoming prorector three years later. In 1847 he began to act as *privat-docent* in the university, and founded with Reinhardt the *Archiv für pathologische Anatomie und Physiologie*, which, after his collaborator's death in 1852, he carried on alone, and in 1848 he went as a member of a Government Commission to investigate an outbreak of typhus in Upper Silesia. About the same time, having shown too open sympathy with the revolutionary or reforming tendencies of 1848, he was for political reasons obliged to leave Berlin and retire to the seclusion of Würzburg, the medical school of which profited enormously by his labours as professor of pathological anatomy, and secured a wide extension of its reputation. In 1856 he was recalled to Berlin as ordinary professor of pathological anatomy in the university, and as director of the Pathological Institute, formed a centre for research whence has flowed a constant stream of original work on the nature and processes of disease. On 14th October 1901, his eightieth birthday was celebrated in Berlin amid a brilliant gathering of men of science, part of the ceremonies taking place in the new Pathological Museum, near the Charité, which owes its existence mainly to his energy and powers of organization. On that occasion all Europe united to do him honour, many learned societies sent delegates to express their congratulations, the King of Italy gave him his own portrait on a gold medallion, and among the numerous addresses he received was one from Kaiser Wilhelm II., who took the opportunity of presenting him with the Grand Gold Medal for Science. In the early part of 1902 he slipped from a tramcar in Berlin and fractured his thigh; from this injury he never really recovered, and his death occurred in Berlin on 5th September 1902.

Wide as were Virchow's studies, and successful as he was in all, yet the foremost place must be given to his achievements in pathological investigation. He may, in fact, be called the father of modern pathology, for his view, that every animal is constituted by a sum of vital units, each of which manifests the characteristics of life, has almost uniformly dominated the theory of disease since the middle of the 19th century, when it was enunciated. The beginnings of his doctrine of cellular pathology date from the earliest period in his career. When, towards the end of his student days in Berlin, he was acting as clinical assistant in the eye department of the Berlin Hospital, he noticed that in keratitis and corneal wounds healing took place without the appearance of plastic exudation. This observation led him to further work, and he succeeded in showing that in vascular organs the presence of cells in inflammatory exudates is not the result of exudation but of multiplication of pre-existing cells. Eventually he was able to prove that the biological doctrine of *omnis cellula e cellula* applies to pathological processes as well as to those of normal growth, and in his famous book on *Cellularpathologie*, published at Berlin in 1858, he established what Lord Lister has described as the "true and fertile doctrine that every morbid structure consists of cells which have been derived from pre-existing cells as a progeny." But in addition to bringing forward a fundamental and philosophical view of morbid processes, which has probably contributed more than any other single cause to vindicate for pathology the place which he claimed for it among the biological sciences, Virchow made many important contributions to histology and morbid anatomy and to the study of particular diseases. The classification into epithelial organs, connective tissues, and the more specialized muscle and nerve, was largely due to him; and he proved the presence of neuroglia in the brain and spinal cord, discovered crystalline hæmatoidine, and made out the structure of the umbilical cord. Medical science further owes to him the classification of new growths on a natural histological basis, the elucidation of leucæmia, glioma, and lardaceous tumours, and detailed investigations into many diseases—tuberculosis, pyæmia, diphtheria, leprosy,



RUDOLF VIRCHOW.
(From a photograph by Elliott and Fry, London.)

typhus, &c. Among the books he published on pathological and medical subjects may be mentioned *Vorlesungen über Pathologie*, the first volume of which was the *Cellularpathologie* (1858), and the remaining three *Die Krankhaften Geschwülste* (1863–67); *Handbuch der speziellen Pathologie und Therapie* (3 vols., 1854–62), in collaboration with other German surgeons; *Gesammelte Abhandlungen zur wissenschaftlichen Medizin* (1856); *Vier Reden über Leben und Kranksein* (1862); *Untersuchungen über die Entwicklung des Schädelgrundes* (1857); *Lehre von den Trichinen* (1865); *Ueber den Hunger-typhus* (1868); and *Gesammelte Abhandlungen aus dem Gebiete der öffentlichen Medizin und der Seuchenlehre* (1879). In England his pathological work won general recognition. The Royal Society awarded him the Copley medal in 1892, and selected him as Croonian lecturer in the following year, his subject being the position of pathology among the biological sciences; and in 1898 he delivered the second Huxley memorial lecture at Charing Cross Hospital.

Another science which Virchow cultivated with conspicuous success was anthropology, which he did much to put on a sound critical basis. At the meeting of the Naturforscherversammlung at Innsbruck in 1869, he was one of the founders of the German Anthropological Society, of which he became president in the following year; and from 1869 onwards he presided over the Berlin Anthropological Society, also acting as editor of its proceedings in the *Zeitschrift für Ethnologie.* In ethnology he published a volume of essays on the physical anthropology of the Germans, with special reference to the Frisians; and at his instance a census, which yielded remarkable results, was carried out among school children throughout Germany, to determine the relative distribution of blondes and brunettes. His archæological work included the investigation of lake dwellings and other prehistoric structures; he went with Schliemann to Troy in 1879, fruits of the expedition being two books, *Zur Landeskunde der Troas* (1880) and *Alt-trojanische Gräber und Schädel* (1882); in 1881 he visited the Caucasus, and on his return published *Das Gräberfeld von Koban im Lande der Osseten;* and in 1888 he accompanied Schliemann to Egypt, Nubia, and the Peloponnese.

As a politician Virchow had an active career. In 1862 he was elected a member of the Prussian Lower House. Professing advanced Liberal and democratic views, he was a founder and leader of the Fortschrittspartei, and the expression *kulturkampf* had, it is believed, its origin in one of his electoral manifestoes. For many years he was chairman of the finance committee, and in that capacity may be looked upon as a chief founder of the constitutional Prussian Budget system. In 1880 he entered the Reichstag as representative of a Berlin constituency, but was ousted in 1893 by a Social Democrat. In the Reichstag he became the leader of the Opposition, and a vigorous antagonist to Bismarck. In the local and municipal politics of Berlin again he took a leading part, and as a member of the municipal council was largely responsible for the transformation which came over the city in the last thirty years of the 19th century. That it has become one of the healthiest cities in the world from being one of the unhealthiest, is attributable in great measure to his insistence on the necessity of sanitary reform, and it was his unceasing efforts that secured for its inhabitants the drainage system, the sewage farms, and the good water-supply, the benefits of which are reflected in the decreased death-rate they now enjoy. In respect of hospitals and the treatment of the sick his energy and knowledge were of enormous advantage to his country, both in times of peace and of war, and the unrivalled accommodation for medical treatment possessed by Berlin is a standing tribute to his name, which will be perpetuated in one of the largest hospitals of the city. Of his writings on social and political questions may be mentioned *Die Erziehung des Weibes* (1865); *Ueber die nationale Entwicklung und Bedeutung der Naturwissenschaften* (1865); *Die Aufgaben der Naturwissenschaften in dem neuen nationalen Leben Deutschlands* (1871); *Die Freiheit der Wissenschaft im modernen Staat* (1877), in which he opposed the idea of Haeckel—that the principles of evolution should be taught in elementary schools—on the ground that they were not as yet proved, and that it was mischievous to teach a hypothesis which still remained in the speculative stage.

Vire, chief town of arrondissement, department of Calvados, France, 36 miles south-west of Caen, on the railway from Paris to Granville. A library (30,000 volumes) and a small museum are installed in the Hôtel de Ville (17th and 18th centuries). Ancient buildings are the Church of Notre Dame, of the 13th and later centuries, a fortified 13th-century gateway, the Tour d'Horloge, flanked by two crenelated towers, and a picturesque fragment of a 12th-century château, on a cliff overlooking the Vire, which is approached by a fine esplanade with triple rows of lime trees. A centenary monument of the Revolution stands in the Place Nationale; in the public garden is a statue of Marshal de Matigon (1525–1597); and the native poets Chênedollé (1769–1833) and Castel (1758–1832) are represented, the former by a marble bust, the latter by a bronze statue. The Church of St Anne's is a handsome modern edifice with numerous statues. Cloth, hosiery, carding machines, and metallic boxes are manufactured, and fine granite, much of which is dressed in the town, is quarried in the vicinity. There is considerable trade in grain, dairy produce, and granite. Vire grew up around a castle built in the 12th century by Henry I. of England. South-west of the town is the gorge called Vaux-de-Vire, where the satiric songs, hence known as "Vaudevilles," had their origin. Population (1881), 6263; (1901), 6207.

Virginia.—A state on the eastern coast of the United States. It was one of the thirteen commonwealths that established the American Union, and has played a leading part in every great crisis of that country's history. In the Civil War it was the chief battleground, and suffered more than any other state; but after years of courageous effort its material progress is now steadily upwards.

Population.—In 1880 the population was 1,512,565; in 1890, 1,655,980; and in 1900, 1,854,184, a gain for the latter decade of 12 per cent., as compared with 9·5 per cent. for the preceding decade. Of the population in 1900, 925,897 were males and 928,287 females; 1,834,723 were native-born, and 19,461 (only 1 per cent.) foreign-born. The white population is increasing much more rapidly than the coloured. In 1880 there were 880,858 whites and 631,616 negroes; in 1890, 1,020,122 whites and 635,438 negroes; in 1900, 1,192,855 whites and 660,722 negroes. Out of 301,379 adult white males, 36,493 (12·1 per cent.) were illiterate (unable to write); while out of 146,122 adult negro males, 76,764 (52·5 per cent.) were illiterate. In 1880 there were six cities — Richmond, Norfolk, Petersburg, Lynchburg, Alexandria, and Portsmouth — with over 10,000 inhabitants each. In 1900 there were three others in addition, Roanoke, Newport News, and Danville. Richmond in 1900 had a population of 85,050; Norfolk (46,624), Petersburg (21,810), Roanoke (21,495), Newport News (19,635), Lynchburg (18,891), Portsmouth (17,427), Danville (16,520), Alexandria (14,528). The total land surface is 40,125 square miles, the average density of population being 46·2 in 1900 per square mile, as compared with 41·3 ten years earlier.

Education.—The following are the statistics of the school population—all between five and twenty-one years old :—

Year.	White School Population.	Coloured School Population.	White Pupils Enrolled.	Coloured Pupils Enrolled.	White Schools.	Coloured Schools.	White Teachers.	Coloured Teachers.
1890	376,657	275,388	220,210	122,059	5358	2153	5550	1963
1899	...	...	241,696	117,129	6492	2314	6671	2165
1900	425,658	265,662	250,697	119,898	6587	2335	6761	2193
1901	...	...	258,222	123,339	6637	2311	6809	2199

The progress of the state university has been rapid, increasing from 306 students in 1886–87 to 670 on 19th January 1901, while the teaching staff rose during the same period from 24 to 55. In the school for the deaf and the blind, who are taught various trades in addition to the common branches, there were 153 deaf and 57 blind pupils on 22nd December 1900.

Penal and Insane Institutions.—On 1st October 1899 the penitentiary contained 1263 convicts (224 white and 1039 coloured), and the state farm 253 (56 white, 197 coloured). Besides these, 28 coloured convicts were hired out, making a total of 1544 (280 white and 1236 coloured). The net gain to the state from the labour of the convicts for the year ending 30th September 1899 was $46,598. On 30th September 1900 the asylum for insane negroes at Petersburg (including insane epileptics in separate building) contained 868 patients. At the same date the three asylums (at Staunton, Williamsburg, and Marion) for insane whites contained 1918.

Religion.—The religious statistics of the eight most numerous denominations were in 1890 as follows :—

Denominations.	Members.	Number of Churches.	Value of Church Property.
Baptists . . .	303,134	1938	$3,152,582
Methodists . . .	154,693	1646	2,910,853
Presbyterians . .	27,746	369	1,234,501
Episcopalians . .	20,420	332	1,700,075
Campbellites . .	14,100	148	240,929
Roman Catholics. .	12,356	44	458,800
Lutherans . . .	12,220	136	344,915
Dunkards . . .	7,244	93	78,473

Of the Baptists, 199,871 were negroes, owning 977 of the churches. Of the Methodists, 27,855 were negroes, owning 210 of the churches.

Industry.—The number of farms in the state in 1900 was 167,886, with an acreage of 19,907,883, of which 10,094,805 acres were improved, 9,813,078 unimproved. The value of farm property was $323,515,977, and of the products $86,548,545, as compared with $42,244,458 ten years earlier. The principal farm crops were Indian corn, valued at $16,233,756 ; hay, $7,670,082 ; tobacco, $7,210,195 ; wheat, $6,161,000 ; forest products, $3,797,116 ; and orchard fruits, $2,662,483. The following table shows the manufacturing and mechanical industries as returned at the censuses of 1880, 1890, and 1900 with the percentage of increase :—

	1880.	1890.	1900.	Percentage of Increase.	
				1880–1890.	1890–1900.
Number of establishments . .	5,710	5,915	8,248	3·6	39·4
Capital	$26,968,990	$63,456,799	$103,670,988	135·3	63·4
Wage earners	40,184	53,566	72,702	33·3	35·7
Value of product	$51,780,992	$88,363,824	$132,937,910	70·6	50·4

The leading industries, with the value of their products, are: tobacco, $21,278,266 ; flour and grist mills, $12,687,267 ; lumber and timber, $12,137,177 ; iron and steel, $8,341,888 ; foundries and machine shops, $4,833,137 ; and cars and shop construction by steam railway companies, $6,277,279. Virginia has become one of the greatest shipbuilding states in the Union, Newport News and Richmond being the chief centres.

Railways, Banks, &c.—In 1899 there were 3691 miles of railways and canals in Virginia, of which 985 belonged to the Norfolk and Western, 665 to the Southern, and 619 to the Chesapeake and Ohio. The value of all railway and canal property was $55,460,759, and the net income of the same was $1,340,001. The value of all the property of the ten steam navigation companies (the two principal ones being the Old Dominion Steamship Company and the Virginia Navigation Company) was $825,752. The value of all property of express companies was $36,808, and that of all telegraph and telephone property was $653,320. In 1900 there were 128 banks, including 12 savings banks and 42 national banks. The total par value of shares was $10,595,661, and the market value was $11,652,452. In 1893–94 there were 83 building and loan associations.

Finances.—In 1899 the assessed value of real estate was $311,385,454, of which sum coloured persons owned $11,643,164. The assessed value of all personal property was $102,886,723, of which coloured persons owned $3,303,773. The total assessed value of all property was $414,272,177. The taxes on property and the income and capitation taxes amounted to $2,080,967, of which $183,932 was assessed on coloured persons. The receipts from liquor licences for the year ending 30th September 1899 were $255,542, and from other licences, $382,168. The total receipts of the state from all sources were $3,475,404, and the total expenditures, $3,111,430. On 6th December 1900 the state debt amounted to $26,806,434.

History.—The most important episode in recent history is the controversy over the state debt. This debt, amounting to nearly $39,000,000 when Virginia seceded from the Union, had been contracted chiefly for the purpose of buying stock in turnpike, canal, and railway companies. During the War of Secession additional debt was contracted, but as the payment of this was forbidden in the Fourteenth Amendment to the United States Constitution, we are concerned only with the *ante bellum* debt. At the close of the war, the citizens of Virginia found themselves impoverished as few peoples have ever been. The Northern armies had seized cattle, horses, sheep, hogs, and crops, and had destroyed many fences, stables, barns, and dwellings; while a social and economic revolution, more sweeping than the French, had suddenly given freedom to the slaves, upon whose value as property the state's ability to pay its debts had been largely based. Still both Houses of her legislature passed a Bill pledging payment in full of her share of the debt—viz., two-thirds of the sum due before the creation of the state of West Virginia took from Virginia one-third of her soil and population. In 1878 a new party sprung up led by General Mahone, and known as the "readjusters," openly advocating repudiation of a part of the debt. Mahone had been a candidate for nomination as governor by the Democrats, as the great majority of the white people called themselves, but failed to secure it. Too astute, however, to proclaim himself a Republican, he continued to label himself Democrat, and announced as his programme the "readjustment" of the debt. The negroes followed their new master. In the elections of 1879 and 1881 Mahone triumphed completely, and having both the legislature and Governor of Virginia under his control, proceeded to repudiate a considerable portion of the debt. Before his victory the Democrats had passed a Bill (March 1879) enabling the holders of state bonds to fund them in new bonds with tax-receivable coupons. Mahone's legislation, however, forbade tax-collectors to receive coupons; and the United States Supreme Court gave a decision which seemed to uphold the constitutionality of this device for evading the acceptance of coupons. The bondholders still maintained the fight; but the conflict became one of legal technicalities, case after case being taken into the Federal courts to test the constitutionality of the various legislative Acts. In 1892 the battle ended by a compromise, under which the bondholders secure much more than at one time seemed possible; while Virginia, though still heavily burdened with debt, is paying the interest, and steadily acquiring the financial strength to pay the principal also.

Recent Political History in Virginia.—Except during the period when a considerable minority were led by the debt question into temporary alliance with the negroes, the vast majority of white Virginians have enrolled themselves, since the War of Secession, in the so-called Democratic party. For a time they styled themselves Conservatives; and this name indicated more correctly their aim. In 1872 the state was carried by General Grant, the Republican candidate for the Presidency, but the Democratic candidate, Horace Greeley, was a former abolitionist, and therefore obnoxious to the people of Virginia. The state has voted for every Democratic Presidential candidate since that time. No Republicans, and only one "Readjuster"—Cameron, in 1881—has ever been elected Governor of Virginia. Mahone strained every nerve to be elected as a Republican in 1889, but was beaten by more than 42,000 majority; and since then the Democratic party has been in complete control. In 1893 the Opposition called itself the "Populist" party, but was thoroughly beaten. In July 1900 a law went into effect requiring Virginian railways to provide separate, though equal, accommodation for negroes and whites. A constitutional convention was held in 1901 to frame a new Constitution. This was proclaimed, on 10th July 1902, as the organic law of the commonwealth. In many respects the new instrument is a great improvement upon the old, the executive, legislative, and judiciary departments being all conservatively remodelled with a view to increased efficiency and diminished expense, while the financial system is so modified as to promote the equalization of burdens, increase the revenue, and lower the rate of taxation. Important, too, is the "state corporation commission," consisting of three members to be appointed by the Governor, and clothed with power to issue all charters to domestic corporations and all licences to foreign corporations to do business in the state, as well as with the power and duty of supervising, regulating, and controlling transportation and transmission companies. But the most important change relates to suffrage, the aim being to disfranchise as many negroes and as few whites as possible without violating the United States Constitution, which forbids disfranchisement *on the ground* of race, colour, or previous condition of servitude. To accomplish this aim the following provisions will be in force till 1st January 1904. Any male citizen twenty-one years of age who has resided two years in the state, one year in the city, county, or town, and thirty days in the voting precinct, may be *registered* as a voter for life, provided (1) that he has fought in the army or navy of the United States or the Confederate States or any single state; or (2) that he is a son of such soldier or sailor; or (3) that he has paid for the preceding year at least one dollar in taxes on property; or (4) that he can read and explain any section of the Constitution, or, at any rate, understand and explain its meaning when read to him. Through one or another of these four gates nearly every white man in the state can enter. Very few negroes, however, can enter through the first three, and it is confidently expected that not only most of those unable to read, but many of those who can, will fail of entrance through the fourth gate. This is the "understanding clause," preferred by the Virginian Convention to the "grandfather clause" adopted in some other states. After 1st January 1904 these four gates will be closed; and thenceforth any new applicant must not only have paid his poll-taxes for the three preceding years, but must also apply for registration in his own handwriting, stating (without assistance of any sort) his name, age, date, and place of birth, residence, and occupation at the time and for the two preceding years. He must also answer on oath any questions affecting his qualifications as an elector—the questions and answers being officially recorded. So much for the temporary and permanent conditions of registration. But no one, except those who fought on one or the other side in the War of Secession, can actually *vote* who has not paid his poll-taxes for three years, and who cannot prepare and deposit his ballot without aid, unless he be one of those registered before 1st January 1904.

AUTHORITIES.—*Virginia: A Hand-Book, giving its history, climate, and mineral wealth; its educational, agricultural, and industrial advantages.* Published by direction of the State Board of Agriculture. By THOMAS WHITEHEAD. Richmond, 1893.—*Virginia: A History of the People*, by JOHN ESTEN COOKE. Boston, 1883.—*Economic History of Virginia in the 17th Century*, by PHILIP A. BRUCE.—*History of the Virginia Debt Controversy*, by WILLIAM L. ROYALL. Richmond, 1897. (R. H. D.)

Virginia City, a city of Nevada, U.S.A., capital of Storey county, on the eastern slope of Mount Davidson, and on the Virginia and Truckee Railroad, in the southern part of the state, at an altitude of 6339 feet. Following the fortunes of the Comstock lode, over which the city is built, it has declined in prosperity in recent years. The population, which in 1880 was 10,917, was in 1890 but 8511, and in 1900 had further diminished to 2695, of whom 837 were foreign-born and 118 coloured.

Virgin Islands, a presidency of the Leeward Islands colony, West Indies. Population (1891), 4639; (1897), 4769. The inhabitants are peasant proprietors, engaged in raising cattle and vegetables, and in burning charcoal; some are fishermen and boatmen. The climate is more healthy than that of the other West India Islands, and the heat is not so great. The small trade that exists is chiefly with St Thomas. In 1898 the imports were valued at £3943, the exports at £3855. The revenue was £1715 and the expenditure £1783.

Vischer, Friedrich Theodor (1807–1887), German writer on the philosophy of art, was born at Ludwigsburg, 30th June 1807, and was the son of a clergyman. He was educated at Tübingen, and began life in his father's profession. In 1835 he became *privat-docent* in æsthetics and German literature at his old university, was advanced in 1837 to extraordinary professor, and in 1844 to full professor. Immediately afterwards, as the result of a quarrel with the Clerical party, he was suspended for two years by the Würtemberg Government, and in his enforced leisure wrote the first two volumes of his *Aesthetik, oder Wissenschaft des Schönen* (1846), the fourth and last volume of which did not appear till 1857. Vischer threw himself heartily into the great German political movement of 1848–49, and shared the disappointment of patriotic democrats at its failure. In 1855 he became professor at Zürich. In 1866, his fame being now established, he was invited back to Germany with a professorship at Tübingen combined with a post at the Polytechnik of Stuttgart. He died at Gmunden, 14th September 1887. His writings include a great many literary essays collected under the titles *Kritische Gänge* and *Altes und Neues*, poems, an excellent critical study of Goethe's *Faust* (1875), and a successful novel, *Auch Einer* (1878). Vischer was not an original thinker, and his monumental *Aesthetik*, in spite of industry and learning, has not the higher qualities of success. He attempts the hopeless task of explaining art by the Hegelian dialectic. Starting with the definition of beauty as "the idea in the form of limited appearance," he goes on to develop the various elements of art (the beautiful, sublime, and comic), and the various forms of art (plastic art, music, and poetry) by means of the Hegelian antitheses—form and content, objective and subjective, inner conflict and reconciliation. The shape of the work also is repellently Hegelian, consisting of short highly technical paragraphs containing the main argument, followed by detailed explanations printed in different type. Still, Vischer had a thorough knowledge of every branch of art except music, and much valuable material is buried in his volumes if one could detach it from the framework of antiquated theory. In later life Vischer moved considerably away from Hegelianism, and adopted the conceptions of sensuous completeness and cosmic harmony as criteria of beauty; but he never found time to rewrite his great book. His own work as a literary artist is of high quality; vigorous, imaginative, and thoughtful without academic technicality. (H. ST.)

Visconti-Venosta, Emilio, MARQUIS (1829–——), Italian statesman, was born at Milan on 22nd January 1829. A disciple of Mazzini, he took part in all the anti-Austrian conspiracies until the ineffectual rising at Milan on 6th February 1853, of which he had foretold the failure, induced him to renounce his Mazzinian allegiance. Continuing, nevertheless, his anti-Austrian propaganda he rendered good service to the national cause, but being molested by the Austrian police, was obliged in 1859 to escape to Turin, and was appointed by Cavour Royal Commissioner with the Garibaldian forces. Elected deputy in 1860, he accompanied Farini on diplomatic missions to Modena and Naples, and was subsequently despatched to London and Paris to acquaint the British and French Governments with the course of events in Italy. As a recompense for the tact displayed on this occasion he was given by Cavour a permanent appointment in the Italian Foreign Office, and was subsequently appointed secretary-general by Count Pasolini. Upon the death of Pasolini he became foreign minister (24th March 1863) in the Minghetti Cabinet, in which capacity he negotiated the September Convention for the evacuation of Rome by the French troops. Resigning office with Minghetti in the autumn of 1864, he was in March 1866 sent by La Marmora as minister to Constantinople, but was almost immediately recalled and reappointed foreign minister by Ricasoli. Assuming office on the morrow of the second battle of Custozza he succeeded in preventing Austria from burdening Italy with a proportion of the Austrian Imperial debt, in addition to the Venetian debt proper. The fall of Ricasoli in February 1867 deprived him for a time of his office, but in December 1869 he entered the Lanza–Sella Cabinet as foreign minister, and retained his portfolio in the succeeding Minghetti Cabinet until the fall of the Right in 1876. During this long period he was called upon to conduct the delicate negotiations connected with the Franco-German war, the occupation of Rome by the Italians and the consequent destruction of the temporal power of the Pope, the Law of Guarantees, and the visits of Victor Emmanuel II. to Vienna and Berlin. Upon the occasion of his marriage with the daughter of the Marquis Alfieri di Sostegno, grand-niece of Cavour, he was created marquis by Victor Emmanuel II. For a time he remained a member of the parliamentary Opposition, but in 1886 was appointed senator. In 1894, after eighteen years' absence from active political life, he was chosen to be Italian arbitrator in the Bering Sea question and in 1896 once more accepted the portfolio of foreign affairs in the Rudini Cabinet at a juncture when the disasters in Abyssinia and the indiscreet publication of an Abyssinian Green Book had rendered the international position of Italy exceedingly delicate. His first care was to improve Franco-Italian relations by negotiating with France a treaty with regard to Tunis. During the negotiations relating to the Cretan question and the Græco-Turkish war, he secured for Italy a worthy part in the European Concert and joined Lord Salisbury in saving Greece from the loss of Thessaly. Resigning office in May 1898 on a question of internal policy, he once more retired to private life, but in May 1899 again assumed the management of foreign affairs in the second Pelloux Cabinet, and continued to hold office in the succeeding Saracco Cabinet until its fall in February 1901. During this period his attention was devoted chiefly to the Chinese problem and to the maintenance of the equilibrium in the Mediterranean and the Adriatic. In regard to the Mediterranean he established an Italo-French agreement by which France tacitly undertook to leave Italy a free hand in Tripoli, and Italy not to interfere with French policy in the interior of Morocco; and, in regard to the Adriatic, he came to an understanding with Austria guaranteeing the *status quo* in Albania. Prudence and sagacity, coupled with unequalled experience of foreign policy, enabled him to assure to Italy her full portion of influence in international affairs and secured for himself the unanimous esteem of European Cabinets. Though credited with Francophil tendencies, his straightforward interpretation of the Triple Alliance quickly won for him the confidence of Germany and Austria, while the sincerity of his regard for Great Britain contributed to maintain the cordiality of Anglo-Italian relations. His policy was defined by himself in one of his last speeches to the Italian Chamber in the words: "Faithful to our alliances, but constant in our friendships; . . . independent always, isolated never." In recognition of his remarkable services he was created Knight of the Annunziata by Victor Emmanuel III. on the occasion of the birth of Princess Yolanda Margherita of Savoy (1st June 1901).

Vision. See PHYSIOLOGY: *Special Senses.*

Vistula, the chief river of eastern Prussia. In 1888 the Prussian parliament voted a credit of one million sterling for the purpose of preventing or minimizing the inundations to which the lower (deltaic) portion of the Vistula was subjected. The money was spent in the construction (1895) of a straight cut, $4\frac{1}{3}$ miles long, from the confluence of the Elbinger Vistula to the sea, the new waterway being made 1300 feet wide and $11\frac{1}{2}$ feet deep. In 1898 the right-hand deltaic branches of the Vistula, known as the Königsberger and the Elbinger Vistula, were both made navigable by being dredged to a mean depth of 9 feet and widened to 100 feet. Moreover, from Rothebude on the Vistula an artificial channel (the Vistula–Haff canal) has been constructed to the Frisches Haff, a distance of $12\frac{1}{4}$ miles, of which $8\frac{1}{2}$ were actually dug out; the surface width being 59 feet, the bottom width 37 feet, and the minimum depth $5\frac{1}{4}$ feet.

Vitascope. See CINEMATOGRAPH.

Vitebsk, a government of West Russia, adjoining the Baltic Provinces, with an area of 17,440 square miles. It is mainly built up of Devonian red sandstones and red clays, but the Carboniferous formation—both the Lower, characterized by layers of coal, and the Upper—appears in the east. The whole is covered with Glacial and post-Glacial formations, in which remains of extinct mammals and stone implements are found in large quantities. There are numerous burial-mounds containing bones and iron implements and decorations.

The population, which was 1,204,950 in 1884, numbered 1,502,916 (domiciled only) in 1897, of whom 753,898 were women, and 220,170 lived in towns; 62 per cent. of the inhabitants are White Russians, 21 per cent. Letts, 10 per cent. Jews, 5 per cent. Great Russians, and 2 per cent. Poles. Nearly all the artisans are Jews. The government is divided into eleven districts, the chief towns of which are: Vitebsk, Drissa (4240), Dvinsk, formerly Dünaburg (72,231), Gorodok (5509), Lepel (6316), Lutsin (3929), Nevel (9988), Polotsk (20,751), Ryezhitsa (10,681), Sebezh (4344), and Velizh (12,201). The standard of education is low. In 1897 there were only 1022 primary schools attended by 30,800 boys and 8460 girls. Of the total area of 11,161,600 acres, forests covered 4,300,000 acres in 1855; large stretches have since been cut down, but woods still occupy 3,506,000 acres. About 30 per cent. of the total area is cultivated, and of this the peasants own 37 per cent., private persons 55 per cent., the Crown 6·5 per cent., and various institutions 1·5 per cent. Small landowners are especially numerous, the peasants eagerly buying land from their landlords. In 1900, 2,030,200 acres were under cereal crops, and the average yield in 1895–99 was: rye, 4,054,000 cwt.; wheat, 125,000 cwt.; oats, 2,422,000 cwt.; barley, 1,412,000 cwt.; also 7,547,000 cwt. of potatoes, largely cultivated for distilleries. Gardening is highly developed. Industries are in their infancy, and the annual returns of all factories (chiefly distilleries, match factories, chemical works, and plain woollen cloth mills) do not exceed 5,851,000 roubles.

Vitebsk, the capital of the above province, on both banks of the river Düna, 345 miles by rail west of Moscow. Being in railway communication with both capitals, as well as with Riga, Warsaw, and Prussia, and standing on a navigable river, it carries on an active trade, mainly in corn and animal products. Population (1897), 66,143.

Viterbo, a city and episcopal see of the province of Rome, Latium, Italy, 54 miles by rail north-north-west of Rome. The church of Santa Maria della Verita, with 15th-century frescoes, is now used as a public hall. In the neighbourhood are the ancient Etruscan cemeteries Castel d' Asso, Norchia, &c. Viterbo is the centre of the territory of the "patrimony of Peter," which the Countess Matilda of Tuscany gave to the Papal see in the

12th century. The manufactures include soap, matches, and paper. In the vicinity are mines of alum and sulphur. Population (1881), 16,563; (1900), about 16,000.

Vitoria, the capital of the Basque province of Alava, Spain, 31 miles south-south-east of Bilbao. It is the see of a bishop, and lies on the railway from Madrid to France. Electric light and other improvements have been introduced. Population (1887), 27,660; (1897), 30,514.

Vitry le François, chief town of arrondissement, department of Marne, France, 20 miles south-east of Châlons, on the railway from Paris to Strasburg, at the junction of the Marne–Rhine and Haute-Marne canals. The church of Notre Dame is a 17th-century edifice, with fine 18th-century monuments. A convent of the Récollets is now occupied by the Hôtel de Ville, the Palais de Justice, and a small museum; other local institutions are a library with 17,000 volumes and over 70 MSS., communal colleges for boys and for girls, and a hospital. The Avenue Carnot, laid out since 1895 on the site of the former fortifications, connects a new square, containing a military monument, with the railway station, and a bronze statue and square preserve the memory of Roger Collard (1763–1845), a native of the district. There are important cement works, and works for the manufacture of mosaics, bell-casting, and iron-founding; active commerce is carried on in cereals, wood, malt, and wool. The port traffic on the Marne lateral canal amounted in 1900 to 34,330 tons, and on the Haute-Marne to 9868 tons. The present town was built in 1545 by Francis I. to replace the older one of Vitry-en-Perthois (population, 684 in 1901), 2½ miles to the north-east, burned in the previous year by Charles V. The new town was granted various commercial and administrative privileges, which drew to it many inhabitants from the surrounding district. Population (1896), 7709; (1901), 8075.

Vittorio, a town and episcopal see of the province of Treviso, Venetia, Italy, 25 miles by rail north of Treviso. It is a summer resort, with sulphur and saline springs (51·8° to 59° Fahr.), and has been formed by the union of Ceneda and Serravalle. It possesses a cathedral with a fine altarpiece (1547) by Titian, another church with numerous paintings by Amalteo and others, and a statue to Victor Emmanuel (1882). It is a seat of the silkworm breeding and silk-throwing industries, and also carries on manufactures of woollens, paper, cement, and lime. Population (1900), about 11,000.

Vivero, a town of Spain, province of Lugo, in one of the deep fjords of Galicia. It is connected with the opposite bank of the estuary by a bridge of twelve arches and a causeway. It is an old-fashioned place, with a parish church, hermitages, an unpretentious town hall, and schools. Its fishing fleet, the coasting trade, and the agricultural products of the fertile country around are important. Population (1887), 11,926; (1897), 12,477.

Vivisection.—This word means literally the cutting of living animals (see EXPERIMENTS ON ANIMALS), and might be applied to all surgical operations whether practised upon man or animals. As conventionally used, however, it has exclusive reference to operations upon the lower animals undertaken for experimental purposes. Such experiments have for their object the advancement of the sciences of physiology and pathology. From the earliest periods experimental vivisections have occasionally been practised, but it will be readily imagined that before the days of anæsthetics it was difficult to execute them, and not less difficult to draw conclusions. The invention of anæsthetics has greatly extended the scope of the experimental method, because an animal can be kept unconscious and quiet without even a quiver of a muscle during prolonged operations and subsequent observation. Further, the introduction of the antiseptic method has made it possible to subject all tissues and regions of the body to surgical interference, and this has also had the effect of increasing the possibilities of experimental research.

In the year 1876 the practice of vivisection in the United Kingdom was made subject to law, and an Act was passed "To amend the Law relating to Cruelty to Animals." The chief provisions of this Act are as follows:—"A person shall not perform on a living animal any experiment calculated to give pain" except subject to the following restrictions, viz.: (*a*) The experimenter must be licenced by the Home Secretary, and the experiment must be carried on in a place duly registered by the Home Secretary. (*b*) The animal must be anæsthetized, and, if the pain be likely to continue, be killed before recovering from the anæsthetic. (*c*) The experiment must not be performed in illustration of a lecture unless an enabling certificate (in addition to the licence) be granted by two eminent men of science (Certificate C).

Certificates may also be granted by two eminent men of science for dispensing with the use of anæsthetics (Certificate A), and for allowing the animal to survive the initial operation (Certificate B). Some of the domestic animals are specially protected by the Act; thus Clause 5 says, "An experiment shall not be performed without anæsthetics on a dog or cat" (Certificates E and EE), and "and shall not be performed on any horse, ass, or mule" (Certificate F) without enabling certificates granted by two eminent men of science. Clause 2 designates the eminent men of science (certain Presidents of Royal societies and colleges, and medical professors in chartered colleges), two of whom must sign every application for a licence and every certificate granted under the Act. The Home Secretary shall cause "all registered places to be visited from time to time by inspectors" (Clause 10). Clause 8 provides that the Home Secretary may revoke a licence "on his being satisfied that such licence ought to be revoked," and further states that "there may be annexed to such licence any conditions which the Secretary of State may think expedient for the purposes of better carrying into effect the objects of this Act, but not inconsistent with the provisions thereof."

Only the main provisions of the Act are given above but it is as well to state that the Act is rather complicated and not very clear, and that all intending licensees should obtain a copy and endeavour to master it. It is interesting to note that only one attempt (an unsuccessful one) to obtain a conviction under the Act has ever been made. In one sense this is to be regretted, because the Act stands in need of interpretation. The licensees have always obeyed the interpretation of the Home Office, and in fact Clause 8 gives the Home Secretary the power of interpreting the Act in any way he chooses. For example, the interpretation of Clause 5 has given rise to some discussion. This clause provides that "an operation shall not be performed *without anæsthetics* on a cat or dog" unless an enabling certificate be obtained (Certificate E). If anæsthetics be used, and if the animal be killed before recovery, it is clear that a cat or dog may be used without Certificate E. If anæsthetics be used for the initial operation, and the animal be allowed to recover (Certificate B), is it permissible to use a cat or dog without an enabling certificate, E? The Home Secretary has answered this question in the negative, because so long as the animal lives it is in an experimental condition—a somewhat arbitrary decision. The custom is to issue two forms of certificates for the use of cats and dogs, one designated E to be coupled with Certificate A, and the other designated EE to be coupled with B.

The Act was framed for the control of "experiments calculated to give pain." All operations on the lower animals which are not of the nature of experiments, such as gelding and spaying, are still performed without let or hindrance by farriers, and the word "experiment" remains to be interpreted. A veterinary surgeon must sometimes be in grave doubt as to his relations to the Act. Again, the words "calculated to give pain" are left to be interpreted by the licensee. The result is that the man who wishes to perform experiments on living animals of any kind usually protects himself by applying to the Home Secretary for a licence and certificates, and the Home Secretary never takes upon himself the responsibility of saying that the experiments proposed are, from the point of view of pain, too trivial to come under the Act. Thus such experiments as feeding an animal on tuberculous meat, or rubbing the fungus of ringworm on the back of a mouse with a view to transplantation, have been performed under the Act. Such procedures are not in any sense "vivisections," but it is to be noted that the word vivisection is nowhere used in the Act, which is for the control of "experiments calculated to give pain."

Since the Act was framed the science of bacteriology has made great strides, and as a consequence the inoculation of animals (chiefly guinea-pigs and other small rodents) has become increasingly necessary, and the bacteriologist is accustomed to protect himself by becoming a licensee under the Act. Hence the belief is general that although one may vaccinate a baby, a risk of a £50 fine is incurred by vaccinating a guinea-pig. Whether a jury would take this view is doubtful. The writer has closely examined many thousands of inoculated guinea-pigs, and he has never seen one which he could say was in pain. It is quite clear to any one who reads the Act that the framers of it did not contemplate the trivial operation of inoculation. Out of 9151 experiments performed in 1898, no less than 7640 were needle pricks or proceedings equally trivial. (G. V. P.)

Vizagapatam, a town and district of British India, in the Madras Presidency. The town stretches for 3 miles along the coast on both sides of the mouth of a small river and has a station on a short branch of the East Coast Railway, 494 miles north-east of Madras. Population (1881), 30,291; (1891), 34,487; municipal income (1897–98), Rs.44,000. The town owes much to the munificence of the neighbouring Raja of Vizianagram. A water supply has been provided at a cost of Rs.1,60,000, and there is a system of sewage filtration. The European quarter is known as Waltair. There is a considerable Roman Catholic population and a London mission. The exports by sea include rice and sugar. Some weaving is carried on, and a speciality is made of ornamental boxes, &c., carved out of sandalwood, horn, ivory, porcupine quills, and silver. The aided college had 36 students in 1896–97, and the three aided high schools 950 pupils. There are eight printing-presses, issuing a district gazette, and two weekly newspapers in English; three reading-rooms and literary institutions. The hemp-mill producing bags and cloth has 2084 spindles and 98 looms, and employs 800 hands.

The district of VIZAGAPATAM has an area of 17,242 square miles. Population (1881), 2,481,284; (1891), 2,802,992, showing an apparent increase of 13 per cent.; average density, 162 persons per square mile, ranging from 68 in the Agency tract to 421 in the rest of the district. In 1901 the population was 2,933,537, showing a further increase of 5 per cent. The land revenue and rates in 1897–98 were Rs.19,49,413, the incidence of assessment ranging from Rs.2.11.2 per acre in the *rayatwari* lands to R.0.1.7 in the *zamindaris;* cultivated area (in the *rayatwari* lands alone), 235,431 acres, of which 95,298 were irrigated from tanks, &c., including 30,069 from Government canals; number of police, 1727; boys at school (1896–97), 30,366, being 14·5 per cent. of the male population of school-going age; registered death-rate (1897), 31·6 per 1000, the highest rate in the province. The principal crops are rice, millet, other food-grains, and oil-seeds. The district is traversed throughout by the East Coast Railway, opened from Madras to Calcutta in 1901; and it has been proposed to construct a line through the hills from Vizianagram to Raipur in the Central Provinces. The chief seaports are Bimlipatam and Vizagapatam. In 1897–98 the total sea-borne trade was valued at Rs.94,17,240, of which nearly half was with foreign countries.

Vizeu, a town and episcopal see of Portugal, capital of district Vizeu, 50 miles south-east of Oporto, and 4 miles north-west of the Dão (an affluent of the Mondego). The cathedral, which was founded by Count Henrique, contains pictures by the native artist, Grão Vasco. The town stands near the ruins of the ancient *Vacca*, or *Cava de Viriato*, a Roman military colony founded by Decius Brutus, and captured by Viriathus the Lusitanian. Population (1890), 7996. The district of VIZEU, which corresponds to the ancient province of *Beira Alta*, has an area of 1920 square miles, and a population (1900) of 402,799.

Vizianagram, a town of British India, in the Vizagapatam district of Madras, 17 miles from the seaport of Bimlipatam; station on the newly opened East Coast Railway (528 miles north-east of Madras), whence it is proposed to extend a branch north through the hills to Raipur. Population (1881), 22,577; (1891), 30,881; municipal income (1897–98), Rs.35,550. Until recently it was a military cantonment. It contains the residence of a *zamindar* of the same name, who ranks as the first Hindu nobleman of Madras. His estate covers an area of about 3000 square miles, with a population of 900,000. The estimated income is £180,000, paying a permanent land revenue of £50,000. The town possesses many fine buildings, entirely supported by the Maharaja. The college had 96 students in 1896–97; the two high schools 745 pupils. There are two printing-presses, one of which issues a newspaper in English, a library, and a young men's association.

Vladikavkaz, a town and fortress of Russia, northern Caucasia, the capital of the province of Terek, on a plateau, at an altitude of 2340 feet, on both banks of the Terek, where that river issues from the Darial gorge. It is 433 miles by rail from Rostov-on-the-Don, and has regular communication by coach with Tiflis (133 miles). Moreover, a line of railway, running eastwards to the Caspian ports of Petrovsk and Baku, connects Vladikavkaz, or rather the station Beslan, 14 miles north of it, with the Transcaucasian Railway, that is, with Tiflis, Poti, and Batum. It occupies an important military position, defending the only good passage across the central portion of the main Caucasus range, and is also advantageously situated for trade. Consequently its population has grown very rapidly from 2500 in 1859 to 10,000 in 1870, and 43,843 in 1897.

Russians, Armenians, and Jews constitute the bulk of the population, which also contains Ossets, Chechens, Ingushes, and others. The garrison numbers 12,000, besides Cossacks. There are several large distilleries and a number of smaller factories, showing an aggregate annual return of about £200,000. The town is well built, and has gymnasia for boys and girls, about twenty primary schools, a handsome theatre, public gardens, and several monuments to Russian generals. The best quarter of the town is that on the right bank of the Terek; an iron bridge connects it with the commercial quarter.

Vladimir, a government of Central Russia, lying between Moscow and Nijni-Novgorod, with an area of 18,864 square miles. The geology of the province, and especially of its western parts, has been investigated by Professor Nikitin, who has ascertained that under the Glacial and post-Glacial deposits—the lower layers of which contain remains of the mammoth and rhinoceros, and the upper widely-spread fossils of prehistoric forests—occur Lower Chalk deposits and deposits intermediate between the Chalk and the Jurassic ("Volga" deposits). Upper Jurassic (Kellaway and Oxford) and Upper Carboniferous deposits are also found, and at Gorbatoff, Permian marls. Its population, which was 1,359,330 in 1883, numbered in 1897 1,570,733 (domiciled only), of whom 837,512 were women and 183,783 lived in towns.

It is divided into thirteen districts, the chief towns of which are: Vladimir, Alexandroff (6848), Gorokhovets (2783), Kovroff (14,570), Melenki (8904), Murom (12,589), Pereyaslavl Zalesskiy (8662), Pokroff (2925), Shuya (18,968), Sudogda (3406), Suzdal (8000), Vyazniki (7398), and Yurieff Polskiy (5637). Ivanovo-Voznesensk (53,949), Gusevsk, Kholui, and several others are important industrial towns. The *zemstvos* (provincial and district councils) make considerable efforts to spread education and improve the sanitary arrangements, and there were in 1897 1313 primary schools attended by 51,077 boys and 18,021 girls. The peasants hold 5,591,000 acres in communal ownership, and of this 60 per cent. is arable land; 3,802,800 acres belong to private owners, 552,300 acres to the Crown, and 370,000 acres to the Imperial family. The soil is not very fertile and the standard of agriculture is low, the inhabitants being largely engaged in manufactures. Still there were in 1900 1,908,200 acres under cereals, and the average yield in 1895–99 was: rye, 5,588,000 cwt.; wheat, 146,000 cwt.; oats, 2,522,000 cwt.; barley, 183,000 cwt.; various cereals, 567,000 cwt.; also 5,550,000 cwt. of potatoes. Cattle-breeding is only less important than agriculture, and in 1897 there were in the province 190,830 horses, 300,000 horned cattle, 271,000 sheep, and 17,000 pigs. Gardening is very widely spread, and cherries and apples are exported in considerable quantities. Of minerals the only important one is alabaster, of which some 8500 tons are obtained annually. Vladimir ranks third among the governments of European Russia for manufactures. It has some 500 large factories, which employ over 100,000 persons (one-third women), and the aggregate returns of which amounted in 1898 to no less than 206,557,000 roubles. The principal establishments are cotton, linen, and silk mills, dye-works, and rope, paper, cardboard, oil, chemical, machinery, glass, and iron works (producing annually 342,000 cwt. of pig iron and 136,000 cwt. of iron), tanneries and distilleries. Wood, coal, naphtha, and peat are all used as fuel. There are, further, about 1000 small factories, employing about 5000 workers, and domestic industries are to be found in nearly every village; the most important of these minor industries are cotton, linen, and silk weaving, and the making of hardware and glass goods. The movement of shipping on the Volga and its tributaries and sub-tributaries, the Oka, the Klyazma, and the Teza, is considerable. The principal ports are Murom on the Volga, and Kovroff, Vyazniki, and Oryekhoff on the Klyazma. Timber, wood for fuel, and manufactured goods are the chief exports. The province affords a very rich field for research to the archæologist. Numbers of Palæolithic stone implements, mixed with bones of the mammoth and the rhinoceros, and still greater numbers of Neolithic stone implements have been discovered. There are also a great number of burial-mounds belonging to the Bronze and Iron periods, and containing decorations in amber and gold; nearly 2000 such burial-mounds are scattered round Lake Plescheyevo, some of them belonging to the pagan period and some to the early Christian. Coins from Arabia, Bokhara, Germany, and Anglo-Saxon lands are found in great quantities.

Vladimir, the capital of the above government, on the rivers Klyazma and Lybed, 114 miles by rail east of Moscow. It remains an old city, with very unsatisfactory sanitary arrangements, and its industries and trade are below those of several towns in the government. Besides the usual lyceums for boys and girls it has, however, a technical school with about 100 pupils, and its population is now increasing more rapidly, numbering 28,065 in 1897.

Vladimir-Volhynsk, a district town of Russia, in the government of Volhynia, 17 miles N.N.E. of the spot where the frontiers of Russia proper, Poland, and Galicia meet, and 34 miles S.W. of the South-Western Railway at Kovel. It is an ancient town, not mentioned in the annals before 988, but probably in existence in the 9th century under the name of Ladomir. In the 10th century it was the capital of the principality of Volhynia, and in the Middle Ages covered a very large area, and was well fortified. The Tatars and the Lithuanians besieged it and destroyed it several times, but it always recovered, and only fell into decay in the 17th century. It was finally annexed to Russia after the first division of Poland. There are several very interesting ruins in and near the town, including remains of a church supposed to have been built by Vladimir, and of another built in 1160 by Mtsislav; judging from parts of its floor which have been discovered, this latter was very well built, and its length exceeded that of the temple of St Sophie at Kieff. The town contains a good archæological museum, and had in 1897 a population of 9695, three-fourths of whom were Jews.

Vladivostok, the chief Russian seaport and naval station in the Pacific Ocean, situated at the southern extremity of the Maritime Province, comparatively near the point where that government meets both Manchuria and Korea. It is now connected by rail with Khabarovsk (475 miles N.N.E.), the capital of the Amur region, and by means of the Trans-Manchurian Railway with Tchita in Transbaikalia (1280 miles), *viâ* Ninguta, Harbin, Tsitsikar, and Hailar. The town has greatly developed, and has several handsome buildings, a monument to Admiral Nevelskoy, gymnasia for boys and girls, several professional schools, a naval hospital, mechanical and naval works, four steam saw-mills, three steam flour-mills. In 1897 its population was 28,896. The port of Vladivostok grows every year in importance, chiefly for imports; but the great bulk of the latter are for the Government, *i.e.*, either for the Manchurian Railway or for the military. The great drawback of Vladivostok is that it has not, and cannot have, a well-developed hinterland. Efforts have been made by the Russian Government to supply the Usuri region (to the north of Vladivostok) with Russian settlers. However, the physical characters of the valley of the Usuri are such as to prevent a considerable agricultural population from ever being settled there. In 1882, notwithstanding heavy expenditure, only 3000 Russian peasants had been settled in the South Usuri region, in fourteen villages, and only 1500 were added, during the next fifteen years, out of emigrants who had come overland. Besides 28,460 emigrants brought in in ships on 1st January 1899, the agricultural Russian population (in addition to the Cossacks) was 52,724, in 108 villages. Nearly all of these (103) were situated in the South Usuri district, near Lake Hanka, on the littoral near Vladivostok, and only five villages in the central part, *i.e.*, in the valley of the Usuri. The Cossacks numbered at the same time only 11,293, in fifty villages. During the years 1899–1901, 28,256 persons more immigrated (peasants), and a few thousand Cossacks were settled in the territory of the Usuri Cossacks, while on 1st January 1899 there were also 15,190 Koreans—all in the South Usuri district—and a still larger number of Chinese (estimated). Altogether, owing to the peculiarities of the wet climate, the Russian settlers do not prosper.

(P. A. K.)

Vogel, Sir Julius (1835–1899), British Colonial statesman, son of Albert Leopold Vogel, was born in London on 24th February 1835, was educated at University College school, London, and emigrated to Victoria during the exciting years which followed the discovery of gold-fields there. He became editor of a newspaper at Maryborough, stood for the Legislative Assembly and was defeated, and in 1861 left Victoria, carried in the mining rush to Otago, New Zealand, where much gold had just been found. Settling in Dunedin, he bought a half-share in the *Otago Daily Times*, and was soon its editor and a member of the Otago Provincial Council. He made his paper the most influential in the colony, and was returned to the House of Representatives. In 1866 he was head of the Otago Provincial Executive; by 1869 he had made his mark in the New Zealand Parliament, and was treasurer in the ministry of Sir William Fox. Without delay he brought forward his famous public works policy, a scheme for the construction of trunk railways and other public works, the purchase of land from the Maori tribes, and the introduction of immigrants, all to be done with money borrowed in London. At that time New Zealand hardly contained a quarter of a million of white settlers, was exhausted by the ten years' struggle with the Maori, not then ended, and was depressed by the low price of her staple product, wool, and the abatement of a gold-fever. Yet Vogel's sanguine, energetic appeals and remarkable gift of persuasion induced the House of Assembly to adopt a modified version of his scheme. For the next six years he was the most powerful man in the colony. Millions were borrowed, railways were pushed on, immigrants — State and voluntary — streamed in. Lasting peace was made with the Maori, a telegraph line laid to Australia, a steam mail service secured across the Pacific to San Francisco; a Government life insurance office, and a public trust office, were established, both of which proved useful and were well-managed. During a visit to London on the colony's financial business, Vogel succeeded in arranging for the inscription of Colonial loans at the Bank of England, an arrangement afterwards confirmed by an Act of the Imperial Parliament. In 1875 he was knighted. But in 1874 Vogel, until that time a supporter of the Provincial system, decided to abolish it. In this, with the aid of Sir E. W. Stafford and Sir H. A. Atkinson, he succeeded. In the struggle, however, he broke with many of his old allies, and in 1876 suddenly quitted New Zealand to take the post of Agent-General in London. This he held until 1880, and while holding it negotiated a loan for five millions. But having become connected with certain public companies, and the New Zealand Government objecting thereto, he had to resign his position. An attempt, too, which he made in 1880 to enter the House of Commons as Conservative member for Penryn was unsuccessful. Still his influence was great in New Zealand, and when in 1884 he returned thither he was elected by acclamation to Parliament, and at once formed a coalition ministry with the Radical leader, Sir R. Stout. They held office for three years, but though Vogel showed some of his old financial skill, they were not years of prosperity for the colony, or triumph for the Government. A deficit, a rejected scheme of taxation, and a crushing defeat at the polls, ended Vogel's career as a minister. After a few months of failure as leader of an outnumbered Opposition he gave up the contest, left New Zealand for the last time, and for the last eleven years of his life lived quietly near London. Throughout his life he had from time to time to struggle with deafness, lameness, and attacks of acute bodily pain, while an impulsive, speculative nature led him once and again into financial difficulties. The persistency with which he faced trouble and embarrassment, the hopefulness he showed under stress of ill-fortune, the sympathy and pleasantness of manner which won him friends at all times, were elements in his curious and interesting character no less remarkable than the fertility and imaginative power of his busy brain. Vogel was among the pioneers of Imperial Federation; he would have extended Great Britain's influence in the Pacific Ocean had he been allowed. He was the first minister to secure the second reading of a Women's Franchise Bill in New Zealand. As long ago as 1874 he endeavoured to save the New Zealand forests from the reckless destruction by axe and fire which has ever since gone on. In 1889 a novel from his pen, *Anno Domini 2000*, was published, and reached a second edition. He died at East Molesey on 13th March 1899. His wife, who was the daughter of William Clayton, Government architect, New Zealand, two sons, and a daughter survived him. Another son had been killed in the Matabele war in South Africa. Vogel was a Jew of the Ashkenazi rite. (W. P. R.)

Voice.—The voice is produced by vibrations of the vocal cords, and developed in volume and quality by the resonance of the upper cavities. The general mechanism of the larynx has been described in the 9th edition of this work, vol. xxiv. p. 273 *seq.* And there are only a few points to be noticed that have received attention since the date of that article.

1. *The Muscular Mechanisms.*—The vocal cords are tightened by the action of the crico-thyroid, or, as it might be more appropriately termed, the thyro-cricoid muscle. It stretches the thyro-arytenoid ligaments, the free edges of which, covered by mucous membrane, form the vocal cords. The adductors of the cords are the lateral crico-arytenoids, while the posterior crico-arytenoids are the abductors. The arytenoid muscle brings the cords together. Many of the fibres of the thyro-arytenoid are inserted obliquely into the sides of the cord, and in contraction they tighten the cord by pulling on the edge and making it curved instead of straight. Some such action is indicated by the elliptical shape of the rima glottidis in passing from the chest register to the middle register. Other fibres, however, running parallel with the cord may tend to relax it in certain circumstances. All the muscles except the thyro-cricoid (which is innervated by the superior laryngeal) receive nerve filaments from the inferior laryngeal branch of the vagus, the fibres being derived from the accessory roots. Both the abductor and adductor nerves come therefore from the inferior laryngeal. When deeply anæsthetized stimulation of the inferior laryngeal nerve causes abduction of the cord, but if the anæsthesia is slight, then we have adduction (Semon, *Brit. Med. Jl.*, 1886, vol. ii. p. 405). The tonic contraction of the abductors is stronger than that of the adductors, so in a state of rest the glottis is slightly open. The centre of innervation is in the medulla oblongata, and this is dominated by a centre in the Rolandic region of the cerebral cortex.

2. *The Voice Registers.*—The voice has been divided by writers into three registers, the lower or chest, the middle, and the small or head register. In singing, the voice changes in volume and in quality in passing from one register into another. There is remarkable diversity of opinion as to what happens in the larynx in passing through the various registers (see art. "Vocal Sounds," by author and Gray in Schäfer's *Text-Book of Physiology*, vol. ii. p. 1210, along with bibliography, p. 1214). There has also been much discussion as to the production of falsetto tones. Lehfeldt and Johannes Müller held that a weak blast of air caused only a portion of the cords, as regards length, to vibrate; Oertel noticed that when a falsetto tone is produced nodal lines are formed in the cords parallel to their edges, an observation supporting the first contention; Garcia was of opinion that as the voice rose in pitch into falsetto only the ligamentous edges of the cords vibrated; and Hodgkinson showed by

dusting finely powdered indigo into the larynx and observing the blue specks with the laryngoscope that "in the deeper note of the lower register the vibrating margin extended from the thyroid cartilage in front to a point behind the junction of the ligamentous and cartilaginous portions of the cord" (Hodgkinson, *Brit. Med. Jl.*, 1895, vol. ii. p. 482). In singing falsetto tones these additional parts are not thrown into action. Some remarkable and instructive photographs obtained by French show that in proceeding from the lowest to the highest notes of the lower register the cords became lengthened by one-eighth of an inch in a contralto singer's larynx; the same singer, in passing into the middle register, showed a shortening of the cords by one-sixteenth of an inch, and another increase in length when the upper part of the middle register was reached (Semon, *Proc. Roy. Instit.*, London, 1891; French, *Verhandl. d. internat. med. Kong.*, Berlin, 1890).

3. *Vowel Tones.*—During the last few years much attention has been directed to the musical quality of vowels. A vowel is a musical tone produced by the vibrations of the vocal cords. The tone produced by the vocal cords is a mixed one, composed of a fundamental and partials, and certain of the partials are strengthened by the resonance of the air in the air-passages and in the pharyngeal and oral cavities. In this respect the quality of the human voice depends on the same laws as those determining the quality or timbre of the tones produced by any musical instrument. The pitch of the note of a musical instrument, however, depends on the pitch of the first or fundamental tone, while the partials are added with greater or less intensity so as to give a special character to the sound; and in the case of a vowel tone the pitch does not appear to depend on that of the fundamental tone but on the pitch of the resonance cavity, as adjusted for the sounding of any particular vowel. When we wish to pronounce or sing a vowel the oral cavity must be adjusted to a certain form, and it is only when it has that form that the vowel can be sounded. Many attempts have been made to determine the pitch of the oral cavity, with the result that competent observers have given very different estimates, probably because the vowel tones of men of different nationalities are not alike (see art. "Voice," by author, in Schäfer's *Text-book of Physiology*, vol. ii. p. 1215; this also contains full bibliographical references). The nature of vowel tones has been investigated by means of the phonograph by Fleeming Jenkin and Ewing, Hermann, Pipping, Boeke, Lloyd, McKendrick, and others. These observers may be ranged in two divisions—those who uphold the theory of relative as opposed to those who contend for the theory of fixed pitch. Assuming that a vowel is always a compound tone, composed of a fundamental and partials, those who uphold the relative pitch theory state that if the pitch of the fundamental is changed the pitch of the partials must undergo a relative change, while their opponents contend that whatever may be the pitch of the tone produced by the larynx, the pitch of the partials that gives quality or character to a vowel is always the same, or, in other words, vowel tones have a fixed pitch. The methods by which this problem can be investigated are mainly two. The pitch of the oral cavity for a given vowel may be experimentally determined, or an analysis may be made of the curve-forms made on the wax cylinder of the phonograph when a vowel is sung into it. By such an analysis, according to Fourier's well-known theorem, the curve may be resolved into the partials that take part in its formation, and the intensity of those partials may be thus determined. The observations of Donders, Helmholtz, König, and others as to the pitch of the resonating cavities gave different results. Greater success has followed the attempts made by Hermann, Boeke, McKendrick, Lloyd, and Marichelle to analyse the curves imprinted on the phonograph. (Examples of such phonograms are given by the author in the article on "Vocal Sounds" in Schäfer's *Physiology*, vol. ii. p. 1228; see also PHONOGRAPH.)

The following is an instructive analysis by Boeke of the curves representing the tones of a cornet, and it illustrates the laws that govern the production of quality in such an instrument:—

Note . .	1	2	3	4	5	6	7	8	9	10	Partials.
f =170 vibs. .	1	1·05	1·22	1·15	1·01	0·80	0·53	0·28	0·13	0·10	,,
c′ =256 ,, .	1	0·92	0·81	0·53	0·39	0·20	0·07	0·04	0·06	0·04	,,
g′ =384 ,,	1	0·76	0·46	0·14	0·09	0·06	0·07	0·02	0·01	0·01	,,
c″ =512 ,, .	1	0·92	0·30	0·14	0·15	0·09	0·07	0·06	0·03	0·02	,,

These figures represent the relative intensities of the partials entering into the formation of the note, and it will be observed that the intensity gradually diminishes. This analysis may be contrasted with that of the vowel *āā* sung by Boeke (æt. 50) on the notes *f* and *c′*, and the same vowel sung on the notes *g′* and *e″* by his son (æt. 12).

Man, æt. 50, singing *āā*.

Pitch . .	1	2	3	4	5	6	7	8	9	10	Partials.
f =170·6 vibs.	1	0·86	0·46	**1·74**	**1·90**	1·55	0·51	0·54	0·43	0·44	,,
c′ =256 ,,	1	0·49	**1·96**	**1·25**	0·60	0·56	0·23	0·05	0·06	0·10	,,

Boy, æt. 12, singing *āā*.

Pitch . .	1	2	3	4	5	6	Partials.
g =384 vibs. .	1	**1·22**	**2·67**	0·45	0·17	0·06	,,
e′ =640 ,, .	1	**8·09**	1·45	0·53	..	..	,,

It will be observed that in both these cases the intensity of the partials does not fade away gradually as we proceed from the lower to the higher partials, as with the cornet, but that certain partials are intensified more than others, namely, those printed in black. In other words, the *form* of the resonating cavity develops particular partials, and these modify the quality of the tone. If we multiply the vibrational number of the fundamental tone by the number of the partial we obtain the pitch of the resonance cavity; or if we take the mean of the partials reinforced, we obtain the pitch of the mean resonance. Lloyd applies this method to the above figures, as follows:—

	Partials Reinforced.	Mean Partial.	Pitch in Complete Vibration.
Man's *āā*.			
f =170·6 vibs. . . .	4–6	4·96	846
c′ =256 ,, . . .	3–4	3·39	868
Boy's *āā*.			
g′ =384 vibs. . .	2–4	2·82	1084
e″ =640 ,, . . .	1–3	2·04	1307

This analysis shows: (1) That the man's resonance rises slightly (half-semitone) in ascending seven semitones in the middle of his register; (2) that the boy's resonance rises three semitones in ascending nine semitones in the upper half of his register; and (3) in the mid-register the boy's resonance is to the man's as 5 : 4. Thus, as we sing a vowel in an ascending scale the pitch of the oral cavity slightly changes, or, in other words, the pitch of the resonating cavity for a given vowel may be slightly altered. Lloyd supports the view that vowels owe their quality not to the resonance of a partial or partials of a certain fixed pitch, but to the relative pitch of two or more partials. He describes a pharyngeal or α-resonance and an oral or β-resonance, and the ratio of these resonances, or the radical ratio, as he calls it, determines the nature of the vowel. Thus, for A, as in "fat," the lower resonance has a pitch of 736, while the upper has 1121. The radical ratio is therefore

$$\frac{1121}{736} = 1{\cdot}47.$$

It would appear that both theories are partially true; they are not mutually exclusive. The view of Donders that each vowel has an oral cavity of unchangeable and fixed pitch is too exclusive, and, on the other hand, it cannot be denied that each vowel has a predominant partial or predominant partials which give it a definite character, and which must be produced by the oral cavity as a whole, or by the double resonance of portions of the cavity, as suggested by Lloyd. As we sing a vowel in an ascending scale the form of the resonance cavity may slightly change, but not sufficiently to alter the quality of the vowel. Thus we still detect the vowel tone. A singer almost instinctively chooses such vowels as best suit the resonating arrangements of his or her voice, and avoids vowels or words containing vowels that would lead to the production of notes of inferior quality.

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Volcanoes. See GEOLOGY.

Volcano Islands, three small islands forming part of the Japanese empire, and known in Japan as Kwazan-rettô (series of volcanic islands). They are situated between 24° and 26° N. and 141° and 142° E. Their names are Kita-iwô-jima, Iwô-jima, and Minami-iwô-jima. Kita-iwô-jima—which, as its name (kita) implies, is the most northerly of the three—rises to a height of 2520 feet above the water, and Minami-iwô-jima, the most southerly, to a height of 3021 feet.

Volchansk, a district town of Russia, in the government and 53 miles N.E. of the town of Kharkoff, connected by a branch line (29 miles) with Byelgorod on the Kursk–Kharkoff Railway. Owing to the activity of the *zemstvo* (or district council) the primary schools in the town and the district are in an exceptionally good condition. In addition to a normal school for teachers the town contains several tanneries, while there are in the district several important distilleries and sugar works. The town was founded in 1674, and had in 1897 a population of 11,322.

Volga, the chief river of European Russia, and by far the largest river in Europe, rising on the Valdai plateau in the province of Tver, and after a sinuous course of 2325 miles entering the Caspian Sea at Astrakhan. It drains an area covering 563,300 square miles, or more than the aggregate areas of Germany, France, and the United Kingdom, with a population of over fifty millions. The total length of navigable rivers in its basin is 19,728 miles, that is, 38 per cent. of the length of all navigable rivers in European Russia. In 1898 the Volga and its tributaries were navigated by 1392 steamers of 86,775 horse-power, and 7600 other vessels of 5,505,000 tons. The Neva and the canals joining it to the Volga were further navigated by 362 steamers of 118,830 horse-power, and 7102 other vessels of 2,056,000 tons. Thus 55 per cent. of all the steamers plying in European Russia belong to the Volga basin.

The traffic on the Volga continues to be enormous, notwithstanding the competition of the railways. In 1897 14,515,000 tons of goods were transported in the basin of the Volga (including about 4,000,000 tons on rafts), of which 3,615,000 tons were timber, 1,540,000 tons wood for fuel, 2,291,000 tons cereals, 3,011,000 tons naphtha and various oils, 604,000 tons salt, and 3927 tons various goods. Further, no less than 125,000 tons were transported by way of canals from the Volga to the Neva, and 70,000 tons in the opposite direction, and 70,000 tons from the Volga to the Northern Dvina (Archangel), and 35,000 tons in the opposite direction. Considerable efforts have been made to keep the depth of the main channel always the same; naturally, it varies to such an extent that in summer the river can only be navigated by vessels with one-half the draught and one-third the cargo of those it will receive in spring. A dozen dredging machines are kept continually at work, while some forty steamers are stationed near the main sandbanks to assist vessels running aground. The leakage from the boats which transport naphtha up stream from the Caspian Sea is so great that fears have been excited that it may seriously affect the fishing industry. The following table shows the principal river ports, together with the movement of shipping in an average year:—

Chief River Ports on the Volga.	Vessels.		Tons.			Approximate Value of Trade.
	Entered.	Cleared.	Imported.	Exported.	Total.	
						Roubles.
Astrakhan . .	2,724	3228	938,000	3,734,000	4,672,000	73,900,000
Tsaritsyn .	6,412	1482	1,152,000	462,000	1,614,000	47,000,000
Rybinsk . .	3,760	6295	590,000	172,000	762,000	33,800,000
Nijni-Novgorod .	12,960	7585	4,092,000	84,000	4,176,000	25,800,000
Saratoff .	1,639	1738	923,000	128,000	1,051,000	17,800,000

The chief ports for the export of cereals are Samara (278,600 tons), Balakovo (200,000 tons), Saratoff (100,000 tons), and Rovnoye (80,000 tons), all on the Volga, and Chistopol on the Kama (100,000); for salt, Vladimirovka on the Volga (200,000), and Novo Usolie and Dedyukhino on the Kama (100,000 and 50,000 tons respectively); for iron, Levchinsk on the Chusovaya (100,000 tons); for naphtha, Astrakhan. From the last-named over 2,870,000 tons of naphtha and naphtha refuse, and 500,000 tons of refined oil and other naphtha produce are shipped; 660,000 tons are unloaded at Tsaritsyn to be shipped by rail into the interior of Russia, 606,000 tons at Saratoff, over 700,000 tons at Nijni-Novgorod, and about 150,000 at Rybinsk. Wood is chiefly shipped from Vetluga and Makarieff on the Unzha. The export of eggs and poultry, both alive and dead, has assumed important dimensions; the chief exporting governments (in the Volga basin) are Kazan, Samara, Saratoff, and Nijni-Novgorod. As a rule, the goods are shipped for long distances, varying, according to the class of goods, from 200 miles to 1060 miles; the average distance is 552 miles, so that the whole traffic is represented by 15,390 ton-miles (23,085 metric ton-kilometres) for all European Russia, as against 27,580 ton-kilometres for the traffic on all railways. Of the river traffic denoted by the above figure, about 55 per cent. falls within the basin of the Volga. As to cost it is estimated to be only one-third of that by rail.

(P. A. K.)

Volhynia, a government of South-West Russia, on the Austrian frontier, with an area of 27,473 square miles. Its population, which was 2,096,500 in 1884, numbered 2,997,902 (domiciled only) in 1897, of whom 1,485,461 were women, and 231,083 lived in towns. It is divided into twelve districts, the chief towns of which are Zhitomir, which is also the capital of the province, Dubno (13,785), Kovel (17,304), Kremenets (17,618), Lutsk (18,525), Novgrad Volhynskiy (16,873), Ostrog (14,530), Ovrutch (6057), Vladimir Volhynskiy (9695), Rovno (24,905), Staro-Konstantinoff (16,527), and Zaslavl (12,688). The standard of education is relatively high, and school gardens are extending in the villages.

The conditions of peasant ownership differ from those which prevail in other parts of Russia, and of the total area of 17,582,720 acres the peasants held in 1896 only 8,120,000 acres; 42 per cent. of the total was in the hands of private owners a considerable number of Germans having settled and bought land in the province. Forests occupied in 1897 5,632,000 acres, covering nearly 50 per cent. of the area in the north (that is, in the so-called Polyesie), and 15 per cent. elsewhere. Agriculture is well developed in the south, and in 1900 there were 4,222,400 acres under cereal crops alone. The average yield in 1895–99 was: rye, 8,817,000 cwt.; wheat, 4,290,000 cwt.; oats, 5,721,000 cwt.; barley, 2,135,000 cwt.—all cereals, 5,801,000 cwt.; also 14,290,000 cwt. of potatoes, which are largely grown for distilleries. The beet crop of 1899 was estimated at 6,126,000 cwt., and that of tobacco (1500 acres) at 1000 tons. Gardening and apiculture (150,000 hives) are widely engaged in with excellent results, and large quantities of fruit are exported. The livestock is increasing, especially horses in the southern districts; in 1898 there were in the province 748,550 horses, 845,360 horned cattle, 916,000 sheep, and 613,000 pigs. Lignite and coal, some graphite and kaolin are mined, as also amber, which is often found in very big lumps. Manufacturing industries are not very highly developed. The factories are limited to a number of large sugar works and distilleries, some woollen cloth mills, and candle, tobacco, and agricultural machinery works, and their aggregate annual returns do not exceed 25,000,000 roubles. Domestic industry in the villages is chiefly limited to the making of all sorts of wooden goods, including parquetry. The exports of grain and timber, chiefly to Germany and Great Britain, and of wool and cattle, are considerable. The chief imports are agricultural machinery and manufactured goods.

Vołkovysk (*Wołkowysk*), district town of Russia, in the government of Grodno, 52 miles by rail east of Byelostok. It is an ancient town, the possession of which was long disputed by the princes of Volhynia and Lithuania, it being held first by one and then by the other. It was finally annexed to Russia after the first division of Poland. It has two flour-mills and several small factories, and had in 1897 a population of 10,584.

Vollmar, Georg von (1850–——), German Socialist, was born at Munich in 1850. He was educated in a school attached to a Benedictine monastery at Augsburg, and in 1865 entered the Bavarian army as a lieutenant in a cavalry regiment. He served in the campaign of 1866, and then entered the Papal army as a volunteer. In 1869 he returned to Germany, and during the war with France served in the army railway department. He was severely wounded at Blois and pensioned. Permanently crippled by his wounds he devoted himself to political and social studies. In 1872 he was converted to the principles of Social Democracy, and as soon as his health was sufficiently restored threw himself with great energy into the political agitation. In 1877 he became editor of the party organ at Dresden, and under the Socialist law was repeatedly condemned to various terms of imprisonment, and was also expelled from that city. From 1879 to 1882 he lived at Zürich, then the headquarters of Social Democracy, when besides attending the university he took part in editing the *Social-Demokrat*. In 1881 he was elected member of the Reichstag, and from 1883 to 1889 was a member of the Saxon Diet. Since 1885 he has resided in Bavaria, and it is to him that is chiefly due the great success of the Socialists in the older Bavarian provinces; he succeeded in completely defeating the Clerical party on their own ground, so that Munich was in 1902 represented in the Reichstag by four Socialists. His great popularity and influence in Bavaria have given him a peculiar position in the party and have enabled him to use his power to found a more moderate and opportunist section. He has decisively dissociated himself from the doctrine of a sudden and violent overthrow of society, and urged his associates to co-operate in bringing about a gradual development towards the Socialistic state. He has refused to identify Social Democracy with the extreme views as to religion and the family advocated by Bebel; he has expressed his approval of the military and foreign policy of the German Government, when, as in the Triple Alliance, it is necessary to preserve the safety of Germany from foreign aggression, and has shown himself willing to co-operate with the Governments in practical measures for improving the condition of the working man. He successfully resisted attempts made in 1891 to expel him from the party in consequence of an important speech in which he explained his position, and in the Bavarian Diet, of which he has been a member since 1893, he has won for his party a better position than they have secured elsewhere. He has even succeeded in establishing occasional co-operation between Social Democrats and Liberals in opposition to measures of the Government which seemed dangerous to liberty.

Volo, a seaport town of Greece, on the east coast of Thessaly, in the province of Larissa, at the head of the Gulf of Volo. It is the chief seaport and second industrial town of Thessaly, connected by rail with the town of Larissa. The anchorage is safe, vessels loading and discharging by means of lighters. The port has a depth of 23 to 25 feet. Population (1889), 11,029; (1896), 16,232.

Vologda, one of the largest governments of European Russia, bordering on the Urals, and bounded on the N. by Archangel and Yaroslavl, on the E. by Tobolsk, on the S. by Perm, Vyatka, and Kostroma, and on the W. by Novgorod and Olonets. It has an area of 150,498 square miles, exceeding that of Great Britain, and its population, which was 1,172,250 in 1883, in 1897 numbered 1,365,587 (domiciled only), of whom 710,930 were women and only 57,407 lived in towns.

It is divided into ten districts, the chief towns of which are: Vologda, Gryazovets (3205), Kadnikoff (2356), Nikolsk (2550), Solvychegodsk (1710), Totma (4562), Ustyug Velikiy (11,307), Ust-Sysolsk (4463), Velsk (1796), and Yarensk (991). There were 1153 primary schools in 1898, attended by 40,090 boys and 9500 girls. Of the total area of 98,539,000 acres, 87,989,000 acres are covered with forests. Agriculture is the chief occupation of the people, but it thrives only in the three south-western districts, where dairy-farming and the making of butter and cheese are rapidly developing. In the remainder of the province only 4 per cent. of the area is under fields. Cattle-breeding occupies considerable numbers, and there were in the province in 1897 243,630 horses, 549,500 horned cattle, 419,820 sheep, and 51,000 pigs. A little salt is raised, and there are a few iron works, but manufacturing industries are in their infancy, the annual returns of all factories barely exceeding 4,300,000 roubles; the chief branch is the weaving of linen in the villages. Trade is limited to the export of linen, timber, a little iron, salt, hides, furs, fish, and game, and since Archangel lost so much of its foreign trade, the export of these has greatly fallen off.

Vologda, the capital of the above government, on the river Vologda above its junction with the navigable river Sukhona, connected by rail with the Volga, opposite Yaroslavl (128 miles), and with Archangel (395 miles). Its buildings are chiefly of wood. It has a few distilleries, tanneries, and oil, soap, tobacco, candle, and fur-dressing works, and carries on trade with St Petersburg, where it exports grain, hides, and eggs, and Archangel, to and from which nearly 400 vessels pass by way of the river Sukhona every year. In 1897 it had a population of 27,822.

Volta, the largest river of the coast of Upper Guinea, from the Gambia to the Niger, with a length of about 900 miles. Although its lower course had been known since the early discoveries of the Portuguese, from whom it received its present name on account of the winding nature of its stream, it was only within the last fifteen years of the 19th century that the extent of its basin—extending as it does far north within the bend of the Niger—was first made known. There are two main upper branches, known respectively as the Black and White Volta, the Black Volta being probably the more important.

Their sources lie on the grassy plateaux to the north of the forest belt of the Guinea coast, the Black Volta rising (as the Baule) in about 11° N., 4° 50′ W. Its course is at first east and north-east to 12° 25′ N., at which point, after receiving a tributary from nearly 14° N.—the most northerly point of the basin—it turns sharply south, maintaining that general direction till 8° 15′ N. Here it is deflected east, and even north, by a mountain range composed of sandstone and granite, which it finally breaks through by a narrow pass, in which its width is only some 60 yards. Elsewhere it has a general width of 150 to 200 yards. In 0° 50′ W. it receives the White Volta, which flows generally south from about 13° N. and likewise breaks through a narrow gap in the plateau escarpment. Both rivers are described as noble streams during four months in the year, but in the dry season they shrink greatly, reaching their lowest level at the end of January. Below the junction the Volta flows south-east and south, turning, however, east for 40 miles just north of 6°. In 7° 37′ N. it receives on the left bank a large tributary, the Oti, coming from 12° N. In its lower course, through the forest belt, the river has often a width of over half a mile, with a depth in places of 40 to 50 feet in the rains, but in 6° 18′ N. it traverses a pass in which its width is narrowed to 30 yards. Its use as a waterway is limited by a number of rapids, the lowest of which occur in 6° 7′ N., above the trading port of Akuse. Its mouth is also obstructed during the greater part of the year by a bar. The lower Volta was explored by Bonnat in 1875, but the upper basin was first traversed by the German traveller Krause (1886–87) and the French Captain Binger (1888). It has since been explored by a number of colonial officials —German, French, and British. Between 6° 41′ and 8° 8′ N. the Volta forms the boundary between the Gold Coast and German Togoland, while the upper course of the Black Volta separates the Gold Coast from the French Sudan and Ivory Coast.

See Binger, *Du Niger au Golfe de Guinée* (Paris, 1889); Northcote, *Report on the Northern Territories of the Gold Coast* (London, 1899); and various papers and maps in the *Mitteilungen aus den Deutschen Schutzgebieten.* (E. He.)

Volterra, a town and bishop's see of the province of Pisa, Tuscany, Italy, 51 miles south-east of Pisa by rail. The national museum (1731), with the Etruscan cinerary urns, is now in the Tagassi Palace, which also contains a library, mediæval sculptures, and a collection of coins. There are an industrial institute, mineral spring (saline), iron-works, and the staple industries in alabaster, and salt-pans. Population (1881), 7349; (1900), about 7500.

Voltri, a lively industrial town of the province of Genoa, Liguria, Italy, on the coast, 9 miles north-west of Genoa by rail. Its principal industries are iron-works and shipbuilding yards, cotton, woollen, and jute mills, confetti and paper factories. It also possesses a pilgrimage church and a technical school. At Acquasanta, 3 miles to the north, are mineral baths (71·6° Fahr.). Population (1881), 7238; (1900), about 7500.

Vorarlberg, the most westerly province of the Austrian empire. It consists of three districts (Bregenz, Bludenz, and Feldkirch), which are under the administrative authority of the "statthalter" (or "prefect") at Innsbruck, but possess a Governor and Diet of their own (twenty-one members), and send three members to the Imperial Parliament. Vorarlberg is composed of the hilly region of the Bregenzerwald, and (to its south) of the mountain valley of Montavon or of the upper Ill, through which an easy pass leads to the Tirolese valley of Paznaun, and so to Landeck. Near Bludenz the Kloster glen parts from the Ill valley; through the latter runs the Arlberg railway (1884)—beneath the pass of that name (5912 feet)—to Landeck and Innsbruck. The Ill valley is bounded on the south by the snowy chain of the Rhätikon (highest point, the Scesaplana, 9741 feet, a famous view-point), and the Silvretta (highest point, Gross Piz Buin, 10,880 feet), both dividing Vorarlberg from Switzerland; slightly to the north-east of Piz Buin is the Dreiländerspitze (10,539 feet), where the Vorarlberg, Tirolese, and Swiss frontiers unite.

The total area of Vorarlberg is 1004·3 square miles. Of this 88¼ per cent., or about 886 square miles, is reckoned "productive," 30 per cent. of this limited area being occupied by forests, while 118 square miles rank as "unproductive." According to the census of 31st December 1890, the population of the Vorarlberg amounted to 116,073 souls. All were Romanists save 1216, and all German-speaking save 3085 Italians. The largest town in the province is Dornbirn (which comprises several adjacent villages), of which the population was 10,678 in 1890. In 1890 Bregenz, the political capital of the Vorarlberg, had 5396 inhabitants (now about 7000); Feldkirch, 3811 (now about 4000); and Bludenz, 3265 (now 4504). Of all the Austrian Alpine lands Vorarlberg is the richest in milk products. In 1890 it possessed 58,231 horned cattle, and 12,424 goats; the total amount of milk produced has been reckoned as high as 15½ million gallons per annum, of which nearly one-half is made into cheese. It is reckoned that in 1893 there were 265,000 spindles in the Vorarlberg, employing about 7000 workmen, while embroidery at home supported from 13,000 to 14,000 persons.

Authorities.—J. R. von Bergmann. *Landeskunde v. Vorarlberg.* Innsbruck, 1868.—Max Haushofer. *Tirol and Vorarlberg.* Bielefeld and Leipzig, 1899.—O. von Peister. *Das Montavon.* Augsburg, 1884.—J. Staffler. *Tirol und Vorarlberg*, 5 vols. Innsbruck, 1839–46.—A. Waltenberger. *Algau, Vorarlberg, und Westtirol*, 8th edition. Innsbruck, 1896. See also the list of books at the end of Tirol, especially vol. xiii. (*Tirol 'u. Vorarlberg*), Vienna, 1893, of the great official work entitled *Die oesterreichisch-ungarische Monarchie in Wort und Bild.*

(W. A. B. C.)

Voronezh, a government of South Russia, with an area of 25,448 square miles. Owing to emigration from the province to Siberia its population only increased from 2,532,840 in 1883 to 2,546,255 (domiciled only) in 1897, of whom 1,279,196 were women and 173,907 lived in towns. The inhabitants are about equally divided into Great Russians in the north, and Little Russians in the south, but there are some 3000 Germans, 1500 Jews and Karaites, and 1200 Poles. The government is divided into twelve districts, the chief towns of which are: Voronezh, Biryuch (13,194), Bobroff (3891), Boguchary (6853), Korotoyak (9391), Nizhne-Dyevitsk (2426), Novokhopersk (6088), Ostrogozhsk (21,891), Pavlovsk (7221), Valuiki (7085), Zadonsk (8313), a great monastery, and Zemlyansk (6126). Several villages, such as Buturlinovka (21,694), Kalatch (12,928), and Vorontsovka (12,000), are more populous than some of the district towns, and carry on a considerable trade. The standard of education is higher than in many of the central governments, and there were in 1898 30 middle schools attended by about 6500 pupils, and 1545 primary schools attended by 73,000 boys and 17,440 girls. Owing to a very fertile soil agriculture is successfully prosecuted. The peasants own 67 per cent. (9,914,000 acres) of the land, the Crown and the Imperial domains 3 per cent., and private owners 30 per cent. Nearly seven-tenths of the total area is arable land, and in 1900 5,807,100 acres were under cereal crops. The average yield in 1895–99 was: rye, 11,614,000 cwt.; wheat, 4,848,000 cwt.; oats, 4,238,000 cwt.; barley, 2,137,000 cwt.; various cereals, 4,074,000 cwt.; also potatoes, 8,216,000 cwt. Aniseed, sunflowers, tobacco, and beetroot are also widely cultivated, and much attention is also paid to the growth of the pineapple. There are large tracts of excellent pasture land, and cattle-breeding is carried on with much success; good breeds of cart-horses and trotters are obtained. There were 181 breeding establishments in 1897, those at Hrenovoye and Chesmenka being the most important, and in 1897 the province contained 405,000 horses, 555,560 horned cattle, 1,209,000 sheep, and 214,000 pigs. Forests cover nearly 8 per cent. of the area, and in many villages large numbers of the inhabitants are engaged in their homes in the making of wooden goods. Other domestic industries, such as the making of fire-bricks, pottery, carpets, hosiery, boots, peasants' gloves, and sheepskins, and the extraction of grindstone, are developing year by year. Factories (mostly flour-mills, distilleries, and oil, sugar, and tobacco works) show a yearly return of 18,800,000 roubles. Several cattle fairs are held along the banks of the Don, and assist in maintaining an active internal trade.

Voronezh, the capital of the above government, on the river of same name, 5 miles above its junction with the Don, and 331 miles by rail south-east of Moscow. It is one of the best-built and most picturesque provincial towns of Russia. It is situated on the steep bank of the river, and is surrounded by three large suburbs—Troitskaya, Yamskaya, and Tchizhovka. It was here that Peter I. laid, in 1695, the beginnings of the Russian fleet, and that, in 1772, the first shareholders' company for marine trade was formed in Russia. The house of Peter I., which had been turned into a private wool-cleansing establishment, has now been restored, and a yacht club occupies the building of the Tsar's admiralty. There are monuments to Peter I. and to the two Voronezh poets, Koltsoff and Nikitin, a much venerated monastery, two museums, and several public libraries. The theatre is renowned in the history of the drama in Russia. Of schools there are two gymnasia for boys and three for girls, one *real*-school, a corps of cadets, a teachers' seminary, railway schools, and so on. Population (1897), 84,146.

Vorontsovka, a village of Russia, in the government and 90 miles south-east of the town of Voronezh. It has several tanneries and holds important fairs, and its inhabitants have a reputation for the manufacture of cheap hunting rifles. Population (1897), 11,753.

Vörösvágás, a village of northern Hungary, in the county of Sáros. In the Dubnik mines, belonging to this village, exists the only opal mine in Europe. The opal was mined there 800 years ago for its beautiful play of colours, and it was known in trade as a precious stone under different names, according to its tints. The largest piece hitherto found weighs 549 grammes (2940 carats), is 12 cm. long, 6 cm. broad, and 2–7 cm. thick, and is preserved in the museum of natural history of the Court in Vienna. It is estimated to have a value of four million crowns.

Vosges, a department on the eastern frontier of France, resting on the mountain chain of that name, bordering it on the east, and watered by the Meurthe and the Moselle.

Area, 2305 square miles. The population (413,707 in 1886) had increased in 1901 to 419,784. The births in 1899 were 10,441, of which 931 were illegitimate; deaths, 9069; marriages, 3163. The schools in 1896 numbered 949, with 50,000 pupils, only 1½ per cent. of the population being illiterate. Of the entire surface 1,360,970 acres were in 1896 under cultivation, 538,460 acres being plough-land and 11,115 acres vineyards. The largest part of the rest is laid out in natural pastures and grass lands. The wheat reaped in 1899 was valued at £451,000; meslin, £81,150; rye, £131,200; oats, £381,000; potatoes, £696,000; natural pastures and grass lands, £731,000; vines, £182,000. The department in 1899 owned 31,230 horses, 145,570 cattle, 59,330 sheep, 77,110 pigs, and 15,470 goats. The production of milk (1899) was valued at £791,000. In 1898 there were dug up 1683 metric tons of lignite and 1220 of peat. The industry in metals in 1898 produced 145 metric tons of iron and 3818 tons of steel, valued at £33,000. The textile industry, however, takes precedence of all the others. The spinning and weaving of calico and other cottons employed, in 1898, 600,000 spindles and 23,000 looms at Épinal, St Dié (19,226), and Remiremont (8874). Wool-spinning is also a brisk industry; cheese is made at Gérardmer (8075). Épinal, the capital, has (1901) 21,392 inhabitants.

Vosmaer, Carel (1826–1888), Dutch poet and art-critic, was born at The Hague on 20th March 1826. He was trained to the law, and was successful in that profession, holding various judiciary posts, until 1873, when he withdrew entirely from legal practice. In early life he cultivated literature but little, and only as an amateur. His first volume of poems, 1860, did not contain much that was remarkable. His temperament was starved in the very thin air of the intellectual Holland of those days, and it was not until after the sensational appearance of Multatuli (Edward Douwes-Dekker) that Vosmaer, at the age of forty, woke up to a consciousness of his own talent. In 1869 he produced an exhaustive monograph on Rembrandt, which was issued in French. Vosmaer became a contributor to, and then the leading spirit and editor of, a journal which played an immense part in the awakening of Dutch literature; this was the *Nederlandsche Spectator*, in which a great many of his own works, in prose and verse, originally appeared. The remarkable miscellanies of Vosmaer, called *Birds of Diverse Plumage*, appeared in three volumes, in 1872, 1874, and 1876. In 1879 he selected from these all the pieces in verse, and added other poems to them. In 1881 he published an archæological novel called *Amazone*, the scene of which was laid in Naples and Rome, and which described the raptures of a Dutch antiquary in love. Vosmaer undertook the gigantic task of translating Homer into Dutch hexameters, and he lived just long enough to see this completed and revised. In 1873 he came to London to visit his lifelong friend, Sir (then Mr) Lawrence Alma-Tadema, and on his return published *Londinias*, an exceedingly brilliant mock-heroic poem in hexameters. His last poem was *Nanno*, an idyl on the Greek model. Vosmaer died, while travelling in Switzerland, on 12th June 1888. His literary activity was very great during the last fifteen years of his life, and he had become a powerful factor in the imaginative world of Holland. He was unique in his fine sense of plastic expression; he was eminently tasteful, lettered, refined. Without being a genius, he possessed immense talent, just of the order to be useful in combating the worn-out rhetoric of Dutch poetry. His verse was modelled on Heine and still more on the Greeks; it is sober, without colour, stately, and a little cold. He was a curious student in versification, and it is due to him that hexameters were introduced and the sonnet reintroduced into Holland. He was the first to repudiate the traditional, wooden alexandrine. In prose he was greatly influenced by Multatuli, in praise of whom he wrote an eloquent treatise, *Een Zaaier* (*A Sower*); it was interesting that the glowing, irregular spirit of Douwes-Dekker should have been that which peculiarly appealed to the refined and sculpturesque Vosmaer. He was also somewhat under the influence of English prose models. His numerous contributions to art-criticism have not the durable value of his imaginative writings. Vosmaer was an isolated and transitional figure in Dutch literature, and will hold a place in its history. (E. G.)

Voting Machines.—The election of public officers by ballot is so complicated a process, and so slow in giving returns, that various machines have been invented for registering and counting ballots mechanically.

In some, the voter unlocks the apparatus by the act of opening the door of the voting compartment, and on leaving locks it, so that it will not register until the door is opened by the next voter. One of the early machines—the Meyer American, legalized in one state as early as 1892—was so arranged that a vote for one candidate, effected by pushing a knob, locked all other possible votes for the same candidate until the voter left the booth. The names of candidates were arranged in a vertical row on the face of the machine, the offices were arranged horizontally. By pushing the proper knob the vote for a given candidate for a specific office was recorded. Many machines use dial or counter mechanism, which can be instantly read, but give no record on paper. In the McTammany machine paper tally slips, one for each candidate, amendment or office to be voted for, are fed through the machine, and each voter punches a hole in the proper sheets to express his preferences. This machine presupposes that the voter knows how to read. In the Rhines machine, a variation of the McTammany, all the marking devices are set at once, and a single additional movement registers them simultaneously. The Bardwell Votometer exposes a vertical face or board marked for each set of votes. As the voter enters a bar is lifted, which unlocks the machine, and it is lowered after him, closing the booth; he records his vote by inserting a key in any desired aperture in the board, and if he makes an error he can reset the machine and correct it. If he wishes to vote in some way not arranged for on the face of the machine, a ballot-box is provided. On leaving the booth an exit bar locks the machine until the next voter enters. When a voter is qualified to vote on certain issues only the attendant at the back of the machine can lock any set for which the particular voter has no franchise. The number of votes is recorded by the dial system, so that the results can be returned in a few minutes at the close of the election. The capacity of this machine is put at 600 voters per statutory election day by the New York State Commission on Voting Machines. In the Howe machine a printed record is obtained. The voter passes through a turnstile into a chamber where he is faced by a number of handles corresponding to the number of candidates. When he pulls one of these he changes a numerical printing apparatus in the machine; the actual printing is done by the further motion of the turnstile as he leaves. There may be any number of handles, and by an interlocking apparatus the number of candidates for whom any one voter can vote may be limited in any desired manner. The records belonging to each handle are printed vertically in separate columns on a long roll of paper; hence the lowest figure in each column at once gives the number of votes which have been cast in favour of the candidate to whom that column is appropriated. In addition there is another column in which is recorded the total number of votes which have been cast; the figure it gives must correspond with that shown by the numerical counter attached to the turnstile. In connexion with the machine a clerical check has been devised which, in the event of any particular voter's vote being challenged, enables his record in the machine to be traced without difficulty, so that it can be discovered for whom he voted, and consequently from which total his vote, if disallowed, is to be deducted. Voting machines are legalized and in use in various places in the United States, but not in the United Kingdom.

Voznesensk, a town of Russia, in the government of Kherson, on the left bank of the river Bug, at the head of its navigable course, 61 miles from Nikolaieff (railway station), to which steamers ply regularly. It is a river port of some importance, and holds four large fairs annually. The town is well built, and contains a cathedral, a large public garden, and several distilleries and breweries. Population (1897), 14,178.

Vranya, or VRANYÉ, the most southerly town of the kingdom of Servia, 7½ miles from the Macedonian frontier, on a slope descending from Mount Placevitza to the plain of the Upper Morava, in a very picturesque and fertile country. In the Russo-Turkish war of 1877 it was captured by the Servian army from the Turks, and the Congress of Berlin sanctioned its remaining within the new boundary of Servia. It is the seat of the prefecture and a tribunal, and has a college for secondary education, and a modern hospital kept up by district rates. A regiment of the regular infantry is stationed there as garrison. Vranya is an important station on the railway line, Nish–Salonica, with a custom house, principally for merchandise imported into Servia *viâ* Salonica. Its inhabitants are employed chiefly in the cultivation of flax and hemp, and in the making of ropes, which have an established reputation in the markets of the Balkan Peninsula. Four and a half miles to the east of Vranya there is a much frequented summer resort called Vranyska Banya, with baths of hot sulphurous mineral water. Population (1900), 11,921.

Vratza, chief town of a department, Bulgaria, and the seat of a bishopric, situated on the Vzatzanska, a tributary of the Botounia, 59 miles north-west of Sofia. It possesses tanneries and a considerable general trade. Both its wine and its jewellery have a high reputation. A school of sericulture has been established. During 1876 and 1877 many of the inhabitants of Vratza and neighbourhood suffered greatly from the atrocities of the Tcherkess, until the town was taken by the Russians after a short bombardment. Population, about 14,000.

Vries Island. See IZU-NO-SHICHI-TÔ.

Vryburg. See BECHUANALAND.

Vryheid. See TRANSVAAL.

Vurjeevandas Madhowdas (1817–1896), a Hindoo merchant of Bombay, of the Kapole Banin caste, was born on 28th January 1817 at Gogla, in Kathiawar, whence his father came to Bombay with Sheth Manoredas for trading purposes. Vurjeevandas was educated in Bombay; after learning Gujrathi he received a good English education at the Fort St George School and Boswell's Academy. When his father died in 1840 he entered into partnership with Narotumdas, his eldest brother, who commenced business along with Sorabji Shapoorji Bengallee, C.I.E., as guarantee brokers to the well-known firm of W. and A. Graham. Some years later he started a new firm under the name of Vurjeevandas and Sons, and by shrewd and diligent management soon became one of the wealthiest merchants in Bombay. He married in 1833 and had six children. His private life was extremely simple. He was appointed a justice of the peace and a member of the Bombay Port Trust. He took a keen interest in the Royal Asiatic Society and the Bombay University, where a prize has been established to commemorate his name. His charitable disposition found vent in many forms. He constructed the Madhow Bang in memory of his father, and gave it to the use of poor Hindus, endowing it with nearly five lacs of rupees. He built a *dharmushala* in Bombay, at the cost of Rs.57,000, in memory of his brother Mooljibhoy, and another one at Nassick at a cost of half that sum. The magnificent sanatorium which he built in memory of his youngest son Rumhoredas at Sion Hill, at a cost of about Rs.125,000, is a great boon to the poor people of his community. He also established a dispensary at Matoonga at a cost of Rs.40,000, and a *sadavart* for the relief of indigent Hindus, and for giving an annual feast to the poorer members of his caste at a cost of Rs.37,000. He died on 12th January 1896.

Vyatka, a Russian government lying to the north-east of that of Nijni-Novgorod, with an area of 59,124 square miles. It consists of an undulating plateau reaching its highest level (1400 feet) in the north-east and gently sloping to the south-west, and according to Professor Krotoff's researches it is mainly built up of Permian deposits which crop out in the north, but are covered elsewhere by Jurassic sands and clays with layers of limestone and burning slates. Glacial boulder clay containing polished and scratched boulders covers wide areas, as do post-Glacial clays and iron-ore-bearing sands. These last reach in certain places a thickness of 70 feet, and were deposited in extensive lakes which covered the territory at a relatively recent period. In consequence of emigration to Siberia the population only increased from 2,859,000 in 1883 to 3,082,788 (domiciled only) in 1897, of whom 1,608,994 were women and 90,905 lived in towns. The bulk of the inhabitants (78 per cent.) are Russians; Votyaks form 12 per cent., Cheremiss 5 per cent., and Tatars 4 per cent., the remainder being Bashkirs, Tepteres, &c. The government is divided into eleven districts, the chief towns of which are Vyatka, Elabuga (9776), Glazoff (3415), Kotelnitch (4236), Malmyzh (3508), Nolinsk (4763), Orloff (3256), Sarapul (21,395), Slobodskoi (10,052), Urzhum (4423), and Yaransk (4824). Izhevsk (21,500) and Votkinsk, or Kamsko-Votkinsk (21,000), have important iron-works. The *zemstvos* (or provincial and district councils) are among the most active in Russia in their efforts to spread education, to develop domestic industries and agriculture, to organize the village posts, and to improve the sanitary arrangements. In 1899, 68 infirmaries with 116 doctors and 396 assistants and midwives were maintained by the *zemstvos*, and no less than 803,000 applications for medical aid were made in the villages. The primary schools numbered 1581 in 1898, and were attended by 84,000 pupils. Nearly half of the surface is covered with forests (17,084,000 acres), two-thirds of which belong to the Crown, and hunting (especially squirrel-hunting) still retains commercial importance, as does fishing. The peasants, who form 89 per cent. of the population, own 16,841,000 acres, the Crown 20,144,000 acres, the iron-works 1,148,000 acres, and private persons 826,000 acres. Vyatka is now one of the chief grain-producing governments of Russia, the area under cereal crops (7,967,100 acres in 1900) being only exceeded in the government of Samara. The average yield in 1895–99 was: rye, 21,252,000 cwt.; wheat, 432,000 cwt.; oats, 14,933,000 cwt.; and barley, 2,587,000 cwt.; also potatoes, 4,406,000 cwt. Flax and hemp are extensively cultivated, and large numbers of cattle are kept, but they are mostly of poor breed. There were in the province in 1897, 663,000 horses—some of which belonged to a race of good ponies that are widely exported—1,068,900 horned cattle, 262,700 sheep, and 158,000 pigs. Domestic industries occupy large numbers of the inhabitants, who turn out in considerable quantities almost every variety of goods. Iron ores, alabaster, grindstones, limestone, peat, fireclay, and copper are all raised, and mining and smelting operations afford occupation to 15,000 persons; in 1897, 6700 cwt. of copper, 23,900 tons of pig iron, 26,170 tons of iron, and 12,330 tons of steel were obtained. The chief iron-works are at Votkinsk, the annual returns of which amount to £190,000. Manufacturing industries are largely developed, and in 1898 there were 647 factories which showed an aggregate yearly return of 28,300,000 roubles. The principal establishments are tanneries, steam flour-mills, and hardware, machinery, paper, and fur-dressing works.

Vyatka, capital of the above government, on the left bank of the river Vyatka, at the head of the navigation on the Northern Dvina, connected by rail with Perm (458 miles) and Kotlas (353 miles). It is a rapidly-growing town, and has several distilleries, tanneries, and candle works. It carries on a considerable trade in grain, salt, metals, animal products, and various manufactured goods, which it exports to Moscow (mainly) and Archangel. It has gymnasia for boys and girls, a *real*-school, a theological seminary, and a number of primary schools. Population (1897), 24,782.

Vyernyi (formerly ALMATY), a town and fort of Asiatic Russia and the capital of the province of Semiryechensk, situated at the northern foot of the Trans-Ili Alatau, at an altitude of 2430 feet. Water is obtained for irrigation from the river Almata, and its climate is warm and healthy. It is well built and provided with boulevards and surrounded by rich gardens. It has the usual educational institutions, a school of gardening and sericulture, a public library, and a few distilleries, tanneries, and oil works. In 1897 its population was 22,982. It is notable as having been the centre of one of the most remarkable earthquakes of recent years. On 9th June 1887 shocks were experienced which lasted from 4 A.M. to 4.35, and transformed the whole town into a heap of ruins. The force of the earthquake was found to be 10, according to the scale of Forel, and the total number of shocks was about 600. More than 1000 houses were destroyed and 332 persons were killed or died from wounds. The earthquake spread over a very large area, shocks being felt at Serghiopol in the north, Kashgar in the south, and Tashkent and Urumchi in the east; it seems, indeed, to have been experienced over an irregular ellipse of which the major axis ran south-west to north-east for nearly 1000 miles, and the minor axis had a length of 600 miles. The area of greatest destruction, also elliptic in its form, had a length of 67 miles, and a width of about 35 miles. The cause of the earthquake was found to have been the giving way of deep-lying strata on the northern slope of the Trans-Ili Alatau, at a depth of about 7 miles below the surface.

See Professor MUSHKETOFF, "The Earthquake at Vyernyi," in *Memoirs* of the Russian Geological Committee, vol. x., 1890; also VOZNESENSKY in the Meteorological *Annual* of the Russian Academy of Science, vol. xii., No. 4 (in German).

(P. A. K.)

Vyrnwy, Lake, an artificial reservoir in the north-west of Montgomeryshire, Wales, for the water supply of Liverpool (see WATER SUPPLY). It was formed by damming the river Vyrnwy, which flows through Montgomeryshire and joins the Severn above Shrewsbury. The lake has added largely to the beauties of the district.

Vyshnevolotskaya Sistema, one of a series of Russian waterways linking the Neva and the Volga. It has a length of nearly 540 miles, and has not only opened up the district which it traverses to the Baltic trade, but forms the most valuable medium of transit for Eastern products from the Caspian to St Petersburg.

Wabash, a city of Indiana, U.S.A., capital of Wabash county, on the river Wabash, and the Cleveland, Cincinnati, Chicago, and St Louis, and the Wabash railways, in the northern part of the state, at an altitude of 710 feet. It has railway repair works, agricultural implement factories, and other manufactures. Population (1880), 3800; (1890), 5105; (1900), 8618, of whom 498 were foreign-born and 134 negroes.

Wace, Henry (1836– ——), English theologian, was born in London, 10th December 1836, and educated at Marlborough, Rugby, King's College, London, and Brasenose (Oxford). He was ordained in the Church of England in 1861, and held various curacies in London, being chaplain at Lincoln's Inn in 1872 and preacher in 1880. From 1875 to 1896 he was prominently connected with King's College, London, where he was professor of ecclesiastical history, and subsequently (1883) principal. Both as preacher and writer Dr Wace, who took his D.D. degree in 1883, became conspicuous in the theological world. He was Boyle lecturer 1874 and 1875, and Bampton lecturer 1879; and besides publishing several volumes of sermons, he was co-editor of the *Dictionary of Christian Biography* (1877–87), and editor of *The Speaker's Commentary on the Apocrypha.* He took a leading part as the champion of historic orthodoxy in the controversies with contemporary Rationalism in all its forms, and firmly upheld the importance of denominational education and of the religious test at King's College; and when the test was abolished in 1902 he resigned his seat on the council. In 1881 he was given a prebendal stall at St Paul's, and in 1889 was appointed a chaplain-in-ordinary to Queen Victoria. When he resigned the principalship of King's College in 1896 he was made rector of St Michael's, Cornhill.

Waco, a city of Texas, U.S.A., capital of McLennan county, on the river Brazos, at the mouth of the Bosque, towards the eastern part of the state, at an altitude of 400 feet. The site is level, the street plan regular, it has abundant water from artesian wells, and the streets are well paved. It is a railway centre of much importance, since five lines intersect here—the Houston and Texas Central; the Missouri, Kansas, and Texas; the St Louis South-Western; the San Antonio and Aransas Pass; and the Texas Central. With these facilities Waco has become one of the leading shipping-points for the cotton crop. The city contains cotton compresses, flour-mills, woollen and cotton mills. It contains several educational institutions, among which are Baylor University, Waco Female College, and Paul Quinn College (for coloured). Population (1890), 14,445; (1900), 20,686, of whom 1196 were foreign-born and 5826 negroes.

Wadai, a Mahommedan kingdom of the Central Sudan, occupying an area of some 100,000 square miles east of Lake Chad, much of the surface being arid and barren. By the Anglo-French agreement of 1898–99 the influence of France over the country was finally recognized, but no French traveller has yet entered the country, of which little definite information has been obtained since the journey of Matteucci and Massari (1880). The sultan, whose residence is at Abeshe or Abeshr, claims more or less influence over Kanem, north-east of Lake Chad, the borders of which were traversed in 1899–1900 by the French expeditions under Joalland and Foureau, and which has since been the scene of fighting between the French and the Tuaregs. In Wadai itself a revolution took place in 1901, owing to feuds among the ministers and great vassals of the crown. The Sultan Brahim was deposed, and Abugazali, son of a former sultan, set up in his place. Another disturbing factor was the famous Sheikh el Senussi, who retired to Wadai from the Jarabub oasis in the northern Sahara, and took part in the opposition to the French in Kanem until his death in 1902. In the south, the country of Dar Runga, once regarded as forming part of Wadai, seems to have become virtually independent under its Senussite sultan, whose capital, situated near the source of the Bangoran, a branch of the Shari, has been visited by French travellers from the south. According to M. Prins, Mahommedan influence was established in these parts about 1850, but the tenets of that religion are very loosely adhered to. With the closing of the route from Wadai to the Nile at the time of the Mahdist rebellion and the decline of the Kuka–Tripoli route owing to disturbances in Bornu, the road across the Sahara to Benghazi *viâ* Kufra oases acquired some importance. The rulers in Wadai are the Mabas, a Negro race converted to Islam, but the sparse population of the country includes various other elements, including Arabs. The main occupation of the people is pastoral, and the chief exports to the north are ivory and ostrich feathers. The bulk of the natives of Dar Runga are of the Negro Banda stock.

See NACHTIGAL, *Sahara und Sudan*, vol. iii., Leipzig, 1889; MASSARI, in *Kosmos*, 1882; PRINS, in *La Géographie*, March 1900.

Waddington, William Henry (1826–1894), French statesman and diplomatist, was born at St Remi-sur-l'Avre, in the department of Eure-et-Loir, on 11th December 1826. He was the son of a wealthy Englishman who had established a large spinning factory in France and had been naturalized as a French subject. After receiving his early education in Paris, he was sent to Rugby, and thence proceeded to Trinity College, Cambridge, where he was second classic and Chancellor's medallist, and rowed for the University in the winning boat against Oxford. Returning to France, he took up his French nationality, and for some years devoted himself to archæological research, particularly numismatics and epigraphy. With this purpose he undertook travels in Asia Minor, Greece, and Syria, the fruits of which were published in two *Mémoires*, crowned by the Institute, and in his *Mélanges de numismatique et de philologie* (1861). Except his essay on *The Protestant Church in France*, published in 1856 in *Cambridge Essays*, his remaining works are likewise archæological. They include the *Fastes de l'Empire romain*, and editions of Diocletian's edict and of Lebas's *Voyage archéologique.* He was elected in 1865 a member of the Académie des Inscriptions et Belles-Lettres. It was not till middle life that he entered on his political career. After standing unsuccessfully for the department of the Aisne in 1865 and 1869, he was returned by that constituency at the elections of 1871. His opinions remained always those of a Moderate Liberal, but he sympathized with Thiers when he was attacked by the Conservative party. He was minister of public instruction in the Dufaure cabinet from 19th May 1873 to the fall of Theirs on the 24th of the same month. In 1876, having been elected Senator for the Aisne, he was again entrusted by Dufaure with the ministry of public instruction, with which, as a Protestant, he was not permitted to combine the ministry of public worship, usually attached to it. His attitude aroused the violent hostility of the Clerical party, without satisfying the more advanced spirits on his own side. His most important project, a Bill transferring the conferment of degrees to the State, passed the Chamber, but was thrown out by the Senate. He continued to hold his office under Jules Simon, with whom he was overthrown on the famous *seize Mai*, 1877. The triumph of the Republicans at the general election brought him back to power in the following December as minister of foreign affairs under Dufaure. He was the French plenipotentiary at the Berlin Congress, where he represented his country under exceptionally delicate and trying conditions with much dignity and tact, and made a strong impression upon Bismarck. He successfully upheld French claims to a protectorate over the Christians of the Levant, and it was on his motion that the Congress pronounced in favour of an extension of the Greek frontier. An ardent sympathy with Greece was indeed conspicuous throughout his connexion with European politics. The cession of Cyprus to Great Britain was at first denounced by the French newspapers as a great blow to his diplomacy, but he obtained, in a conversation with Lord Salisbury, a promise that Great Britain in return would allow France a free hand in Tunis, and subsequent French influence in that country is the natural development of his policy. In December 1878 he delivered a speech that was received with much enthusiasm, declaring that he had maintained the interests of France while leaving her unfettered by conditions. Early in the following year Dufaure retired, and on 4th February Waddington succeeded him as prime minister and minister of foreign affairs. Holding office by sufferance of Gambetta, he halted in an undetermined attitude between the Radicals and the reactionaries till the delay of urgent reforms lost him the support of all parties. He lacked, moreover, the coolness needed for facing the noisy interruptions of the Opposition. He succeeded on 2nd December in obtaining a vote of confidence from the Chamber, but found himself forced on 27th December to retire from office. He refused the offer of the London embassy, and in 1880 was reporter of the committee on the adoption of the *scrutins de liste* at elections, on which he delivered an adverse judgment. In 1883, after representing France at the coronation of the Tsar Alexander III., he accepted the London embassy, which he continued to hold till 1893. His English descent and education stood him in good stead; nevertheless, during the occasional difficulties that arose between Great Britain and France, notably on the Egyptian question, he showed an exceptional tenacity in defence of his country's interests. Throughout his career as ambassador he had retained his seat in the Senate, and aspired to a resumption of his political career; but at the commencement of 1894 he was rejected by his department, the Aisne. He did not long survive this defeat, and died on 13th January 1894. (H. ST.)

Wade, Sir Thomas Francis (1818–1895), British diplomatist, born in London on 25th August 1818, was the son of Major Wade of the Black Watch, by his wife Anne, daughter of William Smythe of Barbavilla, West Meath. His father was appointed in 1823 military secretary to Sir Lowine Cole in Mauritius. Here he received his grounding in knowledge, and was subsequently educated at Harrow and Trinity College, Cambridge (1837), where, however, he remained only one year, his father having purchased for him a commission in the 81st Regiment. From his corps he in the following year (1839) exchanged into his father's old regiment, the 42nd Highlanders, with which he served at Limerick, Templemore, Cork, and the Ionian Islands. While at Corfu he devoted his leisure to the congenial study of Italian and modern Greek. On receiving his commission as lieutenant in 1841 he exchanged into the 98th Regiment, then under orders for China, and landed in Hong Kong in June 1842. The scene of the war had at that time been transferred to the Yangtse-kiang, and thither Wade was ordered with his regiment. There he took part in the attack on Chinkiang-fu and in the advance on Nanking. Already on his voyage out he had, with the great linguistic facility which he possessed, taken to the study of Chinese, and having improved his knowledge on the spot, he was on the return of the regiment to Hong Kong appointed interpreter to the garrison. In 1845 he was appointed interpreter in Cantonese to the Supreme Court of Hong Kong, and in 1846 assistant Chinese secretary to the superintendent of trade, Sir John Davis. In 1852 he was appointed vice-consul at Shanghai. During his tenure of this office the progress of the Taiping rebellion had so disorganized the administration in the neighbourhood of Shanghai that it was considered advisable to put the collection of the foreign customs duties into commission, a committee of three, of whom Wade was the chief, being entrusted with the administration of the customs. This formed the beginning of the Imperial Maritime Customs Service. In 1855 Wade was appointed Chinese secretary to Sir John Bowring, who had succeeded Sir J. Davis at Hong Kong, and undertook a mission to Cochin-China on international concerns. On the declaration of the second Chinese war in 1857 he was attached to Lord Elgin's staff as Chinese secretary, and with the assistance of Mr H. N. Ley he conducted the negotiations which led up to the treaty of Tientsin (1858). In the following year he accompanied Sir Frederick Bruce in his attempt to exchange the ratification of the treaty, and was present at Taku when the force attending the mission was treacherously attacked and driven back from the Peiho. On Lord Elgin's return to China in 1860 he resumed his former post of Chinese secretary, and was mainly instrumental in arranging for the advance of the special envoys and the British and French forces to Tientsin, and subsequently towards Peking. For the purpose of arranging for a camping ground in the neighbourhood of Tungchow he accompanied Mr (afterwards Sir) Harry Parkes on his first visit to that city, where on the next day Parkes with Mr Loch and others was by an act of shameless treachery made prisoner. In the succeeding negotiations Wade took a leading part, and on the establishment of the legation at Peking he took up the post of Chinese secretary of legation. In 1862 he was made a Companion of the Bath. On the return of Sir Frederick Bruce to England in 1864 he remained as *chargé d'affaires*, and again from 1869 to 1871, when he was appointed minister, he filled the acting post. The Tientsin massacre in 1870 entailed long and difficult negotiations, which were admirably conducted by Wade. On the assumption of power by the Emperor T'ung-chih he, in common with his colleagues, requested an audience in accordance with the treaties, which was for the first time granted as a right. The murder of Mr Margary near Manwyne in Yunnan in 1875 threatened at one time to cause a rupture with the Chinese Government, and as a matter of fact Wade did leave Peking. But the Chinese finding that he was in earnest despatched Li Hung-Chang after him to Chefoo, where the two diplomatists arranged the penalties which were to be paid for the crime, and concluded a convention which, after a considerable interval, was ratified by the Governments. Wade was then made K.C.B., and in 1883 retired from the service. On his return to England the attractions of his old university induced him to take up his residence at Cambridge, where he was appointed the first professor of Chinese. He died there on 31st July 1895. In 1889 he was made G.C.M.G. In 1868 he had married Amelia, daughter of Sir John Herschel. (R. K. D.)

Wadhwan, a town of India, in the Gujarat division of Bombay, the capital of a petty state of the same name, and the junction of the Kathiawar railway system with the Bombay and Baroda line, 389 miles north of Bombay. Population (1881), 16,949; (1891), 24,604. It has considerable trade and manufactures. The school for *girasias* or feudatory nobles had 60 pupils in 1896–97, who were maintained at a total cost of Rs.10,452, and the high school had 254 pupils. There are two printing-presses. The civil station is under British administration. The state of Wadhwan has an area of 237 square miles. Population (1891), 42,438.

Wady Halfa. See under Egypt and Sudan.

WAGES.

I. The United Kingdom.

THE meaning of the term *wage*, the distinction between real and nominal wages, the various items properly included in the term, and the economic causes which determine relative wages and wages in general, with historical illustrations, are sufficiently discussed in the *Ency. Brit.* vol. xxiv. p. 306 *seq.* In the present article it is proposed to discuss the statistical measurement of wages, and to tabulate some of the most significant figures. The simplest method of procedure is to calculate first *nominal* wages, including in that term "all money wages, regular or occasional, and perquisites and expectations, reckoned over a given period in the currency of a given time and place" (Palgrave's *Dict. of Pol. Econ.* iii. p. 639). For general statistical purposes of comparison it is usually impossible to allow for expectations of pensions, for facilities for subsidiary earnings, for liability to want of work owing to commercial depression, for the shorter or longer part of a lifetime which can be spent at a particular occupation (see Walker, *The Wages Question*, p. 33 *seq.*), or for the relation of the value of services rendered by central or local governments to the amount paid in taxes or rates. Having determined nominal wages for labour at two or more districts or times, the second step is to estimate *real* wages, defined by Prof. Walker (*ibid.* p. 12) as "the remuneration of the hired labourer as reduced to the necessaries, comforts, or luxuries of life," by some mechanism for comparing the purchasing power of money at those districts or times. Nominal money wages are paid either for labour, without specific reference to its amount, performed in a given time (*time-wage*), or for labour of a given amount without specific reference to the time occupied (*piece-wage*). Mr D. F. Schloss (*Methods of Industrial Remuneration*, p. 11 *seq.*) distinguishes also *task-wages*, where there is an agreement to perform a certain minimum of work in the given period, but the wage is otherwise a time-wage, and *progressive wages*, where a premium in addition to a time- or piece-wage is given for efficiency exceeding a specified minimum. Wages *in kind*, food, clothing, house-room, gratis or at a reduced price, are not uncommon, and these benefits can be valued in currency and added to nominal wages. Lastly, remuneration for labour may take the form of an allotted share in the actual produce or in profits, under a co-operative copartnership or profit-sharing scheme: where the labourer has not a voice in the management, all such payments are properly included in nominal wages; where he has, a difficult distinction should be drawn between profits and wages.

Real and nominal wages.

Rates of nominal wages can be stated: (i.) per *unit of labour* performed—this would be a good method if quantity of labour were measurable; (ii.) per *piece*—as with ordinary *piece-wages;* this is useful for comparison when the kind of work changes little, as with compositors, but of limited use even in a single occupation, since methods of work vary so much, and of none for comparison of occupations; (iii.) per *hour*—the hourly rate in the building trades is important, but the number of hours per week and the intensity of an hour's work vary greatly; (iv.) per *day*—the number of days' work in a normal week differs with occupation; (v.) per *week*—this is the rate usually stated in wage records, and serves for comparisons by age, sex, class of work and district, and at various dates, in those cases where allowance is possible or not necessary for seasonal variations in employment or for seasonal payments; (vi.) per *year*—this measurement should be generally attempted, since all seasonal fluctuations of work and annual payments are included, and a comparison of annual earnings in two trades shows all the essential conditions except any special liability to disease, the duration of working life, and the influence of commercial credit cycles; (vii.) per *working lifetime*—this measurement would be very valuable, especially in comparing men's and women's wages, if trustworthy averages could be obtained.

Wages vary with age, sex, trade, specific occupation, and district. The following table gives a general view of the difference under the first three of these headings.

Average Weekly Wages in October 1886 in the United Kingdom.[1]

	Women.		Girls (under 18).		Men.		Lads (under 18).	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
General average	12	8	6	4	24	7	8	11
Number of trades included	23		19		38		37	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Cotton manufacture	15	3	6	10	25	3	9	4
Woollen ,,	13	3	7	5	23	2	8	6
Worsted and stuff manufacture	11	11	6	2	23	4	6	6
Linen manufacture	8	11	4	11	19	9	6	3
Jute ,,	9	7	4	8	19	4	6	8
Silk ,,	10	1	5	8	22	3	7	2
Hosiery ,,	11	6	8	3	24	5	9	6
Coal, iron ore, and ironstone mines	...		...		22	11	10	9
Metalliferous mines	...		...		16	6	7	0
General engineering, iron and brass foundries, and machinery trades	...		...		25	9	9	1
Shipbuilding, iron and steel	...		...		29	3	12	2
Pig-iron (blast furnaces)	...		...		24	6	10	8
Breweries	...		...		24	3	9	9

Police, 27s. 7d.; printing and engraving (newspapers), men, 37s. 1d.

Annual Earnings, 1886; valuing all payments in kind.—Mercantile seamen,[1] £65; seamen and petty officers, R.N.,[1] £65; army (N.C.O. and men),[1] £48. Agricultural labourers[2]: England and Wales, £36; Scotland, £47; Ireland, £23. On railways[1]: 1886, £59; 1891, £61, 10s.

Female domestic servants, average of annual money wage,[3] 1898, London, £18; rest of England and Wales, £16; Scotland, £16, 10s. (*circa*).

Average Weekly Wages in the Building Trades.[1]

	January.				July.			
	1886.		1891.		1886.		1891.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Masons	27	11	30	10	32	8	34	6
Bricklayers	31	0	32	3	35	6	36	11
Carpenters and joiners	31	8	33	9	34	2	35	3
Painters	27	6	29	2	31	9	33	7
Builders' labourers	19	1	19	9	21	7	22	9

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[1] *General Report on the Wages of the Manual Labour Classes*, 1893, pp. xiii. xviii. xxix. xxxiii. 25, 26, 27, 470 *seq.*, C. 6889.

[2] *Journ. Stat. Soc.*, 1899, pp. 564, 567.

[3] *Report on the Money Wages of Indoor Domestic Servants*, 1899, pp. 8, 10, C. 9346.

In making use of this and other tables, it must be remembered that no wage statistics pretend to great accuracy; those quoted in this article may be regarded as trustworthy estimates, whose accuracy and extent of application must be gathered from the original authorities. The figures given above show general averages for all workers in a trade; the following table shows how great is the variation in different occupations in the same trade, even when only the averages for those occupations are given.

Average Weekly Wages in Engineering and Machinery Works, October 1886.[1]

(Northumberland, Durham, and Cleveland District.)

	Men.				Assistant Boys.	
	No. employed.	Time-Wages.	No. employed.	Piece-Wages.	No. employed.	Time-Wages.
		s. d.		s. d.		s. d.
Ironmoulders	207	28 5	129	34 0	161	8 8
Core-makers	31	27 8	17	35 1	16	8 9
Fettlers or dressers	43	22 2	21	29 0	11	7 11
Planers	31	24 3	12	30 9	6	7 0
Drillers and screwers	79	22 8	26	28 9	10	7 1
Riveters	88	31 10	21	38 5	73	12 4
Smiths	104	28 3	23	43 4	51	9 10
Smiths' strikers	82	19 10	27	28 11		
Platers	28	36 5	24	46 7	11 20	7 0 14 4[2]
Holders-up	29	24 2	7	29 5	...	...
Bolt-makers	...	...	3	36 10	...	...
Pattern-makers	95	29 11	...	...	45	8 0
Brass-finishers	16	28 5	...	...	15	8 2
Turners	84	29 6	...	...	97	8 2
Fitters and erectors	201	29 0	...	...	92	8 3
Unclassed—men	108	27 0	78	26 5	...	...
Unclassed—boys	191	8 1	29	15 4	...	...
Rivet heaters—boys	47	7 2	23	11 4	...	...

Weekly Time-Wages: Men.

	No.	s. d.		No.	s. d.
Foremen	124	45 7	Labourers	731	18 10
Stovemen	8	17 8	Slotters and borers	17	25 10
Watchmen	12	20 7	Millwrights	13	30 9
Carters	11	21 5	Belt makers and menders	5	22 0
Painters	11	26 3			
Cupola men	38	23 6	Stationary engine-men	41	21 7
Coppersmiths	11	29 6			
Brass-founders	12	28 11	Storekeepers and timekeepers	20	23 3
Crane-hands	30	20 11			
Carpenters and joiners	50	28 0			

Before giving statistics of variation by district, it is necessary to develop a scheme of tabulation. Let a series of figures be arranged in ascending order; the figure which lies half-way up the list, so that there are as many entries above as there are below it, is called the median (M in the sequel), those one-quarter and three-quarters up are the quartiles (Q_1, Q_3), those one-tenth and nine-tenths up are two of the deciles (D_1, D_9); A, Min., and Max. represent the arithmetic average of the items included, and the minimum and maximum respectively. The following table shows the variation of the wages and working hours for the same occupations, recognized in districts throughout the kingdom by certain trade unions.

	1	2	3	4	5	6	7	8	9	10	11
	s. d.	s. d.	s. d.	d.	hrs.	s.	s.	s. d.	d.	s. d.	s. d.
Min.	28 0	23 6½	23 6½	4¾	49	28	26	26 0	3½	18 0	18 0
D_1	33 0	28 0	30 0	6½	50	30	28	30 0	5	28 0	30 0
Q_1	35 4	30 7¼	32 11½	7	54	32	30	31 6	5½	29 6	31 6
M	37 4	33 9	35 3¾	8	55½	34	32	34 0	6	31 6	34 0
Q_3	39 7	36 0	37 8	8½	56½	36	34	36 0	6¼	34 0	35 0
D_9	40 10½	37 8	40 0¼	9	56½	38	36	38 0	6¾	35 0	38 0
Max.	41 3	42 4½	42 4½	9½	61½	38	38	38 0	8½	40 6	40 6

Columns 1, 2, 3, 4, 5.—*Operative Bricklayers' Society*[3]: each district counted as one unit. 1, 2, 3, summer weekly wages; 1, England north of Warwickshire; 2, rest of England and Wales; 3, United Kingdom; 4, hourly rate (all); 5, summer weekly working hours (all), 1893.

Columns 6, 7, 8.—*Friendly Society of Ironfounders*[3]: each district counted as one unit, weekly wages. 6, England, north of Warwickshire; 7, rest of England and Wales; 8, United Kingdom, 1893.

Column 9.—*Typographical Association*[4]: piece-rate per 1000 ens brevier on newspapers other than daily; each district counted as one unit; United Kingdom, 1893.

Columns 10, 11.—*Amalgamated Society of Engineers*[5]: weekly wages, United Kingdom. 10, Each district counted as one unit; 11, each member counted as one unit, supposed earning standard rate of his district, 1891.

The rates dealt with in the preceding table are the standard minimum recognized by the trade unions; in some cases they are higher than the wages actually paid, where the union is trying to raise wages, in others lower, where the more efficient workmen are paid above the minimum rate. In many cases rates are stated both by men's and masters' societies, and occasionally the masters' statement is higher than the men's, though the reverse is more frequent. Mr F. W. Lawrence (*Local Variations in Wages*, p. 31 *seq.*) finds that the recognized wages are, in the great majority of selected cases, those actually paid. The above table indicates that the level of wages in the north of England is considerably higher than that in the south, and this tendency would be more marked if London had been excluded. Mr Lawrence (*loc. cit.* p. 18) finds that wages bear a close relation to the population of the districts in which they are paid, "the larger the town the higher the wage," and that the excess above a certain minimum is roughly proportional to the square root of the number of inhabitants. The causes of this difference are not yet clearly known; higher rents, greater efficiency of work, and better facilities for trade union action are some of the factors.

Use of average.

In discussing the progress of wages it has been usual to estimate the arithmetic average (the quotient of total wages paid divided by number earning), and it has been objected that the change in this quantity shows very little, since an increase may be due to the high wages of a small body of men, while the great mass may be actually losing ground. This difficulty would be surmounted if we could estimate the median, quartiles, and deciles at various dates; but since the material is not to hand for this, we may usefully notice that these quantities bear a fairly definite relation to the average; in fact, that wages of a great miscellaneous body of workers are grouped about their average according to a fairly definite law (Bowley, *Wages in the United Kingdom in the Nineteenth Century*, sec. iii.). There are very few collections of statistics of wages paid to a sufficiently large number of workers; the following table contains the analysis of four such groups:—

Grouping of Wages.

	United Kingdom.		London.				United States.			
	1	2	3	4	5	6	7	8	9	10
	s. d.	p. c.	s. d.	p. c.	s. d.	p. c.	$[6]	p.c.	$	p. c.
D_1	16 0	66	21 3	69	20 0	69	1·29	64	1·20	69
Q_1	20 0	82	25 3	81	22 6	78	1·60	80	1·41	81
M	24 3	100	31 0	100	29 0	100	2·00	100	1·75	100
A	24 7	101	...	...	...	...	2·17	108	2·00	114
Q_3	28 9	119	37 6	121	35 0	121	2·50	125	2·46	140
D_9	34 0	140	44 0	142	41 0	141	3·25	162	3·00	171
	356,000 men		75,000 men		75,000 men		5,000 men		6,500 men	

These figures are only approximate. Column 1 is deduced from the Board of Trade report on wages (*loc. cit.*) and refers to the year 1886; column 3 from Mr Booth's *Life and Labour of the People*, ix. p. 371; and column 5 from the same source, corrected in accordance with suggestions there made. Columns 7 and 9 are compiled from the *Senate Report on Wholesale Prices, Wages,*

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[1] *General Report on the Wages of the Manual Labour Classes*, 1893, pp. xiii. xxix. xxxiii. 25, 26, 27, 470 *seq.*, C. 6889.

[2] Piece.

[3] Compiled from *Standard Time Rates*, pp. 2 *seq.* and 179 *seq.*

[4] *Standard Piece Rates*, p. 172 *seq.*, C. 7567, I., II., 1894.

[5] Compiled from *Fifth Report on Trade Unions*, Board of Trade, 1893, p. 220 *seq.*, C. 6990, 1893.

[6] This column is given in the inflated currency of 1875.

and Transportation (Washington, 1893) for 1875 and 1891 respectively. The figures in each of these columns are expressed as percentages of the corresponding medians, and so given in the adjacent columns. The lowest line gives the number of workers included in the groups.

These examples are too few to establish a law, but they point to the following scheme: the median is a little below the average; the quartiles are respectively $\frac{4}{5}$ and $\frac{5}{4}$, and in the United Kingdom the deciles nearly $\frac{5}{7}$ and $\frac{7}{5}$ of the median. A law of grouping will remain unchanged, if the proportionate demand for and supply of labour of various degrees of excess or defect from normal skill do not vary; there is an impression among authorities that the tendency is to increase the demand for skilled labour, but this will only affect the law of grouping if this increase outpasses the increase of normal skill. At the least it may be granted that the change in grouping may be expected to be slow, and that this tentative law gives us some means of constructing the actual distribution of wages when we only know the median or average. The less typical American figures for 1860, not here tabulated, however, show a different grouping.

Besides these numerical relations, we may generally notice that in a large group of wage figures there is a tendency to mass about two different sums. The following table is an excerpt from the Board of Trade *General Report* already cited, pp. 470–1:—

Percentage Number of Men paid at Various Rates in October 1886.

	Number concerned.	Under 10/	Of 10/ and under 15/	Of 15/ and under 20/	Of 20/ and under 25/	Of 25/ and under 30/	Of 30/ and under 35/	Of 35/ and under 40/	Above 40/
Cotton manufacture.	32,000	0	1·2	27·3	27·4	14·1	22·6	4·9	2·5
Silk manufacture.	2,000	0	14·4	39·2	16·3	12·4	5·4	12·1	0·2
General engineering, &c.	42,000	0	1·0	28·5	16·9	28·9	15·2	5·9	3·6
Coal mines, &c.	67,000	0	·6	19·5	48·8	29·4	1·3	·2	·2
All in returns[1]	356,000	·1	2·4	21·5	33·6	24·2	11·6	4·2	2·4

Here we see that there are groups in the cotton manufacture at about 20s. and 32s. 6d., and in the silk at about 17s. 6d. and 37s. 6d.; in general engineering there are less distinctly separated groups at about 17s. 6d. and 27s. 6d.; in the case of coal mines, where the great mass of the work is done by one class of men, there is only one group. In the total there is an indication of an upper group, for if there was only one symmetrical group, the percentage between 30s. and 35s. would be smaller. The figures would result from the following groups:[2]—

	10/ to 15/	15/ to 20/	20/ to 25/	25/ to 30/	30/ to 35/	35/ to 40/	Above 40/
1st group	3	16	29	16	3	..	..
2nd group	..	3	5	8	8	5	3

The numbers cannot be exactly analysed, since the limits of money used in the report are so wide; but the figures are consistent with a large group round 22s. 6d. and a smaller one round 32s. 6d. This tendency to split into two groups is very marked in the American figures used above, and can also be detected in Mr Booth's *Life and Labour*. It can be explained by regarding the working class as made up of two sections — one, the majority, unskilled, and the other skilled; the tendency would probably be more marked in figures of 50 or 100 years ago, for in modern times skill has become more minutely graded, an intermediate class has grown up between the "tradesman" and the labourer, and a minute analysis applied to more complete figures might show four or five instead of two groups. Agricultural wages are not included in the above figures.

As a single measure, the median is at once easier to estimate and more useful to know than the average. The following table shows, probably with fair accuracy, the change of wages in two typical occupations, and contains a rough estimate of the change of the median wage throughout the 19th century. Material perhaps does not exist, and certainly has not yet been compiled, for an accurate and detailed statement. The materials from which the first line is compiled are given by Mr Bowley (*loc. cit.* sec. xii.), the second line comes from the *Journ. Stat. Soc.*, September 1899, and the third is an estimate based on various material summarized by Mr Bowley (*loc. cit.*), and on Mr Wood's article in the *Economic Journal*, December 1899. It is very instructive to notice how the median wage has been moving away from the labourer's wage towards the artisan's since 1840.

Trend of wages in the 19th century.

Table illustrating the Progress of Weekly Wages.

	Approximate Dates.					
	1790.	1810.	1820.	1840.	1860.	1890.
	s.	s. d.	s. d.	s. d.	s d.	s d.
Building artisan, London (summer)	18	29 0	29 0	30 0	33 0	39 6
Agricultural labourer,[3] England .	8	16 0	14 0	12 0	13 6	15 0
Median, adult males, United Kingdom	10	17 6	15 6	14 6	17 0	24 0

The material for dates since 1860 is more complete; the following table gives estimates of the increase in average wages in many of the principal industries, based on Mr Bowley's tables published in the *Journ. Stat. Soc.*, June 1895, September and December 1899, and March 1901, and in the *Economic Journal*, December 1898. More reliance can, in general, be placed on estimates of rates of change than on statical statements of wages; actual wages at the various dates can, however, be estimated from this table in combination with the other statistics given in this article.

Course of Average Money Wages in Selected Industries in the United Kingdom. Wages in each Trade expressed as Percentages of their Value in 1860.

	1860.	1866.	1870.	1874.	1877.	1880.	1883.	1886.	1891.
Agriculture .	100	106	115	144	147	133	129	126	137
Building . .	100	110	112	124	132	128	128	128	132
Cotton . .	100	115	115	141	141	133	141	146	156
Wool. . .	100	106	112	121	130	126	120	115	115
Jute . . .	100	133	...	140	127	120	142	120	140
Flax . . .	100	114	...	129	133	...	...	133	...
Iron[4] . .	100	127	127	143	112	112	110	100	124
Engineering .	100	108	110	124	123	120	127	126	126
Gasworks . .	100	115	120	125	128	128	130	130	149
Seamen[5] . .	100	113	103	129	123	102	118	110	143
Coal-mining .	100	109	106	147	110	103	110	105	147
Compositors .	100	100	103	113	116	116	116	116	121
Average[6] . .	100	112	115	140	135	129	134	132	145

In the above table it must be understood that each date refers to a short period, not to an individual year. If the figures for 1880–91 are compared with the statistics of occupation given in the *Annual Labour Abstract*, it will be found that in general, in those industries where wages have increased faster than the average, relative numbers employed have also increased, and *vice versâ* (*Econ. Journal*, 1896, p. 469). There is, as Sir R. Giffen has pointed out (*Essays in Finance*, 2nd series, p. 421 *seq.*), a continual transference from badly-paid to well-paid trades; and to this we may add a further transference from trades where the rates increase slowly to those where the rates increase fast. Both tendencies are allowed due influence in the line of averages in the above table.

The change year by year is known for some occupations; the figures in the following table are selected as being based on trustworthy evidence and illustrating a wide group of occupations. In this table we may notice the various effects of the cycle of commercial inflation and depression on the different industries, and also pick out the results of such single events as the failure of the City of Glasgow Bank in 1878. From the general view shown by the tables, it is at once clear that wages in some trades make regular slow progress, while in others the fluctuations are rapid and violent, and though there is a marked upward tendency, both since 1860 and since 1880, the highest point of the inflation of the early 'seventies has not in some industries again been touched.

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[1] This line is calculated from the last line of p. 470 of the report.

[2] The dissection into two groups has been performed by the method described by Prof. Karl Pearson, *Phil. Trans. Royal Soc.*, 1894, A. pp. 71–110.

[3] Valuing all special payments and perquisites.

[4] Puddling and blast furnaces.

[5] Merchant service: money wage only.

[6] Allowing for relative numbers at each date, and for relative rates of wages, thus showing the estimated change in the average wage in these industries combined.

Year.	Compositor, London, *weekly* ('Stab).[1]	Carpenter, Edinburgh, summer, *weekly*.[2]		Mason, Glasgow, summer, *weekly*.[2]		Agricultural Labourer *annually*.[3]		Coal Miner, Lanark, *daily*.[2]		Puddler, Cleveland, *per ton*.[4]		Durham—Coal Miner. Percentage above 1879 base, *sliding scale*.[5]
						England.	Scotland.					
	s.	s.	d.	s.	d.	£	£	s.	d.	s.	d.	
1860	33	22	0	25	0	35	36	3	6	6	3	...
1861	,,	,,		25	9	36	,,	3	2	[6]		...
1862	,,	,,		,,		,,	,,	3	1	...		...
1863	,,	,,		,,		,,	,,	3	7	...		...
1864	,,	21	3	,,		,,	,,	4	0	...		...
1865	,,	22	4	28	6	,,	,,	4	1	...		...
1866	36	25	6	27	7	,,	,,	4	6	...		...
1867	,,	,,		28	8	,,	37	4	1	...		...
1868	,,	,,		,,		37	38	3	7	7	3	...
1869	,,	26	6	27	7	38	39	,,		...		...
1870	,,	,,		,,		39	41	3	9	...		...
1871	,,	,,		,,		41	43	4	6	...		...
1872	,,	27	8	29	9	44	46	7	0	...		...
1873	,,	29	9	31	10	46	49	10	0	13	3	...
1874	,,	31	10	34	0	47	51	7	2	11	6	...
1875	,,	34	0	36	1	,,	53	5	4	9	6	...
1876	,,	36	0	40	4	46	54	4	8	9	3	...
1877	,,	,,		42	6	,,	,,	4	1	9	0	8[7]
1878	,,	31	10	27	7	45	53	3	2	7	8	...
1879	,,	27	8	25	6	43	50	4	7	7	1	0
1880	,,	,,		,,		41	48	4	11	8	0	0
1881	,,	,,		27	7	40	46	4	7	7	7	2½
1882	,,	,,		29	9	39	,,	,,		8	4	[illegible]
1883	,,	,,		31	10	,,	,,	5	2	7	5	7½
1884	,,	,,		29	9	38	47	4	7	6	9	7
1885	,,	,,		,,		37	,,	4	1	6	5	6
1886	,,	,,		,,		36	,,	3	10	6	3	4
1887	,,	29	9	,,		37	48	4	2	,,		4
1888	,,	,,		,,		38	,,	,,		6	4	4
1889	,,	,,		30	10	39	,,	5	2	7	3	9
1890	38	31	10	31	10	,,	49	6	2	8	3	30
1891	,,	,,		32	11	40	,,	,,		...		35
1892	,,	32	11	35	1	,,[7]	,,	5	6	...		30
1893	,,	,,		36	1	,,	,,	6	2	7	0	22
1894	,,	34	0	37	2	,,	,,	5	3	6	11	25
1895	,,	,,		,,		,,	,,	4	9	6	9	19
1896	,,	36	1	38	3[7]	39	,,	4	4[7]	,,		15
1897	,,	38	3	,,		,,	,,	4	6	7	0	16
1898	,,	40	4	40	4	40	,,	5	10	7	3	21
1899	,,	,,		,,		,,	,,	6	7	8	0	28½

Irregularity of work.

Annual earnings are affected greatly by the amount of lost time. The following table, from Mr Wood's "Statistics of Working Class Progress since 1860" (*Journ. Stat. Soc.*, 1899) and from the monthly returns published in the *Labour Gazette*, shows the average annual percentage number of unemployed members belonging to those trade unions whose returns are accessible.

Year.	p.c.	Year.	p.c.	Year.	p.c.	Year.	p. c.	Year.	p.c.
1860	1·6	1868	8·5	1876	3·6	1884	7·4	1892	6·2
1861	4·3	1869	7·4	1877	4·4	1885	9·0	1893	7·5
1862	7·8	1870	4·3	1878	6·3	1886	9·5	1894	6·9
1863	5·7	1871	1·8	1879	12·5	1887	7·8	1895	5·8
1864	2·6	1872	1·1	1880	5·9	1888	4·7	1896	3·4
1865	2·0	1873	1·3	1881	3·4	1889	2·1	1897	3·5
1866	3·1	1874	1·8	1882	1·9	1890	2·0	1898	3·0
1867	7·3	1875	2·5	1883	2·2	1891	3·3	1899	2·4

These figures relate only to trades which are strongly "combined," and are not even strictly comparable with each other, since more and more unions are included as the series progresses. On the whole, there is no distinct evidence of improvement or the reverse. The following table, extracted from the *Fifth Annual Abstract of Labour Statistics*, pp. 72–73, shows the fluctuation month by month for certain groups of trades:—

Mean for the 7 years 1892-98.	Percentage of Members Unemployed.												
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	7 years.
All trade unions making returns	6·1	5·8	5·2	4·8	4·7	4·5	4·6	5·0	5·2	5·3	5·3	6·0	5·2
Carpenters and plumbers	4·7	4·2	3·2	2·4	2·1	2·2	2·2	1·9	2·0	2·2	2·4	3·7	2·8
Metal, engineering and shipbuilding trades	8·1	7·6	7·0	6·8	6·5	6·3	6·8	7·2	7·7	8·0	7·9	8·3	7·4
Printing and bookbinding trades	5·0	4·5	3·9	3·9	4·0	4·4	3·9	5·8	5·4	4·6	3·4	4·0	4·4

In the *Wage Census* (Board of Trade), 1886, the following particulars were in all cases obtained: (i.) the number employed in that week of 1885 in which the greatest sum was paid in wages, which may perhaps be assumed to be the number dependent on the factories making returns, say *n*; (ii.) the total amount paid in wages in 1885, say £*a*; (iii.) the average wage paid in a particular week in October 1886, say £*w*. If the whole number of persons *n* had been employed throughout 1885, their earnings would have been approximately £*n* × *w* × 52 = £*e*, say; then the ratio *a* : *e* is a rough measure of the ratio of the average number of weeks' wages obtained to those of a full year's constant work. Applying this method to the principal industries dealt with, we obtain the following figures:—

Rough Estimate of Number of Full Weeks' Wages obtained in the Year 1886.[8]

Industry.	No. of Weeks.	Industry.	No. of Weeks.	Industry.	No. of Weeks.
Cotton	48	Silk	44	Metal mines	49
Wool	45½	Carpet	44	Slate quarries	44
Worsted	46	Lace	49	Granite ,,	43½
Linen	49	Building	44	Stone ,,	37
Jute	50	Railways	44	Roads, &c.	42½
Hemp	42	Coal and iron mines	47	Gasworks	42
General average for above industries, 46.					

This estimate indicates that 12 per cent. on the average were out of work during 1885, a number greater than the 9 per cent. shown by the trade union returns, as might be expected.

A class, of great but unknown number, of manual workers is not taken into account in any of the above statistics relating to wages or employment. This class consists of all those who are permanently out of work, through misfortune, incapacity, idleness, or other causes; of those who occasionally get work, but are not attached to any regular trade; and of large and, on the whole, badly-paid industries, domestic service, home tailoring, service in shops, and others, with regard to which no systematic statistics on a large scale are forthcoming.

Purchasing power of wages.

So far we have dealt with the statistics of *nominal* wages only; imperfect as these statistics are, they are far more complete than those which relate to the purchasing power of money and to *real* wages. We have, indeed, several estimates of the change in the value of money when measured by other commodities, but these depend only on wholesale prices. Among the best known are the index-numbers compiled by Mr Sauerbeck (*Journ. Stat. Soc.*, March, annually). From these we can deduce numbers representing the purchasing power of a sovereign in "general commodities." They are as follows:—

Purchasing Power of Gold in General (Wholesale) Commodities (Average of 1867–77 being 100).

Year.	Index No.	Year.	Index No.	Year.	Index No.	Year.	Index No.
1860	101	1870	104	1880	114	1890	139
1861	102	1871	100	1881	118	1891	139
1862	99	1872	92	1882	119	1892	147
1863	97	1873	90	1883	122	1893	147
1864	95	1874	98	1884	131	1894	159
1865	99	1875	104	1885	139	1895	161
1866	98	1876	105	1886	145	1896	164
1867	100	1877	106	1887	147	1897	161
1868	101	1878	115	1888	143	1898	156
1869	102	1879	120	1889	139	1899	147

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[1] *Journ. Stat. Soc.*, Dec. 1899.

[2] *Wages in the United Kingdom*, Bowley, pp. 89, 90, sec. xiii.

[3] *Journ. Stat. Soc.*, Sept. 1899.

[4] Various authorities.

[5] App. to Labour Commission, and the Labour Department's *Changes in Rates of Wages*.

[6] Where blank spaces are left, figures cannot be accurately given.

[7] Figures after these dates are from new estimates.

[8] From *Archiv für soziale Gesetzgebung und Statistik*, p. 314. Berlin, 1896.

There is good reason for holding that numbers compiled on such principles represent with considerable accuracy the change in general wholesale prices (see *Report* of Brit. Assoc. for 1887, 1888, 1889, Committee on Variations of the Monetary Standard). The fact that wholesale prices have fallen so rapidly makes it certain that there has been a corresponding fall in retail prices, but the extent of this fall as it affects incomes of different amounts is very imperfectly known. The necessary data for the solution of this question are the retail prices of the articles on which wages are spent and the fraction of the wage spent on each article at each date. Since prices of articles change at varying rates, it is clear that the change in purchasing power varies for different incomes, since the size of the income governs the object of the expenditure. At the lowest scale of expenditure in England, bread absorbs a large fraction of the wage, and the price of bread governs the purchasing power; as means increase, meat, clothes, house-rent, luxuries, the cost of personal service, successively come into prominence, so that separate valuations are necessary for many classes. Again, the retail prices of articles vary not only with localities, but also with purchasers, who buy at various times and in various quantities, so that the difficulty of stating them is greatly increased. There are many compilations of budgets of expenditure of workmen in various ranks and countries and periods, but they do not lend themselves to the purpose in hand. The following budgets are offered not as authentic, but as being sufficiently near the facts, shown in authentic collections, to illustrate the problem and its theoretic solution.

Illustrative Artisan's Family Budget.

1860.

	s.	*d.*
Bread, 8 quarterns	4	4
Meat, 5 ℔	2	8½
Bacon, 2 ℔	1	4
Potatoes, 20 ℔	1	0
Flour, 6 ℔	0	10
Rice and meal	1	6
Vegetables	0	6
Butter, 1 ℔	1	1
Milk, 8 pints	1	0
Sugar, 3 ℔	1	3
Treacle, 2 ℔	0	5½
Tea, 4 oz.	1	0
Coffee, 8 oz.	0	8
Soap	0	8
Coal, 1½ cwt.	1	6
Rent	3	0
	22	10
For clothes and sundries	5	2
Weekly earnings	28	0

Cost of this budget at prices of 1900, 25s. 5d. (about).

Hence increased purchasing power of money, 1900 over 1860, 10 per cent.

1900.

	s.	*d.*
Bread, 6 quarterns	2	6
Meat, 8 ℔	5	4
Bacon, 2½ ℔	1	8
Potatoes, 10 ℔	0	6
Flour, 3½ ℔	0	5
Rice, oatmeal, &c.	1	0
Vegetables	0	8
Butter, 2 ℔	2	4
Milk, 8 pints	1	4
Eggs, 6	0	6
Sugar, 4 ℔	0	7
Jam	0	6
Tea, 12 oz.	1	0
Cheese, 1 ℔	0	7
Soap, &c.	0	5
Lights	0	6
Coal, 2 cwt.	2	6
Rent	5	0
	27	4
For clothes and sundries	8	8
Weekly earnings	36	0

Cost of this budget at prices of 1860, 43s. (about).

Hence increased purchasing power of money, 1900 over 1860, 20 per cent.

Illustrative Agricultural Labourer's Family Budget.

1860.

	s.	*d.*
Bread, 9 quarterns	5	3
Bacon, 1½ ℔	0	9
Butter, 1 ℔	1	0
Cheese, 1 ℔	0	8
Tea, 2 oz.	0	8
Sugar, 1 ℔	0	5
Treacle, 1 ℔	0	3
Potatoes	0	4
Soap, &c.	0	3
Light	0	3
Rent	1	0
	10	10
Clothes and sundries	1	2
Weekly earnings	12	0

Cost of this budget at prices of 1900, 10s. (about).

Hence increased purchasing power of money, 1900 over 1860, 20 per cent.

1900.

	s.	*d.*
Bread, 8 quarterns	3	4
Bacon and meat, 4 ℔	2	6
Butter, 1 ℔	1	3
Cheese, 2 ℔	1	2
Tea, 6 oz.	0	6
Sugar, 3 ℔	0	6
Milk, skim, 2 quarts	0	2
Potatoes	0	6
Soap, &c.	0	5
Light	0	3
Fuel, 1 cwt.	1	4
Rent	1	6
	13	5
Clothes and sundries	1	7
Weekly earnings	15	0

Cost of this budget at prices of 1900, 18s. 2d. (about).

Hence increased purchasing power of money, 1900 over 1860, 21 per cent.

It is first to be noticed that these budgets are influenced greatly by the prices of bread and meat in 1860, which we do not know exactly. These are of more importance than the exact quantity of the various articles purchased. Hence the results obtained must be regarded for the present as merely tentative. As regards rent, it is probable that the increase is due partly to better value, especially when water and the benefits from the expenditure of the rates included are considered, partly to increased pressure of population and ground rent; in reckoning the comparative prices, half of the change is debited to each of these. Since the margin between the expenditure on food and the wage can be spent on any object, manufactured goods, clothes, travelling, and so on, it is reasonable to regard this margin as subject to the change in purchasing power of gold shown by wholesale index numbers; this has been done in reckoning comparative prices. It is then seen that the benefit of reduced prices is chiefly in the share of income devoted to bread and in the margin; the former is chiefly to the advantage of the agricultural labourer, the latter to that of the artisan; both benefit in the cheapness of groceries. As a commodity becomes cheaper, more of it is purchased; and as the wage increases, more is spent on dearer goods. This change in objects of expenditure is adequately allowed for, if we reckon the increased purchasing power as above, first on the basis of one, then on that of the other year's budget; the quantity required must lie between the measurements so obtained; in the case of the artisan the increase is therefore between 10 and 20 per cent., and while his nominal wage has increased 29 per cent., his real wage has risen about 48 per cent. $\left(\frac{129}{100}\times\frac{115}{100}\right)$. The corresponding numbers for the agricultural labourer are 25 per cent. and 50 per cent. If we had adopted Mr Sauerbeck's numbers without criticism, the real wages would have shown increments of 104 per cent. and 100 per cent. It must be emphasized that this calculation is not intended actually to evaluate the increase in real wages, but to show the difficulties and dangers of the problem, and to suggest a method of solution when the requisite data have been obtained. Yet we may deduce that real wages have probably risen faster than nominal wages, and that the divergence between them is not so great as that indicated by index-numbers of wholesale prices. There is not space to do more than enumerate the improvements in real wages which come from shortened hours of labour, better conditions of work enforced by legislation, the gift of free education to the labourer's children, and the public benefits open to him as a citizen.

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and Piece Rates, 1894 and 1900; *Reports on Profit-Sharing*, 1894; *Employment of Women and Girls*, 1894; *Gain-sharing*, &c., 1895; *Money Wages of Indoor Domestic Servants*, 1899; *Reports on Trade Unions* (especially 4th, 5th, and 6th), annually since 1887; *Reports on Strikes and Lock-outs*, annually since 1888; *Reports on Rates of Wages in many Trades and General Report* ("The Wage Census"), 1889–93 (Papers by Command: C. 5807, 6161, 6455, 6715, 6889); *Returns of Wages*, 1830–86, 1887 (C. 5172).—2. Miscellaneous: *Factory Inspectors' Reports*, half-yearly since 1835. *Returns of Agricultural Wages*, England, 1860, 1861, 1869, 1870, 1872; Scotland, 1860; Ireland, 1860, 1869. *Agricultural Statistics of Ireland*, annually since 1890. *Merchant Seamen's Wages*, 1867. *Supply of Seamen*, 1873. *Merchant Shipping Returns*, 1890. *Report on Hours of Labour*, 1890. *Wages and Earnings of Agricultural Labourers* (Cd. 346, 1900).—3. Reports of Commissioners: *On Children's Employment*, 1863–67; *Women and Children in Agriculture*, 1867–69; *Agricultural Interests*, 1880–82; *Depression of Trade*, 1886; *Agriculture*, 1894 and 1896; *Labour Commission*, 1893–94 [especially C. 6894, xxiv. and xxv. (Agriculture), and C. 7421, i. (appendix)]; *Financial Relations of Great Britain and Ireland*, 1895–96. See also the more complete bibliography of wages, *Economic Review*, 1898, pp. 504–520; and the shorter bibliographies relating to prices, wages, and workmen's budgets in Palgrave's *Dictionary of Pol. Econ.* iii. pp. 195, 198, 641, 676. (A. L. Bo.)

II. United States.

Nominal wages only are dealt with in this article. By "nominal wages" is meant rates of wages or earnings, without reference to the cost of living. Wage statistics as such were not known in the United States until perhaps 1875. The systematic collection and classification of wages constitute features in modern industrial statistics. For the period anterior to 1875 or thereabouts, therefore, reliance must be placed upon fugitive statements, rates drawn from accounts, and statements found in history. In the early colonial days attempts were made to fix rates of wages by law, but no such attempts have been made since the first half of the 17th century. In 1633 the Massachusetts Bay colony provided that carpenters, sawyers, masons, bricklayers, tilers, joiners, wheelwrights, mowers, and other master workmen should not receive more than two shillings per day. The statute provided that each workman should pay his own board, but if board was furnished they might receive fourteen-pence per day. The best skilled labourers might receive eighteen-pence per day, while the constable could fix the rates for poorer labourers as well as for inferior workmen in the trades. Journeymen tailors were paid twelve-pence per day, but tailors of little skill could be paid only eight-pence, their living being added. Employers paying more than the rates allowed by law, or workmen receiving them, were to be punished. Such statutes did not work well, and were soon repealed, although others were enacted and also repealed. For a long time two shillings per day constituted a fair average wage for mechanical labour. This rate applied to mowers, wheelwrights, and that class of labour. Skilled workmen and labourers were annoyed by regulations fixing wages and imposing fines all through the 17th century, while there were laws in Massachusetts colony forbidding workmen to take wine in part payment for services, and in 1672 labourers were forbidden to demand liquor as any part of their wages. In the same year two shillings per day constituted the pay of common labourers, and this had been the rate for forty years. Four pounds to five pounds per annum was the compensation for women. Field hands (who were Indians to some extent) received eighteen-pence per day. At the close of the 17th century two shillings per day was the rate for common labourers in New England, while in New York they received two shillings and three-pence to three shillings. During the first few years of the 18th century four shillings per day was paid in some parts of the country. Ten pounds sterling per annum was the usual amount earned in Virginia colony. Wages remained fairly steady throughout the 17th century, nor was there any particular change until far into the 18th century. The wages of mechanics were based upon those of farm labourers. At the close of the colonial period the latter were paid about 40 cents per day, the average from 1752 to 1760 being 31 cents. In 1780 butchers were paid 33⅓ and carpenters 52 cents per day. Boat-builders and ship carpenters at the close of the colonial period were able to earn 90 cents, shoemakers 73 cents, and blacksmiths 70 cents per day.

The chief data from which quotations can be made for the period beginning at the close of the Revolutionary War relate very largely to the Eastern and Middle States, as very few can be obtained for other parts of the country. Not much change took place in the rates of wages paid in various trades until the period of 1790 to 1830, when the factory system had become known and its influences felt. During that period most labour was paid higher wages, on account of the greater demand. Carpenters, who were paid in 1790 60 cents a day, received 70 cents in 1800; in 1810, $1·09; in 1820, $1·13, and about the same in 1830, although in the northern parts of the country $1·40 was a fair average during the period from 1830 to 1840. There was not much change for carpenters until 1860. If the wages of labourers, as distinguished from skilled workmen, are taken as representative of general conditions, the records show that they were paid in 1790 about 43 cents a day on the average; in 1800, 62½ cents; from 1800 to 1810, 82 cents; from 1810 to 1820, a little over 90 cents; while during the years from 1840 to 1860 they were paid from 87½ cents to $1 a day. When the 19th century opened, printers were paid about $1 a day, and this rate was increased to $1·75 by 1860. From 1790 to 1800 shoemakers received 73½ cents a day on the average, while from 1820 to 1830 it was $1·06, and by 1860 $1·70 per day. The wages of cotton-mill operatives are not given anywhere for any period prior to 1820, but from then to 1830 they were paid, on the average, 44 cents a day, while during the next ten years they received 90 cents a day. There was little change till 1850, when during the next ten years their average pay was $1·03 per day. Woollen-mill operatives were paid somewhat better rates. During the years from 1820 to 1830 their wage was $1·12 a day, but they received little increase before 1880. After 1830 the records of mills and factories furnish a more complete statement of wages, while reports of agriculture give information in that industry. In 1831 agricultural labourers ranged from 57½ cents to $1 per day. Blacksmiths were being paid $1 to $1·25; carpenters $1·07, but often as high as $1·50, while masons were paid $1·26 per day. After 1873 wages in the principal occupations doubled in most cases. Then came the minute division of labour and separation into classes, so that it is difficult to give an average wage, or at least an average wage gives but little idea of rates of wages for the different classes; so one must look to a classification of wage rates in the last quarter of the 19th century, although we know that paper-mill operatives in 1831 received 66·6 cents, printers $1·25, shoemakers $1·06, cotton-mill operatives 88·6 cents, woollen-mill operatives 94·6 cents, glassmakers $1·13, and millwrights $1·21.

Two industrial depressions occurred between 1830 and 1860, one in 1837 and one in 1857. These, with other influences, helped to keep wages low; nor did they fully recover from the depression of 1857 by 1860, but during the period ending that year there was a decided advance over the rates prevailing in 1830. A few quotations for that period must suffice. Agricultural labourers were paid $1·01 per day, blacksmiths $1·69, carpenters $2·03, masons $1·53, paper-mill operatives $1·17, printers $1·75, shoemakers $1·70, cotton-mill operatives $1·03, woollen-mill operatives 87·3 cents, glassmakers $2·96, and millwrights $1·66. With the exception of woollen-mill operatives, these wages show some increase over 1830. The percentage of increase ranges from 16·3 per cent. for cotton-mill operatives to 161·9 for glassmakers. The examination of twenty different occupations shows that in but one was there an increase in average daily wages. The fluctuation in currency and the financial crisis of 1873 had some effect upon wages during the twenty years from 1860 to 1880, but, comparing the averages for these two years, it is found that agricultural labourers in 1880 received $1·31 per day, blacksmiths $2·28, carpenters $2·42, masons $2·79, paper-mill operatives $2·79, printers $2 18, shoemakers $1·76, cotton-mill operatives $1·40, woollen-mill operatives $1·24, and glassmakers $1·79.

These figures show positive increase in wages in all occupations during the fifty years from 1830 to 1880. Such general averages are somewhat unsatisfactory, but they must be used in the absence of classified data. In some branches of industry, like cotton and woollen and others where there are numerous classes of employés, it is possible to make a gradation which is more satisfactory. Such grades indicate general rates of wages. In the carding department of a cotton factory in Massachusetts wages ranged from $2 for overseers, with thirteen hours of labour, in 1842, to $5 per day, with ten hours of labour, in 1891; while overseers in the weaving branch were increased from $1·75 in 1843 to $5 a day in 1891. Looking at the lower classes of labour in the same establishment, it is found that the average daily wages of pickers and section-hands increased from 71·5 and 69·5 cents respectively in 1842, to $1·03 and $1·64 in 1891, while the hours of work decreased from thirteen to ten. In an establishment in New York the pay of carpenters in 1843 was $1·50 per day, and in 1891 $3·50, while the hours were reduced from ten to eight. Bricklayers' wages increased from $1·75 in 1851 to $4 a day in 1891, while their helpers' pay rose from $1 to $2·50 in the same period, with a decrease of two hours in working time. The rates of pay of draughtsmen in New York increased from $1·75 in 1848 to $5·31 a day in 1891, and foremen blacksmiths from $2·50 to $5·83 in the same period. The pay of locomotive engineers rose from $2·14 in 1840 to $3·77 a day in 1891, and of firemen from $1·06 to $1·96. During the same period the pay of passenger-car conductors increased from $2·11 to $3·84 per day. From 1840 to 1891 the average daily rates of wages for all classes of mechanics and operatives in factories ranged between $1 and $2 per day.

Taking the earnings of common and agricultural labourers for the whole period from 1633 to the present time, it is found that the daily wages for the best labourers rose from 25 to 33 cents immediately preceding the Revolution to 42½ cents immediately after, while in 1891 their wages ranged from $2·50 a day in Montana and $1·25 in New York to 75 cents in the Carolinas. In the latter year farm labourers received from $30 to $40 per month, with board and lodging, in Montana and California, $9 and $10 in the Carolinas and Virginia, and $15 to $20 in New York. Masons (master workmen) received 33·3 cents per day in 1633, and $1 in 1790, while during the busy season of 1891 their wages ranged from $4·50 to $5 per day in California and Colorado, $2·50 in North Carolina, and $2·50 and $3·36 in Pennsylvania and New York.

In 1893 an elaborate report was made by the Senate Committee on Finance, giving the range of wages from 1840 to 1891. This report took 100 as the basis in 1860. In twenty-one industries and from almost 100 separate establishments, and by the use of a simple average, the committee found that wages stood at 87·7 in 1840, at 100 (the basis) in 1860, at 152·4 in 1866, and 160·7 in 1891. So on this basis, which is a mathematical one, the increase was from 87·7 in 1840 to 160·7 in 1891. This shows the mathematical range. On the basis of an elaborate report (sixteenth annual) of the Massachusetts Bureau of Statistics of Labour, making general comparisons for a long term of years, it was shown that the general average increase for the period ending with 1860, compared with that ending 1830, was 52·3 per cent.

Wages in gold were higher in 1891 and 1892 than at any period in the history of the United States prior to 1900. The trend of wages since 1891 is shown by the following table, which does not include wages paid on steam railways and street railways; with the exception of mining, the wages relate to manufacturing only. The table is made on the well-known index number basis, the average for 1891 being placed at 100, and the percentages for other years calculated from that point. It will be seen that in 1900 the general plane of wages in 1891 and 1892 had been more than restored.

Year.	Relative Wage.	Year.	Relative Wage.
1891	100·00	1896	97·93
1892	100·30	1897	98·96
1893	99·32	1898	98·79
1894	98·06	1899	101·54
1895	97·88	1900	103·43

In 1893 a severe industrial depression began, and wages were greatly reduced, the reduction ranging all the way from 10 to 40 per cent., and it was not until the latter part of 1898 and early in 1899 that a very general increase took place. The increase in the coal-mining industry during the year 1899 and the first half of 1900 has been all the way from 10 to 100 per cent. Miners in some districts who a few years ago received 45 cents per ton are now being paid 90 cents per ton. The wages in some industries have not increased much, but in those where an increase has not taken place there was not much reduction. In North Carolina blacksmiths now receive $1·67 as against $1·25 per day in 1890, while in Boston there has been little change, the rate now being $2·55, although some blackmiths are paid as high as $3 per day. There has not been much increase in railway labour wages.

Bricklayers in Augusta, Ga., are now paid $3 per day in place of $2·25 in 1890, and in some other parts of the South they receive $3 per day. In San Francisco bricklayers receive $5 per day; in Cleveland 45 cents per hour; in Buffalo $3·60 per day, although some receive less; in Boston $3·60, and in Chicago $4 per day. Carpenters receive $3·40 a day in Chicago, and as much in many other cities, while plumbers receive $4 per day, as also stone-cutters, gas-fitters, steam-fitters, plasterers, engineers, and tile-setters. It is impossible to give any rates of wages by occupations that can be considered typical of the whole country, for labour conditions vary in so large a country as the United States, and while a carpenter or other skilled workman may receive $4 per day in a large city, in a town near by he may receive but $2·50 a day. The general course of wages can be determined only by a mathematical calculation like that quoted from 1840 to 1891, and by the use of the average wage as distributed by manufacturing industries. Taking the total wages paid in 1850, 1860, 1870, 1880, and 1890, and dividing the total by the number representing the average number of persons (excluding officers and clerks) employed in the manufacturing and mechanical pursuits in those years, an average is found which is fairly indicative of the general progress of wages, although such average is not mathematically correct, owing to the varying divisor used; yet, on the whole, it is fairly satisfactory. Such a calculation shows that the average annual earnings of each employé in such industries, including men, women, and children, were in 1850, $247; in 1860, $289; in 1870, $302; in 1880, $347; in 1890, $445. Wages in 1902 were higher than at any period in the history of the United States. The value of these figures is enhanced by the fact that they are corroborated by separate specific investigations independent of the census reports.

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(C. D. W.)

III. Continental Europe.

No attempt has ever been made by a statistical bureau to collect in a systematic way such wage data for the various countries of Europe as would permit a fair comparison of the wages paid in one country with those paid in another. The statistical or labour bureaus of a few of the Continental countries have in some instances made extensive inquiries regarding wages in certain occupations or industries, but the methods of inquiry and compilation adopted and the time periods selected were so diverse that an accurate comparison of the results of one investigation with those of another is practically impossible.

It may be said in a general way that wages are highest in those countries, or sections of a country, where the greatest progress has been made in industrial development, as in France, Germany, Belgium, and Switzerland, and lowest where the more primitive methods of production are employed, as in Spain, Russia, Austria, Italy, &c. This is perhaps mainly due to the fact that superior methods of production require a higher degree of skill and greater activity on the part of the workers, thus increasing the labour efficiency of the latter, and consequently their value as producers. This is illustrated by the fact that the difference in wages mentioned is usually greatest in the case of skilled labour and occupations involving the use of machinery, as in the textile industries, and least in the case of ordinary unskilled occupations, particularly agricultural labour.

In the larger countries of Europe where much progress has been made in industrial development in certain sections, other sections of the same country often adhere to the older methods, resulting in a great diversity of wages for similar occupations. Thus in the mining districts of Westphalia wages are higher and people live better than in the mining districts of Silesia, Prussia. It is also observed that wages are higher in cities, where the cost of living is greater and the standard of life higher, than in village and rural districts, where workers obtain the necessaries of life for a smaller expenditure of money and where their wants are fewer. An illustration of this is found in an investigation made in 1891[1] by the French Government, which showed that the average wages paid to all employés in 451 establishments, representing all the leading industries, were 5·28 francs per day in Paris, while in 2506 establishments engaged in similar industries in the rest of France the wages were but 3·52 francs per day, or about one-third lower.

Owing to this great variation in the wages paid in the same occupations in the same country, it is apparent that even though fairly accurate wage data were available, instead of the fragmentary material extant, it would still be impossible to establish any figure or set of figures which would represent the average wages of the workers of any country at a given time. In the absence of such average figures, a comparative statement of wages in the different European countries cannot be made. One can only judge in a general way by comparing the wages paid in similar occupations, or in industrial establishments operating under similar conditions, and by observing the general condition of the wage-workers in one country and in another. Such a comparison has led to the conclusions expressed in the beginning of this article.

Perhaps the only investigation ever made in which wage statistics were collected according to a uniform method in different countries was one undertaken by the United States Department of Labor from 1888 to 1891[2] on the cost of production of certain commodities. While this investigation covered a very limited field and was conducted in but a few countries, it affords, as far as it goes, a medium for making some comparisons. Of three establishments considered in this investigation which were manufacturing cotton yarn, one in Germany, employing 332 persons, paid an average of 1·76 marks per day; one in Switzerland, employing 122 persons, paid 2·31 francs per day; and one in Italy, employing 168 persons, paid 1·58 lire per day. Of three establishments manufacturing steel ingots, one in Belgium, employing 88 persons, paid an average of 3·99 francs per day; one in France, employing 186 persons, paid 3·83 francs per day; and one in Italy, employing 256 persons, paid an average of 3·47 lire per day. Of two establishments producing mixed iron and steel, one in Germany, employing 842 persons, paid an average of 2·37 marks per day; and one in Belgium, employing 802 persons, paid an average of 2·77 francs per day. The following tables show the wages paid in a few of the occupations in establishments considered in the above-mentioned investigation:—

Average Daily Wages, 1888–1891.

Cotton Textiles.

Occupations.	France.	Germany.	Switzerland.	Italy.
	Francs.	Marks.	Francs.	Lire.
Card grinders . . .	3·78	2·14	2·59	2·38
Card strippers . .	3·21	1·81	2·28	1·81
Labourers . .	2·90	2·23	2·49	1·71
Overseers, carding .	7·46	4·12	3·26	3·26
Picking-room hands.	2·69	1·76	1·81	1·76
Piecers . . .	2·85	1·26	1·50	1·81
Second hands . .	4·40	3·40	3·32	2·54
Spinners, mule .	4·97	2·14	3·42	3·21

Steel Ingots.

Occupations.	France.	Belgium.	Italy.
	Francs.	Francs.	Lire.
Blacksmiths . . .	4·72	3·47	3·21
Blacksmiths' helpers	3·21	1·76	2·49
Blowers . .	6·27	4·20	3·26
Labourers . .	3·47	3·16	2·33
Ladlemen . . .	4·45	4·09	1·71
Weighmen . . .	3·52	3·47	2·95

The above data seem to indicate that for similar occupations in the countries mentioned, wages were highest in France and lowest in Italy. Germany, Belgium, and Switzerland probably ranked in the order named with regard to wages.

An examination of the fluctuation in wage rates from year to year also shows that the increase in wages in the different countries and industries has been fairly coincident with the development of industry, the increase being most marked and steadiest in those industries and countries where the greatest progress has been made in the improvement of the means of production. Thus during 26 years (from 1870 to 1896) the average wages paid in twenty-one identical occupations increased 25·5 per cent. in Paris, 22 per cent. in Lyons, and 11·3 per cent. in Liége. During this period the wages of agricultural labourers in France decreased, while in Belgium they remained stationary. In Italy, where comparatively little progress has been made, statistics of wages in leading industries from 1888 to 1897 show in some cases a decrease and in others but very little change. In Germany, on the other hand, wherever wage statistics in leading industries are given for a series of years, they show a tendency to increase.

More attention has been given to the subject of wages statistics by the Government of France than by that of

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[1] *Salaires et Durée du Travail dans l'Industrie Française*, 1897.

[2] *Sixth and Seventh Annual Reports of the United States Commissioner of Labor*, 1890, 1891.

France.

any other country of continental Europe. The methods adopted in the various investigations have, however, been so diverse that a comparison of the wage data is somewhat hazardous. The most trustworthy official wages statistics compiled in France at different time periods[1] were those contained in the reports of the industrial inquiries of 1840 to 1845, 1860 to 1865, and 1891 to 1893; the annual inquiries made by local officials in 1853, 1857, and from 1871 to 1885; the statistics of the French mining service, and the reports of local officials in the various departments for 1853, 1874, and 1892. As these are by far the most important wages compilations made in France, a summary of their results is given in the following tables:—

Average Daily Wages of Working People in the Department of the Seine by Sex and Industries, Inquiries of 1840–45, 1860–65, and 1891–93.

Industries.	Inquiry of 1840-45 (Suburbs of Paris).		Inquiry of 1860-65. Paris.		Inquiry of 1860-65. Suburbs of Paris.		Inquiry of 1891-93 (Department of the Seine).	
	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.
	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.
Flour milling	3·00	...	....	...	3·00	...	5·85	...
Starch manufacturing	2·90	...	...	...	3·75	...	4·80	...
Sugar refining	3·00	2·00	3·50	2·00	2·50	1·25	5·50	3·25
Brewing	3·00	...	4·00	...	4·15	...	5·25	...
Pastry and confectionery	3·50	1·25	4·00	1·50	...	...	4·90	2·70
Chemical products and fertilizers	3·00	...	3·00	...	3·50	...	4·70	...
Oil works	2·75	...	...	...	3·10	...	5·60	...
Glue	2·50	...	3·00	...	2·70	...	4·20	...
Stearine, soap, and perfumery	3·00	1·45	3·10	2·00	3·20	1·75	5·05	2·40
Matches	2·25	1·30	4·00	2·00	2·50	1·25	5·25	3·50
Paper and pasteboard	3·30	1·25	4·00	2·00	3·40	1·25	6·00	3·10
Printing	4·15	...	5·00	...	4·50	...	7·10	...
Tanning	4·50	2·00	4·40	...	4·00	1·50	5·45	3·15
Cotton thread	3·50	1·35	4·00	2·00	4·50	2·00	5·35	2·85
Saw-mills	4·00	...	4·00	...	...	...	6·00	...
Surgical instruments	3·00	...	5·00	...	...	...	7·75	...
Music boxes and instruments	3·50	...	5·00	...	...	...	5·80	...
Brick and tile works	4·00	1·25	5·00	1·75	3·50	1·35	5·15	2·25
China and pottery	3·50	0·70	3·00	...	...	...	5·50	3·55
Glass	3·50	1·25	5·00	2·50	3·90	1·60	5·80	2·20
All industries	3·50	1·55	4·50	0·41	4·00	1·70	6·15	3·00

Average Daily Wages of Working People in the Departments of France other than the Seine, by Sex and Industries, Inquiries of 1840–45, 1860–65, and 1891–93.

Industries.	Average Daily Wages. Inquiry of 1840-45.		Average Daily Wages. Inquiry of 1860-65.		Average Daily Wages. Inquiry of 1891-93.		Percentage of Women and Children of Total Working People.	
	Males.	Females.	Males.	Females.	Males.	Females.	Inquiry of 1860-65.	Inquiry of 1891-93.
	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.		
Mines and quarries	1·95	0·85	2·30	1·10	4·10	1·60	10	14
Food products	1·90	1·05	2·10	0·95	3·65	2·00	18	22
Chemical products	2·15	1·10	2·20	1·15	3·70	1·85	23	11
Printing and publishing	2·05	1·00	2·50	1·10	4·00	2·10	42	42
Hides and leathers	2·00	1·00	2·20	1·10	3·70	2·10	9	26
Textiles	1·90	1·00	2·05	0·95	3·45	2·10	55	56
Clothing	...	...	2·25	1·10	3·60	1·90	65	58
Wooden goods	1·85	0·80	2·40	1·15	3·75	1·90	12	10
Furniture	...	...	2·50	1·20	3·65	1·55	38	36
Metal goods	2·40	1·00	2·75	1·20	4·20	1·75	10	12
Building (stonework)	2·00	0·85	2·05	1·10	3·60	1·15	19	5
Glass, china, &c.	1·90	0·90	2·15	1·05	4·00	1·95	25	27
All industries	2·07	1·02	2·76	1·30	4·00	2·20	35	27

Average Daily Wages of Working People reported by Local Officials in the Departments of France other than the Seine, by Occupations, 1853, 1874, and 1892.

Occupations.	1853.	1874.	1892.
	Francs.	Francs.	Francs.
Saddlers and harness makers	2·14	2·95	3·75
Shoemakers	1·68	2·60	3·31
Cartwrights	2·06	3·08	3·76
Carpenters	2·20	3·45	4·32
Horseshoers	1·94	2·90	3·70
Plumbers and tinsmiths	2·04	3·26	4·23
Excavators	1·57	2·55	3·17
Masons	2·07	3·14	4·01
House painters	2·20	3·22	4·24
All occupations	1·99	3·02	3·83

During the period of about fifty years covered by these investigations, wages just about doubled, those of females having increased a little more than those of males. The proportionate increase was not the same, however, in all industries or occupations, nor in all parts of France.

Other French sources from which comparative wage data may be obtained for a series of years are the statistical annuals of France.[2] These annual publications show the following increases in the average daily wages in Paris from 1875 to 1887:—Bakers, 6·65 to 7·00 francs; blacksmiths, 6·50 to 7·00 francs; cabinetmakers, 5·00 to 7·75 francs; carpenters, 5·00 to 7·50 francs; horseshoers, 5·00 to 6·00 francs; house painters, 6·00 to 7·50 francs; masons, 5·00 to 8·00 francs; quarrymen, 4·00 to 5·00 francs; stonecutters, 6·00 to 8·50 francs; tinsmiths, 4·00 to 5·00 francs. In the other principal cities of France the following increase in the average daily wages was shown during the same period:—Bakers, 3·35 to 3·60 francs; blacksmiths, 3·50 to 3·90 francs; cabinetmakers, 3·32 to 3·65 francs; carpenters, 3·17 to 3·60 francs; horse-shoers, 2·98 to 3·35 francs; house painters, 3·36 to 3·85 francs; masons, 3·27 to 3·65 francs; quarrymen, 2·93 to 3·25 francs; stonecutters, 3·70 to 4·05 francs; tinsmiths, 3·11 to 3·45 francs. The average wages per day of both males and females in from fifty-nine to sixty-one skilled trades increased from 3·96 francs in 1875 to 5·34 francs in 1885 in Paris. In the other leading French cities the average daily increase in sixty-two skilled trades was from 2·86 francs in 1875 to 3·18 francs in 1885.

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[1] See *Salaires et Durée du Travail dans l'Industrie Française*, tome iv., 1897.

[2] *Annuaire Statistique de la France*, 1878 to 1888, and 1900, and *Statistique Générale de la France, Statistique Annuelle*, 1886 to 1887.

The statistical annual of France for 1900 contains the following wage rates per hour, compiled from various sources:—

Average Wages per Hour in Paris, 1806 to 1899.

Occupations.	Average Wages per Hour.							
	1806.	1842.	1852.	1856.	1862.	1873.	1880.	1899.
	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.
Blacksmiths	0·50	0·50	0·50	0·55	0·65	0·70	0·775	0·80
Carpenters	0·30	0·40	0·50	0·50	0·60	0·60	0·80	0·90
Excavators	0·225	0·275	0·275	0·30	0·40	0·40	0·55	0·55
Joiners	0·35	0·325	0·35	0·385	0·45	0·50	0·70	0·70
Labourers: building trades	...	0·225	0·225	0·30	0·35	0·40	0·50	0·525
Masons	0·325	0·415	0·425	0·525	0·525	0·55	0·75	0·75
Masons' helpers	0·17	0·245	0·26	0·275	0·335	0·35	0·50	0·50
Roofers	0·55	0·55	0·675	0·70	0·70	0·75	0·85	0·80
Roofers' helpers	0·30	0·40	0·45	0·40	0·45	0·50	0·55	0·55
Stonecutters	0·325	0·42	0·425	0·55	0·55	0·55	0·75	0·75

An original investigation made in 1896 by the United States Department of Labor[1] shows the increase in wages from 1870 to 1896 in Paris and Lyons in a number of well-defined occupations. The following statement was compiled from the published tables:—

Average Daily Wages in Gold in Paris and Lyons, 1870 and 1896.

Occupations.	Daily Wages in Paris.		Daily Wages in Lyons.	
	1870.	1896.	1870.	1896.
	Francs.	Francs.	Francs.	Francs.
Blacksmiths	6·22	8·91	6·53	7·51
Blacksmiths' helpers	4·09	5·18	3·52	3·99
Boilermakers	6·99	8·50	6·01	6·53
Boilermakers' helpers	3·99	4·97	...	...
Bricklayers	5·49	8·50	4·51	5·49
Cabinetmakers	6·63	8·60	4·97	6·01
Carpenters	6·22	8·08	4·35	7·04
Compositors	6·01	6·53	4·97	6·01
Hod carriers	3·52	5·49	...	...
Ironmoulders	6·37	7·20	...	...
Ironmoulders' helpers	4·25	4·87	...	...
Joiners	5·49	6·99	4·97	6·01
Labourers	4·51	4·51	...	...
Labourers, street	...	...	3·26	3·73
Machinists	6·89	7·15	5·80	6·53
Machinists' helpers	4·04	5·08	3·26	4·25
Masons, stone	5·23	7·98	...	...
Painters, house	5·49	6·99	4·77	6·01
Patternmakers	6·32	6·89	5·49	6·74
Plumbers	6·99	7·36	...	...
Stonecutters	4·56	7·77	4·97	6·99
Teamsters	6·11	6·58	4·35*	4·61†
Average daily wages	5·49	6·89	4·77	5·80

* In 1872.

† In addition to wages, teamsters receive from 0·29 to 0·37 francs per day in gratuities.

The tables of wages during each year, as presented in the *Bulletins* of the United States Department of Labor, show that both in Paris and Lyons the increase in wages in the different occupations has been gradual and almost unbroken from year to year during the period from 1870 to 1896. As shown in the above statement, the average daily wages for all the occupations increased during the period from 5·49 francs to 6·89 francs, or 25½ per cent., in Paris, and from 4·78 francs to 5·83 francs, or 22 per cent., in Lyons.

With regard to agricultural labour in France, no such favourable result has been shown, as already mentioned. Statistics published by the French Ministry of Agriculture in 1897[2] show a decline in wages during the decade from 1882 to 1892. Thus the average daily wages of agricultural labourers in the summer season were 3·05 francs in 1882 and 2·85 francs in 1892 for men, and 1·80 francs in 1882 and 1·70 francs in 1892 for women. Male market gardeners received 3·00 francs in 1882 and 2·85 francs in 1892, and female market gardeners received 1·75 francs per day in 1882 and 1·65 francs in 1892. No food or quarters were furnished with these wages.

Germany.

While the available wage statistics of France are sufficient to give a fair idea of the earnings of working people in that country, this cannot be said of the statistics of wages in Germany or any other of the continental countries of Europe, where they are at best incomplete and fragmentary and must be taken for what they are worth. No effort has ever been made to collect and publish wage statistics for the empire of Germany, the only official data available being those published by individual states or by city governments.

Whenever wages data have been collected for a series of years in Germany, the result has generally shown an increase from year to year. Thus in Berlin the returns published from year to year from 1882 to 1891 by the statistical bureau of that city[3] shows the following increase in weekly wage rates:—Blacksmiths from 20 marks in 1883 to 24·53 marks in 1891; cabinetmakers, 16·50 marks in 1882 to 23·22 marks in 1891; carpenters, 18·00 marks in 1882 to 24·00 marks in 1891; house painters, 15·00 marks in 1882 to 24·00 marks in 1890; masons, 18·75 marks in 1882 to 27·40 marks in 1888; stonecutters, 28·50 marks in 1882 to 32·22 marks in 1891; tinsmiths, 17·75 marks in 1882 to 22·09 marks in 1891; horse-shoers, 20·00 marks in 1882 to 22·50 marks in 1891;

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[1] *Bulletin of the United States Department of Labor*, Nos. 18 (1898) and 22 (1899).

[2] *Statistique Agricole de la France: Resultat de l'Enquête Décennale de 1892.*

[3] *Ermittelungen über Lohnverhältnisse in Berlin* (1882 to 1889) and *Statistisches Jahrbuch der Stadt Berlin* (1889, 1891). *Statistisches Amt der Stadt Berlin.*

compositors, 25·00 marks in 1882 to 29·80 marks in 1888; coopers, 18·00 marks in 1883 to 22·11 marks in 1891.

In the shipbuilding yards of Stettin,[1] the following increase in the weekly wages of employés was reported from 1885 to 1899: Carpenters, 17·50 marks to 21·00 marks; joiners, 15·45 marks to 20·00 marks; machinists, 15·90 marks to 22·80 marks; blacksmiths, 17·75 marks to 20·00 marks; labourers, 11·70 marks to 12·55 marks; painters, 12·40 marks to 18·10 marks; riveters, 14·80 marks to 17·10 marks. The monthly wages of domestic servants in Stettin during the same period increased as follows: Housekeepers from 17·85 marks to 23·80 marks; cooks from 14·30 marks to 23·80 marks; kitchenmaids from 7·10 marks to 8·40 marks; nursemaids from 5·90 marks to 9·50 marks; footmen, 28·70 marks to 38·10 marks; housemaids, 8·80 marks to 11·40 marks.

The wages data published in the statistical year-book of Würtemberg show the following increase in the daily earnings of employés from 1885 to 1896: in the chemical industry from 2·27 marks to 2·69 marks; the tobacco industry from 1·29 marks to 1·50 marks; sugar manufacturing, 2·10 marks to 2·85 marks. The yearly earnings of employés in the State railway service of Würtemberg increased as follows from 1891 to 1899:—Foremen, 1559·66 to 1828·33 marks; blacksmiths, 1235·70 to 1414·61 marks; carpenters, joiners, and wheelwrights, 1044·70 to 1240·73 marks; japanners and varnishers, 1028·68 to 1259·52 marks; locksmiths and ironworkers, 1017·14 to 1206·35 marks; moulders, 1184·84 to 1290·02 marks; mounters and tool-makers, 1433·49 to 1571·64 marks; pattern-makers, 1285·17 to 1600 marks; saddlers, 1036·25 to 1317·75 marks; turners, 1183·98 to 1295·98 marks; unskilled labourers, 708·58 to 910·09 marks.

The wages per day of forestry workers in Würtemberg increased as follows:—Wood-cutters, 1895 to 1899, summer work, 1·97 marks to 2·08 marks; winter work, 1·76 marks to 1·84 marks; forestry culture workers, 1891 to 1899, males, 1·89 marks to 2·04 marks; females, 1·12 to 1·20 marks.

The Prussian mine statistics likewise show a steady increase in the wages of employés. The following statement shows the increase in the yearly earnings of mine employés in certain districts from 1888 to 1900:[4]—

Groups of Occupations.	Yearly Earnings of Employés in Coal Mines of the Prussian Districts of				Yearly Earnings of Employés in Metalliferous Mines of Oberharz District, Prussia.	
	Upper Silesia.		Dortmund.			
	1888.	1900.	1888.	1900.	1888.	1900.
	Marks.	Marks.	Marks.	Marks.	Marks.	Marks.
Miners and trammers	565	983	936	1592	670	736
Other underground workmen	558	918	763	1096	760	805
Surface workmen	498	771	797	1125	475	590
All wage workers *	516	877	863	1332	592	665
Superintendents, foremen, and other officers	1452	2045	1393	2020	1028	1902

* Includes also earnings of women and children in Upper Silesia and of children in the other districts.

From 1897 to 1900 the average yearly earnings of all employés in the Prussian coal and lignite mines increased from 964 marks to 1138 marks, or 18 per cent., in three years.

The wages of forestry workers in Baden,[2] published from year to year, increased as follows from 1891 to 1898:—Male wood-cutters, 1·94 marks to 2·24 marks per day; forestry culture workers, males, from 1·80 marks to 2·04 marks; females, 1·25 marks to 1·38 marks per day, without board or lodging.

Belgium.

In Belgium, as in France and Germany, a comparison of wage rates at different periods shows a steady increase in the leading industrial occupations. Thus the wage statistics collected by the United States Department of Labor,[3] for a number of well-defined occupations in Liége, from 1870 to 1896 show the following increase in the average daily wage rates during the twenty-six years:—Blacksmiths from 3·52 francs to 4·61 francs; cabinetmakers, 3·52 francs to 3·68 francs; compositors, 3·32 francs to 4·15 francs; iron-moulders, 3·73 francs to 4·15 francs; machinists, 3·42 francs to 3·52 francs; machinists' helpers, 2·49 francs to 2·69 francs; house painters, 2·85 francs to 3·32 francs; pattern-makers, 3·47 francs to 3·99 francs; stone-cutters, 3·01 francs to 3·68 francs; teamsters, 2·90 francs to 3·06 francs. During the same period the wages of such unskilled occupations as blacksmiths' helpers and iron-moulders' helpers remained nearly stationary, while those of ordinary day labourers decreased from 2·75 francs to 2·69 francs per day. Statistics of wages for shorter periods were given for other occupations, in all of which an increase in wage rates is shown. The daily wages paid in these occupations in 1896 were:—Boilermakers, 3·89 francs; boilermakers' helpers, 3·32 francs; carpenters and joiners, 4·20 francs; hod-carriers, 2·44 francs; stone-masons, 3·68 francs; and plumbers, 3·99 francs. The average daily wages for these occupations increased from 3·08 francs in 1870 to 3·43 in 1896, or $11\frac{1}{3}$ per cent.

Wages of coal-mine labourers in Belgium are published in the reports of the Belgian Ministry of Industry and Labour. According to these returns, the yearly earnings of Belgian coal-mine workers, male and female, were 878·00 francs in 1870, 1031·00 francs in 1876, 920·00 francs in 1880, 812·00 francs in 1885, 1117·00 francs in 1890, 948 francs in 1895, 694·00 francs in 1896, and 1006·00 francs in 1897.

A comparative study of the wages of coal-mine labourers in October 1896 and in May 1900, published by the Belgian labour bureau,[5] shows the following interesting results: Taking the most numerous class of mine workers, the male adults engaged in underground work, it is found that while in 1896 over three-fourths earned form 3 francs to 5 francs, in 1900 less than one-half came within that class, the majority earning 5 francs per day and over. The wages under 2 francs per day have almost disappeared, only 127 underground mine workers coming under that class in 1900, as compared with 1016 in 1896. On the other hand, in 1896 no underground mine worker earned as much as 9·50 francs, while in 1900, 631 earned 9·50 francs and over. It is estimated that male adults engaged in underground work had their daily wages increased about 1·50 francs; male surface workers, about 1 franc; female adults working underground, about 1·25 francs; female adults doing surface work and boys working underground, about 0·50 franc. The wages of boys doing surface work, and of girls, showed no considerable change during the period from October 1896 to May 1900.

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[1] *United States Consular Report*, No. 237, 1900.

[2] *Statistisches Jahrbuch für das Grossherzogthum Baden.*

[3] *Bulletin of the United States Department of Labor*, No. 18, 1898.

[4] *Zeitschrift für das Berg-, Hütten- und Salinen-Wesen im Preussischen Staate.*

[5] *Statistique des Salaires dans les Mines de Houille* (October 1896–May 1900).

The reports of the Belgian census of agriculture contain statistics of wages of agricultural labourers at different time periods in each of the provinces of Belgium. A summary of these statistics shows that male agricultural labourers received 1·18 francs per day in 1846, 1·36 francs in 1856, 2·03 francs in 1874, 2·04 francs in 1880, 1·96 francs in 1890, and 1·98 francs per day in 1895. The daily wages of female agricultural labourers were 0·72 franc in 1846, 0·86 franc in 1856, 1·22 francs in 1874, 1·25 francs in 1880, 1·21 francs in 1890, and 1·22 francs in 1895. Board and lodgings were not furnished with these wages. The wages of agricultural labourers thus showed a tendency to increase from 1846 to 1874, and then apparently remained stationary for the rest of the period.

A fair idea of the range in the prevailing wage rates in different parts of Belgium may be obtained from an investigation made by the communal council of Brussels in May 1896[1] regarding the minimum wages per hour in the principal occupations in the building trades paid by the provinces and communes of Belgium for public works. Two provinces and sixteen communal governments reported minimum wage rates. The following statement, which was compiled from these returns, shows the minimum wage rates per hour paid in the locality where they were highest and in the locality where they were lowest in each occupation respectively:—Blacksmiths, 0·25 franc to 0·40 franc; carpenters and joiners, 0·25 franc to 0·35 franc; drivers, 0·28 franc to 0·30 franc; excavators, 0·20 franc to 0·35 franc; glaziers, 0·30 franc to 0·40 franc; lead and zinc workers, 0·30 franc to 0·40 franc; locksmiths, 0·36 franc to 0·38 franc; marble-workers, 0·30 franc to 0·36 franc; masons, 0·25 franc to 0·40 franc; painters, 0·25 franc to 0·38 franc; paviours, 0·30 franc to 0·45 franc; plasterers, 0·30 franc to 0·36 franc; plumbers, 0·30 franc to 0·45 franc; roofers, 0·40 franc; slaters, 0·30 franc to 0·32 franc; slate roofers, 0·30 franc to 0·40 franc; stonecutters, 0·30 franc to 0·40 franc; whitewashers, 0·30 franc; zinc workers, 0·30 franc to 0·35 franc.

The official wages statistics of other countries of continental Europe are so meagre that they can be but briefly mentioned in this connexion.

Austria.

In Austria the only statistics showing the course of wages from year to year are those published in the year-book of the Austrian Ministry of Agriculture. They show the average daily wages of mine workers for each year from 1892 to 1896. These returns show no perceptible change in the wages of coal and lignite mine workers and blast-furnace men, and a slight increase in the wages of workers in other than coal-mines. According to these returns, the average daily wages of coal miners ranged from 2·10 crowns to 4·20 crowns in 1892, and from 1·50 crowns to 4·00 crowns in 1896; lignite miners received from 2·60 crowns to 4·50 crowns in 1892, and from 2·80 crowns to 4·40 crowns in 1896; ironstone miners received 2·35 crowns in 1892, and 2·70 crowns in 1896; other miners received from 1·50 crowns to 2·25 crowns in 1892, and from 2·15 crowns to 3·00 crowns in 1896; blast-furnace men received from 3·00 crowns to 5·60 crowns in 1892, and from 2·90 crowns to 5·20 crowns in 1896. [Austrian crown (100 hellers) = 10d.]

According to statistics published by the Austrian Ministry of Finance,[2] the following weekly wages were paid to employés in the Government tobacco factories in 1896:—Cigar makers, 8·55 crowns; cigarette makers, 9·70 crowns; other tobacco workers, 8·60 crowns; cardboard box makers, 11·05 crowns; all employés, 8·85 crowns.

The Hungarian Ministry of Agriculture published in 1900 the results of an investigation of the wages of agricultural labourers made in 1898. A summary of the returns published shows the following average daily wages, without board or lodging, paid at different seasons of the year:—Men, spring, 108 hellers; summer, 178 hellers; autumn, 126 hellers; winter, 90 hellers; women, spring, 78 hellers; summer, 116 hellers; autumn, 88 hellers; winter, 66 hellers; children, spring, 54 hellers; summer, 76 hellers; autumn, 60 hellers; winter, 46 hellers. A comparison of these figures with those for the two previous years shows but very slight changes. [100 hellers = 10d.]

The United States consular report of September 1895 contains statistics of weekly wages in Austria and Bohemia, from which the following rates have been compiled:—Austria, 1894—bricklayers, 17·40 crowns; masons, 18·65 crowns; plasterers, 20·00 crowns; plumbers, 20·55 crowns; carpenters, 25·50 crowns; gas-fitters, 30·00 crowns; bakers, 23·60 crowns; blacksmiths, 15·90 crowns; bookbinders, 15·50 crowns; brewers, 24·35 crowns; butchers, 18·00 crowns; brass-founders, 22·00 crowns; cabinetmakers, 15·00 crowns; confectioners, 15·20 crowns; coopers, 19·50 crowns; teamsters, 11·00 crowns; horseshoers, 17·40 crowns; jewellers, 23·70 crowns; millwrights, 15·50 crowns; potters, 24·25 crowns; stonecutters, 20·75 crowns; tailors, 20·15 crowns; telegraphists, 33·65 crowns; tinsmiths, 18·50 crowns. Bohemia, 1891—masons, 13·15 crowns; carpenters, 14·25 crowns; blacksmiths, 12·85 crowns; brickmakers, 11·20 crowns; brewers, 15·45 crowns; brass-founders, 16·55 crowns; cabinetmakers, 14·25 crowns; confectioners, 16·00 crowns; potters, 14·00 crowns. It is not likely that wages in Austria have changed very materially in recent years.

Italy.

The most trustworthy wages statistics of Italy are those published in the Italian statistical year-books.[3] These reports enable one to trace the course of wages in certain occupations from year to year since 1888, and show that, as a general rule, wages have either declined or remained stationary. In Turin carpenters received 3·50 lire per day in 1888 and 3·00 lire in 1897; blacksmiths, 3·50 lire in 1888 and 3·20 lire in 1897; and labourers in machine-shops, 2·20 lire during the entire period from 1888 to 1897. In Genoa machinists received 4·50 lire and blacksmiths 4·00 lire per day during the entire period from 1888 to 1898. In Leghorn machinists received 4·00 lire per day in 1888 and 4·25 lire in 1897; blacksmiths, 3·50 lire in 1888 and 4·00 lire in 1897; labourers, 2·75 lire in 1888 and 3·00 lire in 1897. In the silk industry of Villanovetta female expert spinners received 1·20 lire per day, and female twisters received 1·30 lire per day during the period from 1888 to 1897. In Biella and Tollegno male wool carders received 2·40 lire in 1888 and 3·00 lire per day in 1898; male wool spinners, 4·00 lire per day in 1888 and in 1898; female wool twisters received 1·50 lire per day during the entire period from 1888 to 1898; female woollen weavers received 2·25 lire per day in 1888 and 2·50 lire in 1898. In Schio expert male woollen weavers received 4·95 lire in 1888 and 4·25 lire in 1898; male wool combers, 2·86 lire in 1888 and 2·60 lire in 1898;

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[1] *Minimum de Salaire: Enquête, Mai, 1896. Ville de Bruxelles, Travaux Publiés.*

[2] *Mitteilungen des k.k. Finanz-Ministeriums.*

[3] *Annuario Statistico Italiano*, 1900.

male wool spinners, 5·50 lire in 1888 and 4·50 lire in 1898; male wool shearers, 2·86 lire in 1888 and 2·70 lire in 1898; male woollen dyers, 2·20 lire in 1888 and 2·10 lire in 1898; female woollen weavers received 1·76 lire in 1888 and 1·50 lire in 1898; spoolers, 1·43 lire in 1888 and 1·30 lire in 1898; female wool twisters, 1·43 lire in 1888 and 1·30 lire in 1898. In Caselecchio di Reno male hemp combers received 4·02 lire per day in 1888 and 3·25 lire in 1897; male hemp carders, 2·47 lire in 1888 and 2·55 lire in 1897; male hemp spinners, 2·11 lire in 1888 and 2·42 in 1897; female hemp spinners received 0·80 lira per day in 1888 and 0·76 lira in 1897; and female hemp twisters, 0·86 lira per day in 1888 and 0·77 lira in 1897. [Italian lira (100 centesimi) = 9½d.]

The Italian statistical year-books also contain wage data for the Sardinian silver, lead, zinc, antimony, manganese, iron, and coal mines for each year from 1871 to 1897. The average wages of the better class of miners increased from 3·50 lire per day in 1871 to 5·10 lire in 1876, when they reached their highest point. After this they fluctuated considerably from year to year, being 3·95 lire in 1898. Masons received 4·00 lire in 1871 and 2·92 lire in 1898, the highest average wage rate having been 5·30 lire per day in 1880. Enginemen in mines received 3·50 lire in 1871 and 3·18 in 1898, the highest average rate during the period having been 5·00 lire per day in 1874.

Switzerland.

Wages in Switzerland vary greatly in the different cantons, being highest in the French and lowest in the Italian districts. According to the United States consular report for September 1895, the average wages paid in cotton-mills in 1895 varied between 1·45 francs and 2·50 francs per day. In silk-mills 30 per cent. of the dyers and finishers received less than 1·50 francs, and about 15 per cent. received over 2·00 francs; winders and twisters received 2·00 francs to 2·50 francs per day; spinners, 1·65 francs to 1·75 francs; warpers, 2·50 francs to 3·00 francs; weavers, 2·00 francs to 3·00 francs per day. In foundries and machine-shops unskilled labourers received in 1895 an average of 3·00 francs per day; skilled workers, 2·50 francs to 5·00 francs per day.

Holland.

In Holland, according to the United States consular reports, labourers employed on railways and at the depôts averaged, in 1892, from 0·90 florin to 1·75 florins per day, with gratuities amounting to from 3·10 florins to 4·00 florins per month. Drivers on tramway cars received from 10·10 florins to 14·20 florins, and conductors 13·10 florins per week. Blacksmiths and other workers employed in the carriage factories of the tramway companies earned an average of 15·20 florins per week. Enginemen on steam tramways earned from 12·15 florins to 17·10 florins per week. In 1894 the weekly wages in shipyards were:—Pattern and boiler makers, 15·60 florins; machinists, 16·80 florins; plumbers and pipe fitters, 13·20 florins; carpenters and painters, 12·00 florins; joiners, caulkers, furnacemen, and moulders, 15·00 florins; drillers, 12·20 florins; fitters-up and riveters, 17·50 florins; sheet-iron workers, 12·70 florins; coppersmiths, 14·10 florins; labourers, 10·50 florins. [Dutch florin = 1s. 8d.]

Russia.

Owing to the absence of trustworthy data, and the vast extent of the country, it is difficult to obtain a fair idea of wages in Russia. The following statistics of the wages per day of agricultural labourers in 1897 were obtained from the United States consular report for November 1897:—Nishni-Volga, men, 0·35 rouble to 1·00 rouble; women, 0·20 rouble to 0·40 rouble; central Volga, men, 0·25 rouble to 0·65 rouble; women, 0·15 rouble to 0·40 rouble; southern Steppe, men, 0·40 rouble to 0·60 rouble; women, 0·25 rouble to 0·40 rouble; central agricultural district, men, 0·20 rouble to 0·60 rouble; women, 0·12 rouble to 0·40 rouble. These daily wages were received without board. The annual wages varied from 25 roubles to 100 roubles for a man, the average being perhaps 60 roubles. The annual wages for a woman were from 20 roubles to 60 roubles. [Rouble (100 kopecks) = 3s. 2d.]

The monthly bulletins[1] issued by the city of Moscow show the following average wages per day for the leading occupations each year from 1890 to 1901:—

Average Daily Wages in Moscow.

	Blacksmiths.	Carpenters.	Day Labourers.	Joiners.	Masons.	Painters (House).	Plasterers.	Roofers.	Stove Smiths.
	Kopecks.	Kopecks.	Kopecks.	Kopecks.	Kopecks.	Kopecks.	Kopecks.	Kopecks.	Kopecks.
1890 . . .	128	111	83	159	120	109	112	114	104
1891 . . .	139	99	74	144	96	100	99	98	95
1892 . . .	123	93	66	129	89	91	94	88	88
1893 . . .	123	102	71	125	93	105	100	100	101
1894 . . .	120	99	67	120	94	101	190	98	98
1895 . . .	113	97	65	109	98	101	99	95	95
1896 . . .	100	99	69	111	97	98	99	97	94
1897 . . .	101	96	70	112	97	97	97	94	93
1898 . . .	112	112	70	137	104	106	104	104	103
1899 . . .	112	113	72	136	108	110	108	108	103
1900 . . .	121	124	78	146	116	119	116	115	116
1901 . . .	124	119	77	148	115	117	115	116	116

Greece.

In Greece, according to the United States consular report of March 1896, the following average daily wages were paid in 1895:—Bricklayers from 1·65 drachmas to 2·75 drachmas; butchers, 1·65 drachmas to 3·30 drachmas; carpenters, 2·20 drachmas to 3·30 drachmas; masons, 2·20 drachmas to 3·02 drachmas; painters, 1·65 drachmas to 2·75 drachmas; plasterers, 2·20 drachmas to 3·30 drachmas; shoemakers, 1·65 drachmas to 3·30 drachmas; shipwrights, 2·75 drachmas to 3·85 drachmas; farm labourers, 1·37 drachmas to 2·20 drachmas. Cooks received from 33·00 drachmas to 66·00 drachmas per month; chambermaids from 13·75 drachmas to 27·50 drachmas per month; coachmen, 44·00 drachmas to 55·00 drachmas per month; men-servants, 16·50 drachmas to 44·00 drachmas per month. [Drachma (100 lepta) = 9½d.]

Spain.

In Malaga, Spain, according to the United States consular report of August 1895, the following average daily wages were paid in 1895:—Blacksmiths and locksmiths, 3·00 pesetas to 3·50 pesetas; brickmakers, 4·00 pesetas to 5·00 pesetas; bakers, 3·50 pesetas to 4·00 pesetas; butchers, 3·00 pesetas to 3·50 pesetas; coppersmiths, 2·00 pesetas to 3·00 pesetas; cabinetmakers, 4·20 pesetas to 4·50 pesetas; carpenters, 3·00 pesetas to 3·50 pesetas; caulkers, 4·00 pesetas to 5·00 pesetas; farriers, 2·00 pesetas to 3·00 pesetas; glaziers, 1·75 pesetas to 2·00 pesetas; harness and saddle makers, 3·00 to 3·50 pesetas; ironmoulders, 3·00 pesetas to 5·00 pesetas; laundresses, 1·00 pesetas to 1·25 pesetas;

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[1] *Bulletin Statistique Mensuel de la Ville de Moscou.*

lithographers, 2·00 pesetas to 4·00 pesetas; masons, 2·00 pesetas to 3·25 pesetas; plumbers, 2·00 pesetas to 3·00 pesetas; shipwrights, 4·00 pesetas to 5·00 pesetas; stonecutters, 2·00 pesetas to 4·00 pesetas; shoemakers, 2·50 pesetas to 3·00 pesetas; tramway drivers and conductors, 2·50 pesetas; watchmakers, 2·50 pesetas to 3·50 pesetas. [Peseta (100 centimos) = 9½d.]

Denmark.

In 1900 the Danish Government published a comprehensive compilation of statistics of wages of skilled and unskilled workmen and apprentices in that country,[1] made in connexion with the industrial census of May 1897. The following figures, showing weekly wages of skilled workmen in certain leading occupations, are taken from that report:—Bakers, 18·67 crowns; blacksmiths, 14·54 crowns; bookbinders, 17·83 crowns; boot and shoe makers, 14·68 crowns; cabinet-makers, 18·68 crowns; carpenters, 21·42 crowns; coopers, 19·16 crowns; coppersmiths, 22·92 crowns; glaziers, 18·77 crowns; joiners, 22·55 crowns; locksmiths, 21·66 crowns; masons, 22·30 crowns; painters (house and sign), 22·08 crowns; saddlers and upholsterers, 18·61 crowns; stonecutters, 18·63 crowns; tanners, 18·96 crowns; wheelwrights and coachbuilders, 16·16 crowns. These wages show an increase over those paid in previous years in Denmark. [Danish, Swedish, and Norwegian crown (100 öre) = 1s. 1¼d.]

Sweden.

In Sweden, according to the annual report of the Royal Statistical Bureau for 1901,[2] the average yearly wage in 1899 of a male farm hand was 223 crowns, and of a woman servant 110 crowns, including food and lodging. The actual cost to the employer, counting food, lodging, and wages, was computed as 484 crowns for men and 267 crowns for women. The wages paid in the summer season to day farm labourers were 2·22 crowns for men and 1·22 crowns for women, and in the winter season 1·55 crowns for men and 0·85 crowns for women. These wages have increased steadily since 1880.

Norway.

For Norway the most trustworthy wage statistics are those presented in the statistical year-book of that country for 1900. This publication gives the average wage rates paid in 1880 and 1895 in leading occupations. The rates given show a considerable increase during the fifteen-years period. Thus in the leading cities the wages of blacksmiths were 2·34 crowns in 1880 and 2·71 crowns in 1895; joiners, 2·17 crowns in 1880 and 2·53 crowns in 1895; carpenters, 2·22 crowns in 1880 and 2·86 crowns in 1895; coopers, 2·08 crowns in 1880 and 2·53 crowns in 1895; masons, 3·14 crowns in 1880 and 3·87 crowns in 1895; house painters, 2·34 crowns in 1880 and 2·93 crowns in 1895; bakers, 2·29 crowns in 1880 and 2·82 crowns in 1895; butchers, 2·19 crowns in 1880 and 2·54 crowns in 1895; tailors, 2·30 crowns in 1880 and 2·66 crowns in 1895; shoemakers, 2·00 crowns in 1880 and 2·30 crowns in 1895; cigar-makers, 2·73 crowns in 1880 and 3·44 crowns in 1895. The wages in rural districts for similar occupations were somewhat lower and show a smaller measure of increase. The yearly wages paid to domestic servants were as follows: cities — males, 203·00 crowns in 1880 and 265·00 crowns in 1895; females, 78·00 crowns in 1880 and 100 crowns in 1895; rural districts—males, 153·00 crowns in 1880 and 180·00 crowns in 1895; females, 60·00 crowns in 1880 and 85·00 in 1895.

In studying the preceding wage data, it must be borne in mind that the hours of daily labour varied greatly in the different industries, localities, and countries, and that this variation has had some influence upon the daily, weekly, and monthly wage rates quoted. Furthermore, in the continental countries of Europe it is frequently the custom of employers to give gratuities, prizes, supplies, &c., to their employés, which naturally have a tendency to lower the regular wage rates.

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Wagga Wagga, a town of New South Wales, Australia, in the county of Wynyard, on the left bank of the Murrumbidgee, 309 miles south-west of Sydney. A steel viaduct has been constructed over the river, the approaches being formed by very heavy embankments. The waterworks reservoir has a capacity of one million gallons. There is a considerable amount of gold-mining in the district, which, however, is chiefly a pastoral one, though adapted for agriculture. Population (1881), 4096; (1891), 4596; (1901), 5114.

Wakefield, a city, parliamentary and municipal borough, and market town, Yorkshire, England, in the Normanton parliamentary division of the West Riding (of which it is the shire town), on the Calder, 9 miles south of Leeds by rail. Waterworks, the property of the corporation, were opened in 1888, having cost about £342,465. The bishopric was formed in 1888 almost entirely from that of Ripon. The twelve bells of the cathedral church (All Saints') were re-hung in 1892. The West Riding county offices, erected in 1896 at a cost of £90,000, adjoin the town hall. The county hall, a large and handsome edifice, with octagonal tower and dome surmounting the principal entrance, was opened in 1898. The acute hospital block in connexion with the lunatic asylum at Eastmore was completed at a cost of £100,000 in 1900, and in the same year the Stanley Hall for imbecile patients was rebuilt. A public park was opened in 1893. The municipal and parliamentary boroughs were conterminous until 1885, when the area of the latter was extended. Population (1881), 30,854; (1891, enlarged area), 38,832; (1901), 41,544.

Wakefield, a town of Middlesex county, Massachusetts, U.S.A., containing an area of 10 square miles diversified with small Glacial hills, situated in the north-eastern part of the state. The largest village, known also as Wakefield, is on a line of the Boston and Maine Railroad, at an altitude of 99 feet. Other villages in the town are Greenwood and Montrose. The town was incorporated in 1868. Population (1880), 5547; (1890), 6982; (1900), 9290, of whom 2347 were foreign-born.

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[1] *Arbejdsln samt Svende-og Lærlingeforhold, &c. Denmarks Statistiske Meddelelser, Fjerde Række, Siette Bind, Andet Hæfte.*

[2] *Statistik Tidskrift Utgifven af Kungl. Statistiska Centralbyrån*, 1901.

Waldeck-Pyrmont, a principality of Germany, lying partly between Westphalia and Hesse-Nassau and partly between Lippe and Hanover. Area, 432 square miles; population (1885), 56,575; and (1900), 57,918, thus divided:—Waldeck, 407 square miles and population (1885) 48,598, (1900) 49,282; and Pyrmont, 25 square miles and population (1885) 7977, (1900) 8636. Density, 134 inhabitants to the square mile, giving 122 for Waldeck and 345 for Pyrmont. Of the total population in 1900, 27,935 were males and 29,983 females. Except for 1700 Roman Catholics and 696 Jews, the people are Evangelical Lutherans. Agriculture supported 30,299 persons, or 52·5 per cent. of the total population in 1895. In 1895 the principality included 10,067 farms, of which 8434, or 83 per cent., were each less than 25 acres. In 1900 the live-stock consisted of 38,956 sheep, 40,205 pigs, 30,954 cattle, and 6719 horses. The state revenue and expenditure were both estimated at £77,350 for 1901. In 1900 the public debt was £96,850, and the state contribution to the imperial exchequer £29,090.

Waldeck - Rousseau, Pierre Marie Ernest (1846- ——), French statesman, was born at Nantes on 2nd December 1846. His father, René Waldeck-Rousseau, was a distinguished opponent of Louis Philippe and Napoleon III., and a prominent member of the Republican Assembly of 1848. Like his father, M. Waldeck-Rousseau adopted the profession of the law, but soon entered into politics, and in 1879 was elected deputy for Rennes. He came rapidly to the front, and in 1881 was entrusted with the ministry of the interior in Gambetta's *grand ministère*. He had the same office in the Ferry cabinet of 1883–85, and proved himself the strongest and most resolute man in the ministry. At Angoulême he delivered a remarkable speech, in which he asked that political strife should be reconciled now that the country had given a decisive verdict for Republican institutions, and insisted that the duty of the Government was equally to grant liberty and to enforce order. In 1884 he was instrumental in securing the legal recognition of trade unions. In 1886 he was called to the Paris bar, and soon acquired a foremost place among French advocates. He continued to take part in the debates of the Chamber till 1889, and upheld the action taken by the Government against the Ligue des Patriotes and General Boulanger. A selection of his speeches appeared in 1889, under the title of *Discours parlementaires*. His growing practice now decided him to withdraw from politics. The most noteworthy of the many famous cases in which his cold and penetrating intellect and his power of clear exposition were retained was the defence of M. de Lesseps. In 1894 he returned to public life as senator for the department of the Loire, and in the following January stood against MM. Félix Faure and Brisson for the Presidency of the Republic, receiving the support of the Right, who were soon to become his bitter antagonists. During the confusion into which parliamentary government fell in the next few years, owing to the Dreyfus case, he was recognized as a leader among the Moderate Republicans, who, while averse from violent changes, admitted the necessity of reform in the working of the political machine. The remedy advocated by M. Waldeck-Rousseau was a more frequent use by the ministry of the power of appealing to the constituencies. On the fall of the Dupuy cabinet in June 1899 he was one of the first statesmen summoned by President Loubet, but his efforts to form a Government were unsuccessful. When, however, all other combinations equally proved impracticable, and the very existence of the Republic seemed at stake, he formed, on the second attempt, a ministry of Republican defence in which were united men of the widest divergence on every question except that of maintaining the Republic against Clerical reaction and Cæsarism. The opposite poles were represented by the Socialist leader, M. Millerand, who became minister of commerce, and by the minister of war, General de Galliffet, whose ruthless severity in suppressing the Commune of 1871 rendered him an object of special abhorrence to the Extreme Left. M. Waldeck-Rousseau himself took the ministry of the interior, to which fell the urgent task of suppressing the spirit of disorder with which the country was seething. In his declaration, read to the Chamber on 26th June, he announced his intention of enforcing respect for the law. The prestige that General de Galliffet enjoyed in the army enabled the Government to take the necessary military measures, and to leave the second court-martial of Dreyfus at Rennes an absolutely free hand; and after the verdict a free pardon was granted to Captain Dreyfus without producing any evil consequences. M. Waldeck-Rousseau won a great personal success in October by his arbitration in the strikes at Le Creusot. The prolonged Government prosecution of M. Déroulède and his confederates ended in January 1900 in their condemnation by the High Court. The Senate was staunch in support of M. Waldeck-Rousseau, and in the Chamber he displayed remarkable astuteness in winning support from various groups. The Amnesty Bill, passed on 19th December, chiefly through his unwearied advocacy, went far to smooth down the acerbity of the preceding years. With the object of aiding the industry of wine-producing, and of discouraging the consumption of spirits and other deleterious liquors, the Government passed a Bill suppressing the *octroi* duties on the three "hygienic" drinks—wine, cider, and beer. The Act came into force at the beginning of 1901. But the most important measure of his later administration was the Associations Bill of 1901. Like many of his predecessors, he was convinced that the stability of the Republic demanded some restraint on the intrigues of the wealthy religious bodies. All previous attempts in this direction had failed. In his speech in the Chamber, M. Waldeck-Rousseau recalled the fact that he had endeavoured to pass an Associations Bill in 1882, and again in 1883. He declared that the religious associations were now being subjected for the first time to the regulations common to all others, and that the object of the Bill was to ensure the supremacy of the civil power. The royalist bias given to the pupils in the religious seminaries was undoubtedly a principal cause of the passing of this Bill; and the Government further took strong measures to secure the presence of officers of undoubted fidelity to the Republic in the higher positions on the staff. His speeches on the religious question were published in 1901, under the title of *Associations et congrégations*, following a volume of speeches on *Questions sociales* (1900). As the general election of 1902 approached all sections of the Opposition united their efforts, and M. Waldeck-Rousseau's name served as a battle-cry for one side, and on the other as a target for the foulest abuse. The result was a decisive victory for Republican stability. With the defeat of the machinations against the Republic M. Waldeck-Rousseau considered his task ended, and on 3rd June 1902 he resigned office, having proved himself the strongest personality in French politics since the death of Gambetta.

Waldenses.—The Waldensian valleys lie to the south-west of Turin, in the direction of Monte Viso, but include no high or snowy mountains, while the glens themselves are (with one or two exceptions) fertile and well wooded. The principal town near the valleys is Pinerolo.

Just to its south-west there opens the chief Waldensian valley, the Val Pellice, watered by the stream of that name, but sometimes called inaccurately the Luserna valley, Luserna being simply a village opposite the capital, Torre Pellice; near Torre Pellice the side glens of Angrogna and Rora join the Pellice valley. To the north-west of Pinerolo, up the Chisone valley, there opens at Perosa Argentina the valley of St Martin, another important Waldensian valley, which is watered by the Germanasca torrent, and at Perrero splits into two branches, of which the Prali glen is far more fertile than that of Massello, the latter being the wildest and most savage of all the Waldensian valleys. The total Waldensian population (for they also contain Roman Catholics in no small number) amounts to about 20,000 all told: there are 16 parishes, with 18 pasteurs and 22 temples, and also 2 Sunday schools (3017 children) and 194 day schools (with 4218 children). In 1899 the full members (*i.e.*, communicants) of the Waldensian faith amounted to 12,695. There were, besides, branches at Turin (1 temple, 2 pasteurs, and 750 members), in other parts of Italy, including Sicily (46 temples and as many pasteurs, while the number of members was 5613, of day scholars 2704, and of Sunday school scholars 3707). It is also reckoned that in Uruguay and the Argentine Republic there are about 6000 Waldensians; of these 1253 are full members, while the day scholars numbered 364 and the Sunday school children 670 The total contributions of these parishes (it is not clear whether South America is included) amounted in 1899 to 88,113 francs, to which must be added contributions from Great Britain of 189,802 francs.

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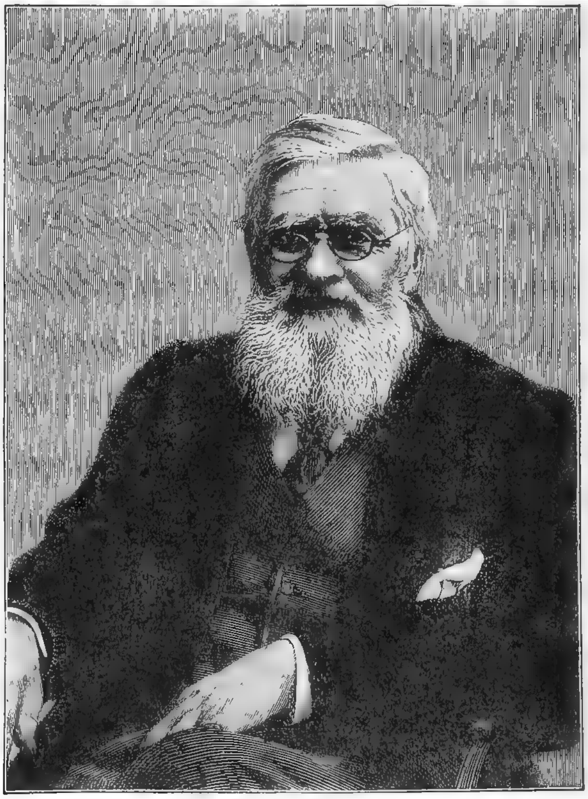
(W. A. B. C.)

Wales. See ENGLAND AND WALES.

Walker, Francis Amasa (1840–1897), American soldier and economist, was born in Boston, Massachusetts, 2nd July 1840, the son of Amasa Walker, who wrote a book on *The Science of Wealth.* He graduated at Amherst College in 1860, studied law, and fought in the Northern army during the whole of the Civil War of 1861–65, rising from the rank of sergeant-major to that of brevet brigadier-general of volunteers—awarded him at the request of General Winfield S. Hancock. As a soldier he excelled in analysis of the position and strength of the enemy. In 1864 he was captured and detained for a time in the famous Libby Prison, Richmond. After the war he became editorial writer on the Springfield (Massachusetts) *Republican,* and later held public offices, as chief of the Government bureau of statistics, superintendent of the ninth and tenth censuses (those of 1870 and 1880), and commissioner of Indian affairs; but from 1873 to his death his work was educational, first as professor (1873–81) of political economy in the Sheffield Scientific School at Yale, and then as president of the Massachusetts Institute of Technology, Boston. While superintendent of the census he increased the scope and accuracy of the records; and at the Institute of Technology he enlarged the resources and numbers of the institution, which had 302 students when he assumed the presidency and 1198 at his death. In other fields he promoted common-school education (especially in manual training), the Boston park system, and the work of the public library, and took an active part in the discussion of monetary, economic, statistical, and other public questions, holding many offices of honour and responsibility. As an author he wrote on governmental treatment of the Indians, *The Wages Question* (1876), *Money* (1878), *Land and its Rent* (1883), and general political economy (1883 and 1884), besides producing monographs on the life of General Hancock (1884) and the history of his own *Second Army Corps* (1886). As an economist, from the time of the appearance of his book on the subject, he so effectively combated the old theory of the "wage-fund" as to lead to its abandonment or material modification by American students; while in his writings on finance, from 1878 to the end of his life, he advocated international bimetallism, without, however, seeking to justify any one nation in the attempt to maintain parity between gold and silver. A collection of posthumously published *Discussions in Education* (1899) was made up of essays and addresses prepared after his taking the presidency of the Institute of Technology: their most noteworthy argument is that chemistry, physics, and the other sciences promote a more exact and more serviceable mental training than metaphysics or rhetoric. Walker's general tendency was towards a rational conservatism. On the question of rent he called himself a "Ricardian of the Ricardians." To his *Wages Question* is due in great part the conception formed by English students of the place and functions of the employer in modern industrial economics. A remarkable feature of his writings is his treatment of economic tendencies not as mere abstractions, but as facts making for the happiness or misery of living men. General Walker died in Boston, 5th January 1897.

Wallace, Alfred Russel (1823-——), British naturalist, was born at Usk, in Monmouthshire, 8th January 1823. After leaving school he assisted an elder brother in his work as a land surveyor and architect, visiting various parts of England and Wales. Living in South Wales, about 1840 he began to take an interest in botany, and commenced the formation of a herbarium. In 1847 he took his first journey out of England, spending a week in Paris with his brother and sister. In 1844–45, while an English master in the Collegiate School at Leicester, he made the acqaintance of H. W. Bates, through whose influence he became a beetle collector, and with whom he started in 1848 on an expedition to the Amazon. In about a year the two naturalists separated, and each wrote an account of his travels and observations. Wallace's *Travels on the Amazon and Rio Negro* was published in 1853, a year in which he went for a fortnight's walking tour in Switzerland with an old school-fellow. On his voyage home from South America the ship was burnt and all his collections lost, except those which he had despatched beforehand. After spending a year and a half in England, during which time, besides his book on the Amazon, he published a small volume on the *Palm Trees of the Amazon,* he started for the Malay Archipelago, exploring, observing, and collecting from 1854 to 1862. He visited Sumatra, Java, Borneo, Celebes, the Moluccas, Timor, New Guinea, and the Aru and Ké Islands. His deeply interesting narrative, *The Malay Archipelago,* appeared in 1869, and he also published many important papers through the London scientific societies. The chief parts of his vast insect collections became the property of the late W. W. Saunders, but subsequently some of the most important groups passed into the Hope Collection of the University of Oxford and the British Museum. He discovered that



Alfred Russel Wallace.
(*From a photograph by the London Stereoscopic Company.*)

the Malay Archipelago was divided into a western group of islands, which in their zoological affinities are Oriental, and an eastern, which are Australian. The Oriental Borneo and Bali are respectively divided from Celebes and Lombok by a narrow belt of sea known as "Wallace's Line," on the opposite sides of which the indigenous mammalia are as widely divergent as in any two parts of the world. Wallace became convinced of the truth of evolution, and originated the theory of natural selection during these travels. In February 1855, staying at Sarawak, in Borneo, he wrote an essay "On the Law which has regulated the Introduction of New Species" (*Ann. and Mag. Nat. Hist.*, 1855, p. 184). He states the law as follows: "Every species has come into existence coincident both in time and space with a pre-existing closely allied species." He justly claims that such a law connected and explained a vast number of independent facts. It was, in fact, a cautious statement of a belief in evolution, and for three years from the time that he wrote the essay he tells us that "the question of *how* changes of species could have been brought about was rarely out of my mind." Finally, in February 1858, when he was lying muffled in blankets in the cold fit of a severe attack of intermittent fever at Ternate, in the Moluccas, he began to think of Malthus's *Essay on Population*, and, to use his own words, "there suddenly flashed upon me the *idea* of the survival of the fittest." The theory was thought out during the rest of the ague fit, drafted the same evening, written out in full in the two succeeding evenings, and sent to Darwin by the next post. Darwin in England at once recognized his own theory in the manuscript essay sent by the young and almost unknown naturalist in the tropics, then a stranger to him. "I never saw a more striking coincidence," he wrote to Lyell on the very day, 18th June, when he received the paper: "if Wallace had my MS. sketch written out in 1842, he could not have made a better short abstract! Even his terms now stand as heads of my chapters." Under the advice of Sir Charles Lyell and Sir Joseph Hooker, the essay was read, together with an abstract of Darwin's own views, as a joint paper at the Linnean Society on 1st July 1858. The title of Wallace's section was "On the Tendency of Varieties to depart indefinitely from the Original Type." The "struggle for existence," the rate of multiplication of animals, and the dependence of their average numbers upon food supply are very clearly demonstrated, and the following conclusion was reached: "Those that prolong their existence can only be the most perfect in health and vigour; . . . the weakest and least perfectly organized must always succumb." The difference between Lamarck's theory and natural selection is very clearly pointed out. "The powerful retractile talons of the falcon and the cat tribes have not been produced or increased by the volition of those animals; but among the different varieties which occurred in the earlier and less highly organized forms of these groups, *those always survived longest which had the greatest facilities for seizing their prey.* Neither did the giraffe acquire its long neck by desiring to reach the foliage of more lofty shrubs, and constantly stretching its neck for the purpose, but because any varieties which occurred among its antitypes with a longer neck than usual *at once secured a fresh range of pasture over the same ground as their shorter-necked companions, and on the first scarcity of food were thereby enabled to outlive them.*" With such clear statements as these in the paper of 1st July 1858, it is remarkable that even well-known naturalists should have failed to comprehend the difference between Lamarck's and the Darwin-Wallace theory. Wallace also alluded to the resemblance of animals, and more especially of insects, to their surroundings, and points out that "those races having colours best adapted to concealment from their enemies would inevitably survive the longest." In 1871 Wallace's two essays, written at Sarawak and Ternate, were published with others as a volume, *Contributions to the Theory of Natural Selection.* Probably, next to the *Origin of Species*, no single work has done so much to promote clear understanding of natural selection and confidence in its truth; for in addition to these two historic essays, there are others in which the new theory is applied to the interpretation of certain classes of facts. Thus one treats of "Mimicry" in animals, another on "Instinct," another on "Birds' Nests." Each of these served as an example of what might be achieved in the light of the new doctrine, which, taught in this way and in an admirably lucid style, was easily absorbed by many who found the more complete exposition in the *Origin* very hard to absorb. In this work, and in many of his subsequent publications, Wallace differs from Darwin on certain points. Thus the two concluding essays contend that man has not, like the other animals, been produced by the unaided operation of natural selection, but that other forces have also been in operation. We here see the influence of his convictions on the subject of "spiritualism." More recently he expressed his dissatisfaction with the hypothesis of "sexual selection" by which Darwin sought to explain the conspicuous characters which are displayed during the courtship of animals. The expression of his opinion on both these points of divergence from Darwin will be found in *Darwinism* (1889), a most valuable and lucid exposition of natural selection, as suited to the later period at which it appeared as the *Essays* were to the earlier. Darwin died some years before the controversy upon the possibility of the hereditary transmission of acquired characters arose over the writings of Weismann, but Wallace has freely accepted the general results of the German zoologist's teaching, and in *Darwinism* has presented a complete theory of the causes of evolution unmixed with any trace of Lamarck's use or disuse inheritance, or Buffon's hereditary effect of the direct influence of surroundings. *Tropical Nature and other Essays* appeared in 1878, since republished combined with the 1871 *Essays*, of which it formed the natural continuation. One of the greatest of his publications was the *Geographical Distribution of Animals* (1876), a monumental work, which every student will maintain fully justifies its author's hope that it may bear "a similar relation to the eleventh and twelfth chapters of the *Origin of Species* as Mr Darwin's *Animals and Plants under Domestication* bears to the first." *Island Life*, which may be regarded as a valuable supplement to the last-named work, appeared in 1880.

Turning to his other writings, Wallace published *Miracles and Modern Spiritualism* in 1881. Here is given an account of the reasons which induced him to accept beliefs which are shared by so small a proportion of scientific men. These reasons are purely experimental, and in no way connected with Christianity, for he had long before given up all belief in revealed religion. In 1882 he published *Land Nationalization*, in which he argued the necessity of State ownership of land, a principle which he had originated long before the appearance of Henry George's work. In *Forty-five Years of Registration Statistics* (1885) he maintained that vaccination is useless and dangerous. Wallace has also published an account of what he holds to be the greatest discoveries as well as the failures of the 19th century, *The Wonderful Century* (1899). Possessed of a bold and intensely original mind, his activities have radiated in many directions, apparently rather attracted than repelled by the unpopularity of a subject. A non-theological *Athanasius contra mundum*, he has the truest missionary spirit, an intense faith which would seek to move the mountains of apathy and active opposition. Whatever may be the future history of his other views, he will always be remembered as an originator of a principle more illuminating than any which has appeared since the days of Newton, as one of its two discoverers whose scientific rivalry was only the beginning of a warm and unbroken friendship.

Wallace was married in 1866 to the eldest daughter of the botanist, Mr William Mitten, of Hurstpierpoint, Sussex. He has two surviving children, Violet, born 25th January 1869, and William Greenell, born 30th December 1871. On his return from the East, Wallace lived with his sister in Westbourne Grove, and, after his marriage, in St Mark's Crescent, Regent's Park. In 1871 he built a house at Grays, Essex, in an old chalk-pit, and after living there four years, moved successively to Dorking (two years) and Croydon (three years). In 1880 he built a cottage at Godalming near the Charterhouse School, and grew nearly 1000 species of plants in the garden which he made. In 1889 he moved to Dorsetshire. Since his return to England in 1862, Wallace has visited the Continent, especially Switzerland, for rest and change (1866, 1896) and the study of botany and Glacial phenomena (August 1895). He also visited Spa, in Belgium, about 1870, and in October 1887 went for a lecturing tour in the United States. He delivered a course of six Lowell lectures in Boston, and visited New York, Newhaven, Baltimore, &c., spending the winter at Washington. The following March he went to Canada and Niagara, and then made his way westwards. He saw the Yosemite Valley, the Big Trees, and botanized in the Sierra Nevada and at Gray's Peak. In July he returned to Liverpool by way of Chicago and the St Lawrence.

The first Darwin medal of the Royal Society was awarded to A. R. Wallace in 1890, and he had received the Royal medal in 1868. A pension was awarded him by Mr Gladstone at the beginning of 1881. Wallace received the degree of D.C.L. from Oxford in 1889, and of LL.D. from the University of Dublin in 1882. He was president of the Entomological Society of London in 1870–71.

A good deal of useful information is given in the biographical introduction to Wallace's *Narrative of Travels on the Amazon and Rio Negro* by the editor, Mr G. T. Bettany. For the purpose of this article, Dr A. R. Wallace has also kindly himself supplied details which could hardly have been recovered in any other way.

Wallace, Lewis (1827-——), American soldier and author, was born in Brookville, Indiana, 10th April 1827. He served in the Mexican war, and on returning to Indiana became a lawyer. He was senator in the state legislature for one year, and at the beginning of the war of 1861 was adjutant-general of the state, but soon entered active service as colonel, and then as brigadier-general of volunteers. He took part in important movements in West Virginia and in the campaigns south of the Ohio river, especially at Fort Donelson and Shiloh. For his gallantry in the operations before Donelson, in which he commanded a division, he was made major-general. When in command of the 8th Army Corps, 9th July 1864, he was defeated by Jubal A. Early at Monocacy Bridge, in Maryland. At the close of the war Wallace was a member of the court for the trial of the assassins of President Lincoln; and was president of the court that tried Wirz, the keeper of Andersonville (Georgia) prison. He was governor of New Mexico, 1878–81, and minister to Turkey 1881–85. As an author, General Wallace made his first appearance in 1873, when he published *The Fair God; or, The Last of the 'Tzins*, a tale of the conquest of Mexico. In 1880 his second historical romance, *Ben-Hur: a Tale of the Christ*, secured a widespread popularity. His later works comprise essays in dramatic composition, a *Life* of President Harrison, an illustrated monograph on *The Boyhood of Christ*, and *The Prince of India* (1893).

Wallace, Sir Richard, Bart. (1818–1890), English art collector and philanthropist, was born in London, 26th July 1818. According to Sir Walter Armstrong (see *Dict. of National Biography*, art. "Wallace"), he was a natural son of Maria, Marchioness of Hertford (wife of the third marquis), under whose auspices the boy was educated, mainly at Paris; but it was generally supposed in his lifetime that he was a son of the fourth marquis (his elder by only eighteen years), and therefore her grandson. At Paris he was well known in society, and became an assiduous collector of all sorts of valuable *objets d'art*, but in 1857 these were sold and Wallace devoted himself to assisting the fourth marquis, who left London to reside entirely at Paris, to acquire a magnificent collection of the finest examples of painting, armour, furniture, and *bric-à-brac.* In 1870 the Marquis of Hertford died unmarried, bequeathing to Wallace an enormous property, including Hertford House and its contents, the house in Paris, and large Irish estates. Pending the reopening of Hertford House, which had been shut up since the marquis had gone to live in Paris, Wallace sent some of the finest of his pictures and other treasures to the Bethnal Green Museum for exhibition; they were then transferred to Hertford House, which had been largely transformed in order to receive them. In 1871 he was created a baronet for his services during the siege of Paris, when he equipped several ambulances, founded the Hertford British hospital, and spent money lavishly in relief. This munificence endeared Sir Richard Wallace to the French people. From 1873 to 1885 he had a seat in Parliament for Lisburn, but he lived mostly in Paris, where, in the Rue Laffitte and in his villa in the Bois de Boulogne, he dwelt among art treasures not inferior to those at Hertford House. In 1878 he was made one of the British Commissioners at the Paris Exhibition, and he was also a trustee of the National Gallery and a governor of the National Gallery of Ireland. He died in Paris, 20th July 1890. He had married in 1871 the daughter of a French officer, by whom he had a son, who, however, died in 1887; and Lady Wallace, who died in 1897, bequeathed his great art collection to the British nation. It is now housed in Hertford House, Manchester Square, which was acquired and adapted by the Government for the purpose.

Wallaroo, a seaport town of South Australia, in the county of Daly, 123 miles by rail north-west by north of Adelaide, on Wallaroo Bay, in Spencer Gulf. It is connected by rail with the celebrated Wallaroo copper mines (near Kadina, at a distance of 6 miles from the port). At Wallaroo Bay are the largest smelting works in the state, ranking with the largest in the world. Gold, silver, and concentrated ores are received from other parts of the continent and from Tasmania for smelting at these works, which have ample facilities for shipment. The Beetaloo reservoir for the supply of the district was constructed at a cost of £1,000,000, and has a storage capacity of eight hundred million gallons. Population (1891), 1685; (1901), about 3500.

Wallawalla, a city of Washington, U.S.A., capital of Wallawalla county. It is situated in 46° 04′ N. and 118° 21′ W., at the northern base of the Blue Mountains, on the Oregon Railroad and Navigation Company and the Washington and Columbia River railways, in the south-eastern part of the state, at an altitude of 923 feet. It is in the famous wheat region of eastern Washington, for which it serves as a shipping-point. It has excellent water-power, with foundries, machine-shops, and flour-mills. Population (1890), 4709; (1895), 7770; (1900), 10,049, of whom 1522 were foreign-born and 33 coloured, including 25 negroes.

Wallingford, a municipal borough, railway station, and market town, Berkshire, England, in the Abingdon parliamentary division of the county, 16 miles north-east of Newbury, on the Thames, here crossed by a bridge of 14 arches. Until 1832 the borough returned two members to Parliament, but in 1885 its representation was merged in that of the county. The old church of St Mary is supposed to have existed shortly after the Conquest. The town hall, built in 1670, was restored and repaired in 1887. Wallingford Castle, of which only the moat remains, was a fortress of great strength, dating from the Roman occupation, destroyed by the Danes, and rebuilt between 1067 and 1071. Population (1891), 2989; (1901), 2808.

Wallingford, a town of New Haven county, Connecticut, U.S.A., in the south-west of the centre of the state, including part of the valley of Quinnipiac river with the hills on either side. It contains the chartered borough of Wallingford and the villages of East Wallingford and Yalesville. The borough, situated in the level valley, is regularly laid out, and has manufactures of silver-plated, britannia, brass, and nickel ware. Population of the town (1880), 4686; (1890), 6584; (1900), 9001; of the borough, (1880), 3017; (1890), 4230; (1900), 6737, of whom 1796 were foreign-born.

Wallis Archipelago. See New Caledonia.

Wallon, Henri Alexandre (1812-——), French historian and statesman, was born at Valenciennes, 23rd December 1812. Devoting himself to a literary career, he became in 1840 professor at the École Normale, under the patronage of Guizot. His works on slavery in the French colonies (1847) and on slavery in antiquity (1848) led to his being placed, after the Revolution of 1848, on a commission for the regulation of labour in the French colonial possessions, and in November 1849 he was elected to the Legislative Assembly by the department of the Nord. He resigned in 1850, disapproving of the measure for the restriction of the suffrage adopted by the majority. In the same year he was elected a member of the Académie des Inscriptions, of which he became perpetual secretary in 1873. Under the Empire he withdrew altogether from political life, and occupied himself entirely with his duties as a professor of history and with historical writings, the most important of which, his history of Joan of Arc, obtained the Gobert prize from the Academy in 1860. Although remaining a Republican, he exhibited decided Clerical leanings in his works, which included a reply to Renan's *Vie de Jésus*, published in 1864. Returning to politics after the Franco-German war, M. Wallon was re-elected by the department of the Nord in 1871, took an active part in the proceedings of the Assembly, and finally immortalized himself by carrying his proposition for the establishment of the Republic with a president elected for seven years, which, after violent debates, was adopted by the Assembly on 30th January 1875. "Ma proposition," he declared, "ne proclame pas la République, elle la fait." Upon the definitive establishment of the Republic M. Wallon became Minister of Public Instruction, and effected many useful reforms, but his views were too conservative for the majority of the Assembly, and he retired in May 1876. He had been chosen a life senator in December 1875. Returning to his historical studies, M. Wallon produced two works of great importance, though less from his part in them as author than from the documents which accompanied them: *Histoire du tribunal revolutionnaire de Paris*, 1880-82, and *Les Réprésentants du peuple en mission et la justice revolutionnaire dans les départements*, 1888-90. M. Wallon has not achieved the highest distinction either as historian or politician, but he has manifested a happy instinct for doing the right thing at the right time. His history of Joan of Arc came at the moment when everything was ripe for an authoritative work, and acquired a reputation as the standard biography which it is not likely to forfeit. His works on the history of the French Revolution were no less seasonable; and his parliamentary action at a critical moment terminated a period of suspense and uncertainty, and procured for a politician not otherwise conspicuous the distinction of founder of the Third French Republic.

Wall-papers. See Mural Decoration.

Walmer, a parish in the Eastern, or St Augustine's, parliamentary division of Kent, England, 2 miles south of Deal, with a station on the South-Eastern and Chatham Railway. It is a member of the Cinque Port of Sandwich. Walmer Castle, which dates from the time of Henry VIII., is the official residence of the Lord Warden of the Cinque Ports. The Duke of Wellington, then Lord Warden, died at the castle in 1852. Since his death the post has been held by, amongst others, Lord

Sidney, Lord Granville, Mr W. H. Smith, Lord George Hamilton, and Lord Salisbury. The Royal Marine Infirmary has been enlarged. Lower Walmer is a bathing resort. Population (1891), 4565; (1901), 5248.

Walsall, a municipal, county (1888), and parliamentary borough and market town of Staffordshire, England, 123 miles by rail north-west of London, on a tributary stream of the Tame. In 1890 the borough was extended. The Science and Art Institute was erected in 1888. The free library was extended and a museum added in 1891. The Grand Theatre dates from 1890. A new cemetery, of 40 acres, was laid out in 1894. An arboretum was enlarged to 32 acres in 1891. As public recreation grounds there are Reed's Wood (46 acres) and Palfrey Park (8 acres). Walsall was the scene of the charitable activities of "Sister Dora" (the late Miss Pattison, for many years at the head of the nursing staff of the Cottage Hospital), to whom a marble statue by Mr F. J. Williamson has been erected in the principal square. According to the census of 1891, there were 5684 persons (1806 females) engaged in the making of harness, which, with other leather trades, forms the staple industry, 2403 in the iron and steel manufacture, and 1447 in manufactures in mixed metals, and 1914 in coal-mining. The great majority of the horses' bits used in the United Kingdom, and a certain proportion of those used in the United States, are manufactured in Walsall and Bloxwich, one of its industrial suburbs. Area of municipal and parliamentary borough, which are coextensive, 7480 acres. Population (1891), 71,789; (1901), 86,440.

Walter.—The name of the Walter family is indissolubly connected with the history of *The Times.* JOHN WALTER (1), the founder of the paper, was born in 1738/9, probably in London, and from the death of his father, Richard Walter (about 1755/6), until 1781 was engaged in a prosperous business as a coal merchant. He played a leading part in establishing a Coal Exchange in London; but shortly after 1781, when he began to occupy himself solely as an underwriter and became a member of Lloyd's, he over-speculated and failed. In 1782 he bought from one Henry Johnson a patent for a new method of printing from "logotypes" (*i.e.*, founts of words instead of letters), and made some improvements in it. In 1784 he acquired an old printing office in Blackfriars, which formed the nucleus of the Printing-house Square of a later date, and established there his "Logographic Office." At first he only undertook the printing of books, but on 1st January 1785, he started a small newspaper called *The Daily Universal Register*, which on reaching its 940th number on 1st January 1788 was renamed *The Times.* The printing business developed and prospered, but the newspaper at first had a somewhat chequered career (see *Ency. Brit.*, 9th ed., vol. xvii. p. 417). In 1789 Mr Walter was tried for a libel in it on the Duke of York, and was sentenced to a fine of £50, a year's imprisonment in Newgate, to stand in the pillory for an hour, and to give surety for good behaviour for seven years; and for further libels the fine was increased by £100, and the imprisonment by a second year. On 9th March 1791, however, he was liberated and pardoned. In 1799 he was again convicted for a technical libel, this time on Lord Cowper. He had then given up the management of the business to his eldest son, William, and had (1795) retired to Teddington, where he died, 16th November 1812. In 1759 he had married Frances Landen (died 1798), by whom he had six children. William Walter very soon gave up the duties he undertook in 1795, and in 1803 transferred the sole management of the business to his younger brother, John.—JOHN WALTER (2) (1776–1847), who really established the great newspaper of which his father had sown the seed, was born 23rd February 1776, and was educated at Merchant Taylors' School and Trinity College, Oxford. About 1798 he was associated with his elder brother in the management of his father's business, and in 1803 became not only sole manager but also editor of *The Times.* He at once put new life into the paper, being careful to maintain its independence of party ties, and carried it on with great energy and tact. His opposition to Pitt in 1803 resulted in the withdrawal by the Government of the appointment as Printer to the Customs which the elder Walter had enjoyed since 1787, but no such pressure had any effect upon the attitude adopted by *The Times.* It was not till about 1810 that John Walter the second handed over the editorial duties to Sir John Stoddart (succeeded in 1816 by Thomas Barnes, and in 1841 by Delane, *q.v.*), and in the meantime he had organized the paper on the main lines afterwards followed. He revolutionized its system of news transmission, obtained the best literary talent on the staff, and above all impressed upon the paper a character of strict anonymity combined with the highest standard of accuracy. In 1810 he defeated an attempt on the part of his compositors to stop the publication of the paper by striking; and in 1814 he introduced steam printing machinery (see *Ency. Brit.*, 9th ed., vol. xxiii., art. TYPOGRAPHY), an improvement on an invention of a German named Koenig. The prosperity of the paper rapidly increased as the result of the energy with which it was conducted. In 1832 Mr Walter, who had purchased an estate called Bear Wood, in Berkshire (where his son afterwards built the present house), was elected to Parliament for that county, and retained his seat till 1837. In 1841 he was returned to Parliament for Nottingham, but was unseated next year on petition. He was twice married, and by his second wife, Mary Smythe, had a family. He died in London on 28th July 1847.—JOHN WALTER (3) (1818–1894), his eldest son, was born at Printing-house Square in 1818, and was educated at Eton and Exeter College, Oxford, being called to the bar in 1847. On leaving Oxford he took part in the business management of *The Times*, and on his father's death became sole manager, though he devolved part of the work on Mr Mowbray Morris. He was a man of scholarly tastes and serious religious views, and his conscientious character had a marked influence on the tone of the paper. It was under him that the successive improvements in the printing machinery at last reached the stage of the "Walter Press" in 1869 (see *Ency. Brit.*, vol. xxiii. p. 707), the pioneer of modern newspaper printing-presses. In 1847 he was elected to Parliament for Nottingham as a moderate Liberal, and was re-elected in 1852 and in 1857. In 1859 he was returned for Berkshire, and though defeated in 1865, was again elected in 1868, and held the seat till he retired in 1885. The history of *The Times* under his proprietorship is referred to elsewhere (see NEWSPAPERS). He was twice married, first in 1842 to Emily Frances Court (died 1858), and secondly in 1861 to Flora Macnabb. His eldest son by the first marriage, John, was accidentally drowned at Bear Wood in 1870; and on Mr Walter's own death on 3rd November 1894 he was succeeded as chief proprietor of *The Times* by Mr Arthur Fraser Walter (born 1846), his second son by the first marriage.

Waltham, a city of Middlesex county, Massachusetts, U.S.A., on the Charles river, and the Boston and Maine and the Fitchburg railways, in the eastern part of the state. The detached villages, among which the population of the town was formerly distributed, have grown and extended until they have merged into an open-built city, irregular in plan and divided into seven wards. The chief industries are watch-making and textile manufacture. Population (1890), 18,707; (1900), 23,481, of whom 6695 were foreign-born.

Waltham Abbey, or WALTHAM HOLY CROSS, a parish, urban district, and ancient market town, in the Epping, or Western, parliamentary division of Essex, England, on the river Lea. The town lies 13 miles north of London by rail. New Government works were built in 1890 at Quinton Hill, half a mile west of the town, for the manufacture of cordite. Population of the urban district (Waltham Holy Cross) and parish (Waltham Abbey) (1891), 6066; (1901), 6547.

Walton-on-Thames, a parish of Surrey, England, 5 miles south-west of Kingston, with a station on the London and South-Western Railway. Since 1895 it has been governed by an urban district council. The village is a favourite resort of anglers and tourists. Population (1891), 7988; (1901), 10,329.

Walton-on-the-Naze, a watering-place of Essex, England, 20 miles east of Colchester, with a station on the Great Eastern Railway. Since 1894 it has been governed by an urban district council. The sea wall was repaired in 1892 at a cost of £14,000. Population of the urban district (Walton-on-the-Naze) and parish (Walton le Soken) (1891), 1586; (1901), 2014.

Wandsbek, a town of the province of Schleswig-Holstein, Prussia, practically forming a populous suburb of Hamburg, of which it lies 3 miles north-east. It is best known as the place of residence of Voss and of Matthias Claudius, who here issued (1771–75) the memorable *Wandsbecker Boten.* There is a monument to Claudius outside the town. Its leading manufactures are spirits, tobacco, oleographs, and other wares. Population (1885), 17,760; (1900), 27,966.

Wappers, Egide Charles Gustave, BARON (1803–1874), Belgian painter, was born at Antwerp, 23rd August 1803. After studying at the Antwerp Academy under the guidance of Herreyns and of Matthieu van Brée, he went to Paris in 1826. The Romantic movement was then astir in France, and in that vehement struggle towards a new ideal artists and political men were thrown together. Wappers was the first Belgian artist to take advantage of this state of affairs, and his first exhibited picture, "The Devotion of the Burgomaster of Leyden," appearing at the appropriate moment, had a marvellous success in the Brussels Salon of 1830. The picture, although political, was in fact a remarkable work, which revolutionized the taste of Flemish painters. Wappers was invited to the Court of Brussels, and was favoured with commissions. In 1832 the city of Antwerp appointed him professor of painting, and his triumph was complete when he exhibited at the Antwerp Salon of 1834 his masterpiece, "An Episode of the Belgian Revolution of 1830" (Brussels Gallery; see Plate). He was subsequently appointed painter to the King of the Belgians, and at the death of Matthieu van Brée he was made director of the Antwerp Academy. Of his very numerous works we may name "Christ Entombed," "Charles I. taking leave of his Children," "Charles IX.," "Camoëns," "Peter the Great at Saardam," and "Boccaccio at the Court of Joanna of Naples." Louis Philippe gave him a commission to paint a large picture for the gallery at Versailles, "The Defence of Rhodes by the Knights of St John of Jerusalem," a work finished in 1844, when he received from the King of the Belgians the title of baron. After retiring from the post of director of the Antwerp Academy, he settled in 1853 in Paris, where he died on the 6th of December 1874.

See J. DU JARDIN. *L'Art Flamand.*—CAMILLE LEMONNIER. *Histoire des Beaux Arts en Belgique.*—ED. FÉTIS. "Notice sur Gustave Wappers," *Annuaire de l'Académie royale de Belgique,* 1884.

WAR.

I. GENERAL PRINCIPLES.

Modern conditions.

IT is not easy to determine whether industrial progress, improved organization, the spread of education, or mechanical inventions have wrought the greater change in the military art. War is first and foremost a matter of movement; and as such it has been considerably affected by the multiplication of good roads, the introduction of steam transport, and by the ease with which draught animals can be collected. In the second place, war is a matter of supply; and the large area of cultivation, the increase of live-stock, the vast trade in provisions, pouring the foodstuffs of one continent into another, have done much to lighten the inevitable difficulties of a campaign. In the third place, war is a matter of destruction; and while the weapons of armies have become more perfect and more durable, the modern substitutes for gunpowder have added largely to their destructive capacity. Fourthly, war is not merely a blind struggle between mobs of individuals, without guidance or coherence, but a conflict of well-organized masses, moving with a view to intelligent co-operation, acting under the impulse of a single will and directed against a definite objective. These masses, however, are seldom so closely concentrated that the impulse which sets them in motion can be promptly and easily communicated to each, nor can the right objective be selected without some knowledge of the enemy's strength and dispositions. Means of intercommunication, therefore, as well as methods of observation, are of great importance; and with the telegraph, the telephone, visual signalling, balloons, and improved field-glasses, the armies of to-day, so far as regards the maintenance of connexion between different bodies of troops, and the diffusion, if not the acquiring, of information, are at a great advantage compared with those of the middle of the 19th century.

War, then, in some respects has been made much simpler. Armies are easier to move, to feed, and to manœuvre. But in other respects this very simplicity has made the conduct of a campaign more difficult. Not only is the weapon wielded by the general less clumsy and more deadly than heretofore, less fragile and better balanced, but it acts with greater rapidity and has a far wider scope. In a strong and skilful hand it may be irresistible; in the grasp of a novice it is worse than useless. In former times, when war was a much slower process, and armies were less highly trained, mistakes at the outset were not necessarily fatal. Under modern conditions, the inexperienced commander will not be granted time in which to correct his deficiencies and give

"An Episode of the Belgian Revolution of 1830." By E. C. Gustave Wappers.

himself and his troops the needful practice. The idea of forging generals and soldiers under the hammer of war disappeared with the advent of "the nation in arms." It is not too much to say that every state in Europe, except Great Britain, can employ the whole of its resources, physical, material, and intellectual, at the outset. Military organization has become a science, most carefully studied, both by statesmen and soldiers. Its principles, as a general rule, have been so thoroughly applied, that the moment war is declared the manhood of the country stands ready, armed, organized, and trained to defend the frontier. The lessons of history have not been neglected. Previous to 1870, in one kingdom only was it recognized that intellect and education play a more prominent part in war than stamina and courage. Taught by the dire disasters of 1806, Prussia set herself to discover the surest means of escaping humiliation for the future. The shrewdest of her sons undertook the task. The nature of war was analysed until the secrets of success and failure were laid bare; and on these investigations a system of organization and of training was built up which, not only from a military, but from a political, and even an economical point of view, is the most striking product of the 19th century. The keynote of this system is that the best brains in the state shall be at the service of the war lord. None, therefore, but thoroughly competent soldiers are entrusted with the responsibility of command; and the education of the officer is as thorough, as systematic, and as uniform as the education of the lawyer, the diplomatist, and the doctor. In all ages the power of intellect has asserted itself in war. It was not courage and experience only that made Hannibal, Alexander, and Cæsar the greatest names of antiquity. Napoleon, Wellington, and the Archduke Charles were certainly the best educated soldiers of their time; while Lee, Jackson, and Sherman probably knew more of war, before they made it, than any one else in the United States. But it was not until 1866 and 1870 that the preponderating influence of the trained mind was made manifest. Other wars had shown the value of an educated general; these showed the value of an educated army. It is true that Moltke, in mental power and in knowledge, was in no wise inferior to the great captains who preceded him; but the remarkable point of his campaigns is that so many capable generals had never before been gathered together under one flag. No campaigns have been submitted to such searching criticism. Never have mistakes been more sedulously sought for or more frankly exposed. And yet, compared with the mistakes of other campaigns, even with that of 1815, where hardly a superior officer on either side had not seen more battles than Moltke and his comrades had seen field-days, they were astonishingly few. It is not to be denied that the foes of Prussia were hardly worthy of her steel. Yet it may be doubted whether either Austria or France ever put two finer armies into the field than the army of Bohemia in 1866 and the army of the Rhine in 1870. Even their generals of divisions and brigades had more actual experience than those who led the German army corps. Compared with the German rank and file, a great part of their non-commissioned officers and men were veterans, and veterans who had seen much service. Their chief officers were practically familiar with the methods of moving, supplying, and manœuvring large masses of troops; their marshals were valiant and successful soldiers. And yet the history of modern warfare records no defeats so swift and so complete as those of Königgrätz and Sedan. The great host of Austria was shattered to fragments in seven weeks; the French Imperial army was destroyed in seven weeks and three days; and to all intent and purpose the resistance they had offered was not much more effective than that of a respectable militia. But both the Austrian and the French armies were organized and trained under the old system. Courage, experience, and professional pride they possessed in abundance. Man for man, in all virile qualities, neither officers nor men were inferior to their foes. But one thing their generals lacked, and that was education for war. Strategy was almost a sealed book to them; organization a matter of secondary importance. It was no part of their duty, they declared, to train the judgment of their subordinates; they were soldiers, and not pedagogues. Knowledge of foreign armies and their methods they considered useless; and of war prepared and conducted on "business principles" they had never even dreamt.

Principles of command.

The study of war had done far more for Prussia than educating its soldiers and producing a sound system of organization. It had led to the establishment of a sound system of command; and this system proved a marvellous instrument in the hands of a great leader. It was based on the recognition of three facts: first, that an army cannot be effectively controlled by direct orders from one headquarters; second, that the man on the spot is the best judge of the situation; and third, that intelligent co-operation is of infinitely more value than mechanical obedience. To explain more fully. In military operations space, time, and opportunity are dominant factors. For many reasons an army in the field can never be closely concentrated, and it is thus impossible for the commander to see everything for himself, to detect with his own eyes every blunder the enemy may commit, or to communicate his orders in such good time that openings shall not be lost. Nor can he forecast and provide for every contingency, for it is generally the unexpected that happens: the enemy's blunders cannot be foreseen; and events move with such rapidity that an order an hour old is often quite inapplicable to the situation. Moreover, if those portions of the army unseen by the commander, and not in direct communication with him, were to await his orders before acting, not only would opportunities be allowed to pass, but other portions of the army, at critical moments, might be left without support. It was understood, therefore, in the Prussian armies of 1866 and 1870, that no order was to be blindly obeyed unless the superior who issued it was actually present, and therefore cognizant of the situation at the time it was received. If this was not the case, the recipient was to use his own judgment, and act as he believed his superior would have directed him to do had he been aware how matters stood. Again, officers not in direct communication with headquarters were expected not only to watch for and to utilize, on their own initiative, all opportunities of furthering the plan of campaign or battle, but, without waiting for instructions, to march to the thunder of the cannon, and render prompt assistance wherever it might be required. It was long before the system was cordially accepted, even in Germany itself; and it has been fiercely criticized. To soldiers whose one idea of command might be summarized in the sentence, "I order, you obey," and in whose eyes unqualified and unthinking obedience was the first of virtues, the new teaching appeared subversive of all discipline and authority. If, they said, subordinates are to judge for themselves whether an order is to be executed or not; if they are to be encouraged to march, to attack, or to retreat, on their own volition; if, in a word, each of them is to be considered an independent commander, the superior can never be certain, at any given moment, where his troops are or what they are doing, and to manœuvre them as a united whole will be out of the question. Was it likely, they asked, that a junior officer left to himself would act as his superior would have directed him to act had he himself been present? Was it not probable that he would hinder rather than further the general plan; and would not such untrammelled freedom lead to independent ventures, prolific perhaps of personal glory, but absolutely destructive of the harmony of action essential to success? These dangers, however, had been foreseen; and while they were recognized as real, they were not considered so inevitable as to forbid the encouragement of an unfettered initiative, nor so formidable as to be insurmountable. The first step was to make a clear distinction between "orders" and "instructions." An "order" was to be obeyed, instantly and to the letter. "Instructions" were an expression of the commander's wishes, not to be carried out unless they were manifestly practicable. But "orders," in the technical sense, were not to be issued except by an officer actually present with the body of troops concerned, and fully aware of the situation; otherwise, "instructions" only would be sent. The second step was to train all officers to arrive at correct decisions, and so to make certain, so far as possible, that subordinates, when left to themselves, would act as their superiors would wish them to do. The third step was to discourage to the utmost the spirit of rash and selfish enterprise. In the German army of to-day the means employed to ensure, so far as possible, correct decisions are, first, a uniform training in handling troops. Every German officer, practically speaking, is educated in the same school and taught to adapt his action to the same principles. The school is that of the General Staff. The principles, few but comprehensive, are those laid down by the chief of staff; and they are disseminated through the army by his assistants, the officers of the General Staff, whom he himself has educated. Each army corps and each division has its own chief of the staff, all of them replicas of their teacher; and no general, so far as possible, is appointed even to the command of a brigade unless he is thoroughly acquainted with the official principles. Instruction is not necessarily given at Berlin. Every commander has not passed through the Kriegsakademie, or served at headquarters. But at field exercises and manœuvres, at war games and staff rides, the official principles, especially those concerned with "orders," are the ground-work of all criticism and the touchstone of every operation. The field exercises, too, are arranged so as to afford constant practice, under competent instructors, in solving the problems which present themselves in war. The second means is a systematic encouragement, from the first moment an officer joins his regiment, of the spirit of initiative, of independent judgment, and self-reliance. Each has his definitive responsibilities, and superiors are forbidden, in the most stringent terms, to infringe on the prerogatives of their subordinates. The third means is the enforcement of the strictest discipline, and the development of *camaraderie* in the highest sense. Despite the latitude that is accorded him, absolute and punctual obedience to the most trifling "order" is exacted from the German officer; while devotion to duty and self-sacrifice, exalted to the same level as personal honour, and inculcated as the loftiest sentiment by which the soldier can be inspired, are trusted to counteract the tendencies of personal ambition. It may be remarked that Napoleon at St Helena, in his criticisms of his marshals, frequently made use of the significant expression that so-and-so failed "because he did not understand my system." It is possible that Moltke, the real founder of the German system, took those words to heart. Be this as it may, he knew not only how to command an army, but how to teach an army; how to form skilled leaders, strategists and tacticians, men who could plan, execute, and instruct; and in this respect he was far superior to Napoleon, or indeed to any general of modern times. In 1866 the system was not quite perfected; but in 1870 there were few German officers who were not thoroughly penetrated with the ideas of the chief of the staff; few who did not thoroughly understand how to interpret, and how to issue, "orders" and "instructions." The benefit to the state was enormous. It is true that the initiative of subordinates sometimes degenerated into reckless audacity, and critics have dilated on these rare instances with ludicrous persistence, forgetting the hundreds of others where it was exercised to the best purpose, forgetting the spirit of mutual confidence that permeated the whole army, and forgetting, at the same time, the deplorable results of centralization in the armies they overthrew. It is inconceivable that any student of war, comparing the conduct of the German, the French, and the Austrian generals, should retain even the shadow of a prejudice in favour of blind obedience and limited responsibility.

Causes of German success.

"To what," asks the ablest commentator on the Franco-German war, "did the Germans owe their uninterrupted triumph? What was the cause of the constant disasters of the French? What new system did the Germans put in practice, and what are the elements of success of which the French were bereft? That system is, so to speak, official and authoritative amongst the Germans. It is the initiative of the subordinate leaders. This quality, which multiplies the strength of an army, the Germans have succeeded in bringing to something near perfection. It is owing to this quality, that in the midst of varying events the supreme command pursued its uninterrupted career of victory, and succeeded in controlling, almost without a check, the intricate mechanism of the most powerful army that the 19th century has produced. In executing the orders of the supreme command, the subordinate leaders not only did over and over again more than was demanded of them, but surpassed the highest expectations of their superiors, notably at Sedan. It often happened that the faults, more or less inevitable, of the higher authorities were repaired by their subordinates, who thus won for them victories which they had not always deserved. In a word, the Germans were indebted to the subordinate leaders that not a single favourable occasion throughout the whole campaign was allowed to escape unutilized. The French, on the other hand, never even suspected the existence of so powerful a factor; and it is for this reason that they met with disasters, even when victory, so to speak, belonged to them by every rule of war. The faults and omissions of the French subordinate leaders are to be attributed to the false conception of the rights and functions of command, to the ingrained habit of blind and inert obedience, based on a principle which allowed no exception, and acting as a law, absolute and immutable, in all degrees of the military hierarchy. To the virile energy of the Germans they could oppose nothing but impetuous courage. Compensation for the more powerful fire of the German artillery was found in the superior weapon of the French infantry. But to the intelligent, hardy, and even at times somewhat reckless initiative of the German subordinate leaders the French had nothing to oppose, in the grand as in the minor operations, but a deliberate inactivity, always awaiting an impulse from above. These were the real causes of the numerous reverses and the swift destruction of the valiant French army, and therein lies the true secret of German strength. Her foes of days to come will have to reckon seriously with this force, almost elementary in its manipulation, and prepare themselves in time to meet it. No well-organized army can afford to dispense with the initiative of the subordinate leaders, for it is the determining factor in modern war, and up to the present it has been monopolized by Germany."

That the Prussian system should be imitated, and her army deprived of its monopoly of high efficiency, was naturally inevitable. Every European state has to-day its staff college, its intelligence department, its schools of instruction, and its courses of field manœuvres and field firing. But that the full import of the German system has been thoroughly realized is very doubtful. So far as the history of warfare since the fall of Paris can be regarded as evidence, the contrary appears to be the case. In many of the campaigns since 1870, brains and system can hardly be said to have played the leading part. Individual generals have made great names as strategists, as organizers, as leaders of men; but want of foresight, inadequate preparation, contempt of the enemy and ignorance of his strength, violation of great principles, and indifferent training, both of the staff and of the troops, have been too often apparent. It is possible that the same faults and deficiencies will be conspicuous, unless a knowledge of the real nature of war is far more widely diffused than it is at present, in the 20th century. It is not quite true that some terrible catastrophe is required to bring home to a nation the vast importance of military efficiency, and to make all men realize in what that efficiency consists. If Jena and Auerstadt made the Prussian army of 1870, and Sedan the French army of 1900, it is to the writings of Mahan that Great Britain owes in large measure the reform of her naval deficiencies. His brilliant analysis of the nature of naval warfare, and his masterly elucidation of the great principles of success and failure, have proved as effective a tonic as the occupation of Berlin or the fall of Paris.

Difficulties of the new conception of war.

But before a new conception of war, such as is involved in Moltke's system, can take hold of the instincts of a people there are many obstacles to be overcome. Not the least is a very natural reluctance to admit that any foreign army is in any way better than their own, just as the loyal citizen of London, Oliver Goldsmith, believed that "nature never exhibited a more magnificent prospect than that seen from the top of Hampstead Hill." But the chief are the traditional ideas that intellectual capacity is of far less value in the field than the military virtues, courage, endurance, and skill at arms, that the problems which confront the general are all to be solved by the exercise of ordinary common sense, and that war is a matter of such simplicity that it is hardly worth serious study. In a lawyer, a doctor, an engineer, in the mates of an Atlantic liner, or the officers of a battleship, the public expects to find a mastery of their profession, a proved capacity for conducting it, and a knowledge that is up to date. Nor does the ordinary layman venture to interfere with these acknowledged specialists. As regards the military art it is far otherwise. Soldiers are not acknowledged as specialists. Few Anglo-Saxons are not secretly convinced that with some knowledge of drill they would be most formidable rivals to the officers of the German General Staff, and many of the fiercest critics of the professional soldier are in exactly the same case as the Austrians of 1866 and the French of 1870. They believe that they possess the military virtues, that they are fearless, cool, and resolute, and they flatter themselves that they are fitted with sufficient common sense to enable them to decide wisely and promptly in critical moments. Nor is it to be denied, especially in a nation of sportsmen, whose familiarity with danger breeds energy and resolution, that so far they are perfectly right. They forget, however, that common sense, to be a really useful guide to the judgment, must be trained common sense, fortified by knowledge and increased by practice, and they forget that encounters with the enemy are only incidents of a campaign. When they assume the form of pitched battles they are undoubtedly the most important incidents. But unless the strategy is sound, unless the preliminary operations, such as the concentration on the frontier, the measures for protecting the communications, the arrangements for fortifying the bases, the marches, the reconnaissances, have been devised and executed in such manner as to enable the troops to meet the enemy under the most favourable conditions; and unless, when the victory has been won, the movements of the army are so directed as to reap the fruits thereof, battles, even if successful, are not likely to produce decisive results. But with strategy, that is, the operations which lead up to battle, and those which follow battle, the ordinary military virtues are not directly concerned, or rather, are much less concerned than intellectual capacity and a wide knowledge of war. For instance, in the war of 1870, the headquarters were so far to the rear that neither Moltke nor his assistants saw a shot fired before the day of Gravelotte, the sixth great battle. It would seem, therefore, to have been perfectly immaterial whether the officers of the headquarters staff possessed a superabundance of the military virtues, or whether they were absolutely without them. Yet the skill with which they planned the preliminaries was the foundation of the victories. Had not the general scheme of operations been thoroughly sound, the judgment and initiative of the subordinate leaders would assuredly have gone astray. But Moltke committed no mistake. Long before war had been declared every possible preparation had been made. And these included much more than arrangements for rapid mobilization, the assembly of superior numbers completely organized, and the establishment of magazines. The enemy's numbers, armaments, readiness, and efficiency had been submitted to a most searching examination. Every possible movement that might be made, however unlikely, had been foreseen, every possible danger that might arise, however remote, discussed and provided against. The concentration on the frontier was so devised that not only were the troops placed in the best position for either invasion or defence, but the chance of even a small reverse was hardly possible. Moreover, when the campaign opened, although half a million of men had to be supplied and manœuvred in a hostile country, and, as each victory brought about a fresh situation, fourteen army corps, every one of them as large as the army with which Wellington fought the battle of Quatre Bras, had to be given a fresh direction, transferred to other roads and assigned a new objective, the French were never offered a real opening from first to last. It is true that the Germans were superior in numbers; but if it be borne in mind that exact information was but seldom forthcoming, that the movements of these huge masses depended on slight indications, and on inferences drawn from a knowledge of war, from a knowledge of the enemy's leaders, and of the influence on those leaders of French public opinion, it will be evident that the successful result was the fruit of a sustained intellectual effort of no ordinary kind.

The popular idea that war is a mere matter of brute force, redeemed only by valour and discipline, is responsible for a greater evil than the complacency of the amateur. It blinds both the people and its representatives to their bounden duties. War is something more than a mere outgrowth of politics. It is a political act, initiated and controlled by the Government, and it is an act of which the issues are far more momentous than any other. And yet no branch of political science is less studied in the Anglo-Saxon communities. That obstacles to a mastery of the subject are very numerous it is idle to deny. A youthful Hohenzollern can be taught by a Moltke; to train the sovereign people to a proper understanding of things military is a different matter. For one thing, it is not easy to find instructors. There is no standard work on war in the English language, no volume of permanent value which deals with the organization, maintenance, and employment of armies from the point of view of the statesman and the citizen. History, as taught at the present day, includes an immense variety of subjects, but there is one subject which it has sedulously shunned, and that subject is the defence of empires. Hardly any well-known political writer, except Spenser Wilkinson, appears to have the least inkling that such knowledge should be part of the intellectual equipment of every educated man, and no great teaching body has yet endeavoured to supply the deficiency. So, in both Great Britain and the United States, organization has been neglected, efficiency has been taken for granted, and the national resources have been either wasted or misused. Costly, ill-planned, and ill-conducted enterprises have been the inevitable result.

Statesmen and war.

It is not pretended that if military history were thoroughly studied all statesmen would become Moltkes, or that every citizen would be competent to set squadrons in the field. War is above all a practical art, and the application of theory to practice is not to be taught at a university or to be learned by those who have never rubbed shoulders with the men in the ranks. But if war were more generally and more thoroughly studied, the importance of organization, of training, of education, and of readiness would be more generally appreciated; abuses would no longer be regarded with lazy tolerance; efficiency would be something more than a political catchword, and soldiers would be given ample opportunities of becoming masters of every detail of their profession. Nor is this all. A nation that understood something about war would hardly suffer the fantastic tricks which have been played so often by the best-meaning statesmen. And statesmen themselves would realize that when war is afoot their interference is worse than useless; that preparation for defence, whether by the multiplication of roads, the construction of railways, of arsenals, dockyards, fortresses, is not the smallest of their duties; and lastly, that so far as possible diplomacy and strategy should keep step. Each one of these is of far greater importance than in the past. In the wars of the 18th century, English cabinets and Dutch deputies could direct strategical operations without bringing ruin on their respective countries. The armies of Austria in 1792–95, controlled as they were by the Aulic Councils, were more formidable in the field than those of the French Republic. In the campaigns of 1854 and 1859 the plans of Newcastle and Napoleon III. worked out to a successful issue; and if Lincoln and Stanton, his Secretary of War, imperilled the Union in 1862, they saw the downfall of the Southern Confederacy in 1865. But in every case amateur was pitted against amateur. The Dutch deputies were hardly less incapable of planning or approving a sound plan of campaign than Louis XIV. The Aulic Council was not more of a marplot than the Committee of Public Safety. Newcastle was not a worse strategist than the Tsar Nicholas I. Napoleon III. and his advisers were quite a match for the courtier generals at Vienna; while Lincoln and Stanton were not much more ignorant than Jefferson Davis. The amateur, however, can no longer expect the good fortune to be pitted against foes of a capacity no higher than his own. The operations of Continental armies will be directed by soldiers of experience whose training for war has been incessant, and who will have at their command troops in the highest state of efficiency and preparation. It is not difficult to imagine, under such conditions, with what condign punishment mistakes will be visited. Napoleon III. in 1859 committed as many blunders as he did in 1870. But the Austrians had no Moltke to direct them; their army corps were commanded by men who knew less of generalship than a Prussian major, and their armament was inferior. Had they been the Austrians of to-day, it is probable that the French and the allies would have been utterly defeated. And to come to more recent campaigns, while American officers have not hesitated to declare that if the Spaniards at Santiago had been Germans or French, the invasion would have ended in disastrous failure, it is impossible to doubt that had the Boers of 1899 possessed a staff of trained strategists, they would have shaken the British Empire to its foundations. The true test of direction of war is the number of mistakes. If they were numerous, although the enemy may not have been skilful enough to take advantage of them, the outlook for the future under the same direction, but against a more practised enemy, is anything but bright.

Preparation for defence.

As regards preparation for defence, history supplies us with numerous illustrations. The most conspicuous, perhaps, is the elaborate series of fortifications which were constructed by Vauban for the defence of France; and there can be no question that Louis XIV., in erecting this mighty barrier against invasion, gave proof of statesmanlike foresight of no mean order. An instance less familiar, perhaps, but even more creditable to the brain which conceived it, was Wellington's preparation of Portugal in 1809–11. Not only did the impregnable stronghold of Torres Vedras, covering Lisbon, and securing for the sea-power an open door to the continent of Europe, rise as if by magic from the earth, but the whole theatre of war was so dealt with that the defending army could operate wherever opportunity might offer. No less than twenty supply depots were established on different lines of the advance. Fortifications protected the principal magazines. Bridges were restored and roads improved. Waterways were opened up, and flotillas organized; and three auxiliary bases were formed on the shores of the Atlantic. Again, the famous "quadrilaterals" of Lombardy and Rumelia have more than fulfilled the purpose for which they were constructed; and both Austria and Turkey owe much to the fortresses which so long protected their vulnerable points. Nor has the neglect of preparation failed to exert a powerful effect. Moltke has told us that the railway system of Germany before 1870 had been developed without regard to strategical considerations. Yet the fact remains that it was far better adapted both for offence and defence than those of Austria and France; and, at the same time, it can hardly be denied that the unprovided state of the great French fortresses exercised an evil influence on French strategy. Both Metz and Strasburg were so far from forming strong pivots of manœuvres, and thus aiding the operations of the field armies, that they required those armies for their protection; and the retreat on Metz, which removed Bazaine's army from the direct road to Paris and placed it out of touch with its supports, was mainly due to the unfinished outworks and deficient armament of the virgin city. Since 1870 it has been recognized that preparation of the theatre of war is one of the first duties of a Government. Every frontier of continental Europe is covered by a chain of entrenched camps. The great arsenals are amply fortified and strongly garrisoned. Strategy has as much to say to new railways as trade; and the lines of communication, whether by water or by land, are adequately protected from all hostile enterprises. It is to be recognized that the amount of preparation must vary with the extent of the frontier and with the character of the foe beyond. For example, to make the vast boundaries of the British Empire as secure as the eastern marches of France would be a financial impossibility and a military folly. Yet this does not imply that questions of defence may be postponed until war is imminent. Plevna has demonstrated, indeed, that hastily-constructed earthworks may be more useful than the most formidable citadel. But it was only the stupidity of the enemy that allowed Plevna to become impregnable.

Concert between diplomacy and strategy.

We now come to the third point, the importance of close concert between strategy and diplomacy. On the continent of Europe they can easily keep pace, for the theatre of war is always within easy reach. But when the ocean intervenes between two hostile states it is undoubtedly difficult to time an ultimatum so that a sufficient armed force shall be at hand to enforce it, and it has been said in high places that it is practically impossible. The expedition to Copenhagen in 1807, when the British ultimatum was presented by an army of 27,000 men carried on 300 transports, would appear to traverse this statement. But at the beginning of the 20th century an army and a fleet of such magnitude could neither be assembled nor despatched without the whole world being cognizant. It is thus perfectly true that an appreciable period of time must elapse between the breaking off of negotiations and the appearance on the scene of an invading army. Events may march so fast that the statesman's hand may be forced before the army has embarked. But because a powerful blow cannot at once be struck, it by no means follows that the delivery or the receipt of an ultimatum should at once produce a dangerous situation. Dewey's brilliant victory at Manila lost the greater part of its effect because the United States Government was unable to follow up the blow by landing a sufficient force. Exactly the same thing occurred in Egypt in 1882. The only results of the bombardment of Alexandria were the destruction of the city, the massacre of the Christian inhabitants, the encouragement of the rebels, who, when the ships drew off, came to the natural conclusion that Great Britain was powerless on land. Again, in 1899 the invading Boers found the frontiers unfortified and their march opposed by an inadequate force. It is essential, then, that when hostilities across the sea are to be apprehended, the most careful precautions should be taken to ward off the chance of an initial disaster. And such precautions are always possible. It is hardly conceivable, for instance, that a great maritime power, with Cyprus as a *place d'armes*, could not have placed enough transports behind the fleet to hold a sufficient garrison for Alexandria, and thus have saved the city from destruction. Nor in the case of a distant province being threatened is there the smallest reason that the garrison of the province should be exposed to the risk of a reverse before it is reinforced. It may even be necessary to abandon territory. It will certainly be necessary to construct strong places, to secure the lines of communication, to establish ample magazines, to organize local forces, to assemble a fleet of transports, and to keep a large body of troops ready to embark at a moment's notice. But there is no reason, except expense, that all this should not be done directly it becomes clear that war is probable, and that it should not be done without attracting public attention. In this way strategy may easily keep pace with diplomacy; and all that is wanted is the exercise of ordinary foresight, a careful study of the theatre of war, a knowledge of the enemy's resources, and a resolute determination, despite some temporary inconvenience and the outcry of a thoughtless public, to give the enemy no chance of claiming first blood. The Franco-German war supplies a striking example. Moltke's original intention was to assemble the German armies on the western frontier. The French, he thought, inferior in numbers and but half prepared, would probably assemble as far back as the Moselle. But, as so often happens in war, the enemy did what he was least expected to do. Hastily leaving their garrisons, the French regiments rushed forward to the Saar. The excitement in Germany was great; and even soldiers of repute, although the mobilization of the army was still unfinished, demanded that such troops as were available should be hurried forward to protect the rich provinces which lie between the Saar and Rhine. But the chief of the staff became as deaf as he was silent. Not a single company was despatched to reinforce the slender garrisons of the frontier towns; and those garrisons were ordered to retire, destroying railways and removing rolling-stock, directly the enemy should cross the boundary. Moltke's foresight had embraced every possible contingency. The action of the French, improbable as it was deemed, had still been provided against; and, in accordance with time-tables drawn up long beforehand, the German army was disentrained on the Rhine instead of on the Saar. Ninety miles of German territory were thus laid open to the enemy; but the temporary surrender of the border provinces, in the opinion of the great strategist, was a very minor evil compared with the disasters, military and political, that would have resulted from an attempt to hold them.

Duties of the War Minister.

It is hardly necessary to observe that no civilian minister, however deeply he might have studied the art of war, could be expected to solve for himself the strategic problems which come before him. In default of practical knowledge, it would be as impossible for him to decide where garrisons should be stationed, what fortifications were necessary, what roads should be constructed, or how the lines of communication should be protected, as to frame a plan of campaign for the invasion of a hostile state. His foresight, his prevision of the accidents inevitable in war, would necessarily be far inferior to those of men who had spent their lives in applying strategical principles to concrete cases; and it is exceedingly unlikely that he would be as prolific of strategical expedients as those familiar with their employment. Nevertheless, although he would be more or less bound by expert advice, and although he might be aware that the attempt to control military operations, even so far as regards the preliminaries of a campaign, is a most dangerous proceeding, yet a knowledge of war could hardly fail to serve him in good stead. Arnold, in his *Lectures on Modern History*, puts the matter clearly: "There must be a point up to which an unprofessional judgment of a professional subject may not only be competent but of high authority, although beyond that point it cannot venture without presumption and folly. The distinction seems to lie originally in the difference between the power of doing a thing and that of perceiving whether it is well done or not. 'He who lives in the house,' says Aristotle, 'is a better judge of its being a good or bad one than the builder of it. He can tell not only whether the house is good or bad, but wherein its defects consist; he can say to the builder, "This chimney smokes, or has a bad draught"; or "This arrangement of the rooms is inconvenient," and yet he may be quite unable to cure the chimney, or to draw out a plan for his rooms which should suit him better. Nay, sometimes he can even see where the fault is which has caused the mischief, and yet he may not practically know how to remedy it.'

Following up this principle, it would appear that what we understand least in the profession of another is the detail of his practice. We may appreciate his object, we may see where he has missed it, or where he is pursuing it ill; nay, may understand generally the method of setting about it, but we fail in the minute details. . . . But in proportion as we recede from those details to more general points, first, as to what is generally called strategy, that is to say, the directing the movements of an army with a view to the accomplishment of the object of the campaign, in that proportion general knowledge and power of mind come into play, and an unprofessional person may without blame speak or write on military subjects, and may judge of them sufficiently." Applying this wise rule to statecraft, the point where civilian control of military operations becomes presumptuous, as well as the extent of that control, may be easily defined. In the first place, to frame a sound strategical plan, whether for defence or invasion, requires not only an intimate acquaintance with innumerable details of which only a professional soldier can really judge, such as methods of supply and transport, the use of fortifications, the effects of climate, the maintenance of the lines of communication, the value of positions, the management of marches, the *morale*, armament, organization, tactics and resources of the opposing forces, but an intimate acquaintance with the principles and stratagems of war. It is here that the amateur strategist fails. He may have read enough to give him a good knowledge of principles, but he has no knowledge of the practical difficulties of war, and his criticism, as a general rule, is consequently of little value. All in war is simple, but the simple is most difficult; and how difficult only those who have made it, who have witnessed with their own eyes the turmoil, the confusion, the friction which even in the best armies attend the most ordinary operation, are in a position to understand. Even a theoretical acquaintance, derived from historical study, of the practical difficulties is insufficient. Unless he who prepares a strategical plan has before his mind's eye a clear picture of all military operations, of marching, quartering, supply, entraining and disentraining, embarkation and disembarkation, and a personal knowledge of the difficulties which attend on war, his work will be of little value. It is essential, too, that he should have a thorough knowledge of both officers and men, of the peculiar characteristics of the army, and of the system on which it works, of its strong points and its weak. A German, suddenly placed in command of British soldiers, would be much at sea, and *vice versâ*. Every army has an individuality of its own. It is a living organism, of a very sensitive temper, and it can neither be properly controlled nor efficiently directed except by those who are in full sympathy with its every impulse.

It would appear, then, that while a statesman may be competent to appreciate the general principles of the projects of operations laid before him, he should never attempt to frame a project for himself. Still less, when once he has approved of a plan of campaign, should he attempt to limit the number of troops to be employed, or to assign the position of the necessary detachments. Nevertheless, a knowledge of war may still be exceedingly useful to him. A Minister of War cannot divest himself of his responsibility for the conduct of military operations. In the first place, he is directly responsible that plans of campaign to meet every possible contingency are worked out in time of peace. In the second place, he is directly responsible that the advice on which he acts should be the best procurable. It is essential, therefore, that he should be capable of forming an independent opinion on the merits of the military projects which may be submitted to him, and also on the merits of those who have to execute them. Pitt knew enough of war and men to select Wolfe for the command in Canada. Canning and Castlereagh, in spite of the opposition of the king, sent Wellington, one of the youngest of the lieutenant-generals, to hold Portugal against the French. The French Directory had sufficient sense to accept Napoleon's project for the campaign of Italy in 1796. In the third place, strategy cannot move altogether untrammelled by politics and finance. But political and financial considerations may not present themselves in quite the same light to the soldier as to the statesman, and the latter is bound to make certain that they have received due attention. If, however, modifications are necessary, they should be made before the plan of campaign is finally approved; and in any case the purely military considerations should be most carefully weighed. It should be remembered that an unfavourable political situation is best redeemed by a decisive victory, while a reverse will do more to shake confidence in the Government than even the temporary surrender of some portion of the national domains. "Be sure before striking" and *Reculer pour mieux sauter* are both admirable maxims; but their practical application requires a thorough appreciation of the true principles of war, and a very large degree of moral courage, both in the soldier who suggests and in the statesman who approves. If, however, the soldier and the statesman are supported by an enlightened public, sufficiently acquainted with war to realize that patience is to be preferred to precipitation, that retreat, though inglorious, is not necessarily humiliating, their task is very considerably lightened. Nothing is more significant than a comparison between the Paris press in 1870 and the Confederate press in 1864. In the one case, even after the disastrous results of the first encounters had proved the superior strength and readiness of the enemy, the French people, with all the heat of presumptuous ignorance, cried out for more battles, for an immediate offensive, for a desperate defence of the frontier provinces. So fierce was their clamour that both the generals and the Government hesitated, until it was too late, to advise the retreat of Bazaine's army; and when that army had been cut off at Metz, the pressure of public opinion was so great that the last reserve of France was despatched to Sedan on one of the maddest enterprises ever undertaken by a civilized state. In 1864, on the other hand, while Lee in Virginia and Johnston in the west were retreating from position to position, and the huge hosts of the Union were gradually converging on the very heart of the Confederacy, the Southern press, aware that every backward step made the Federal task more difficult, had nothing but praise for the caution which controlled the movements of their armies. But the Southern press, in three crowded years of conflict, had learned something of war. In 1866 and 1870 the German press was so carefully muzzled that even had there been occasion it could have done nothing to prejudice public opinion. Thus both the sovereign and the generals were backed by the popular support that they so richly merited; but it may be remarked that the relations between the army and the Government were characterized by a harmony which has been seldom seen. The old king, in his dual capacity as head of the state and commander-in-chief, had the last word to say, not only in the selection of the superior officers, but in approving every important operation. With an adviser like Moltke at his elbow, it might appear that these were mere matters of form. Moltke, however, assures us that the king was by no means a figurehead. Although most careful not to assert his authority in a way that would embarrass his chief of staff, and always ready to yield his own judgment to sound reasons, he expressed, nevertheless, a perfectly independent opinion on every proposal placed before him, and on very many occasions made most useful suggestions. And at the same time, while systematically refraining from all interference after military operations had once begun, he never permitted military considerations to override the demands of policy. In 1866, when it was manifestly of the first importance, from a military point of view, that the Prussian army should be concentrated in a position which would enable it to cross the border immediately war was declared, the political situation was so strained that it was even more important to prevent the enemy from setting foot at any single point on Prussian territory. The army, in consequence, was dispersed instead of being concentrated, and the ultimate offensive became a difficult and hazardous operation. It is true that the king was an able and experienced soldier. Nevertheless, the wise restraint he displayed in the course of two great campaigns, as well as the skill with which he adjusted conflicting factors, are an admirable example of judicious statesmanship. And such statesmanship is not merely a valuable aid to the military chiefs, but it is imperatively demanded by the nature of great wars. Campaigns are not likely to be prolonged. Space has been annihilated by steam; and it was space that was the real cause of such weary struggles as the war in the Peninsula or that of Secession in America. Troops are so easily transported and fed by means of railways and steamers, and organization is so perfect, that, as a general rule, far larger numbers will be assembled for the initial encounters than heretofore. There will be more in front and fewer in rear; and the first battles, therefore, have assumed a new importance. In fact, unless one side has been completely surprised, and merely fights to gain time, they may be as decisive of the war as Jena, Eckmühl, or Waterloo. It is therefore of the utmost importance that when once the plan of campaign has been approved, the military chiefs upon the spot should be given an absolutely free hand.

Moral effect of fire.

The duration of a campaign is largely affected by the deadly properties of modern firearms. It is true that the losses in battle are relatively less than in the days of Brown Bess and the smooth-bore cannon, and almost insignificant when compared with the fearful carnage wrought by sword and spear. The reason is simple. A battlefield in the old days, except at close quarters, was a comparatively safe locality, and the greater part of the troops engaged were seldom exposed for a long time together to a hot and continuous fire. To-day death has a far wider range, and the strain on the nerves is consequently far more severe. Demoralization, therefore, sets in at an earlier period, and it is more complete. When troops once realize their inferiority, they can no longer be depended on. If attacking, they refuse to advance; if defending, they abandon all hope of resistance. It is not the losses they have actually suffered, but those that they expect to suffer, that affect them. The ordeal of facing the hail of modern fire tells so heavily on ordinary flesh and blood that those who have been hotly engaged, if casualties have been very numerous, will seldom be brought to fight again, except on the defensive, the same day, or even the same month. There is no bringing up men again and again to the attack, as in the days of Napoleon; and unless discipline and national spirit are of superior quality, unless even the private soldier is animated by something higher than the mere habit of mechanical obedience, panic, shirking, and wholesale surrender will be the ordinary features of a campaign. These phenomena made themselves apparent, though in a less degree, as long ago as the War of Secession, when the weapon of the infantry was the muzzle-loading rifle, firing at most two rounds a minute, and when the projectiles of the artillery were hardly more destructive than the stone shot of Mons Meg. With the magazine rifle, machine guns, shrapnel, and high explosives, they have become more pronounced than even at Vionville or Plevna. "The retreat of the 38th (Prussian) Brigade," writes Captain Hoenig, an eye-witness of the former battle, "forms the most awful drama of the great war. It had lost 53 per cent. of its strength, and the proportion of killed to wounded was as 3 to 4. Strong men collapsed inanimate. . . . I saw men cry like children, others fell prone without a sound; in most the need of water thrust forth all other instincts; the body demanded its rights. 'Water, water,' was the only intelligible cry that broke from those moving phantoms. The enemy's lead poured like hail upon the wretched remnant of the brigade; yet they moved only slowly to the rear, their heads bent in utter weariness; their features distorted under the thick dust that had gathered on faces dripping with sweat. The strain was beyond endurance. The soldier was no longer a receptive being; he was oblivious of everything, great or small. His comrades or his superiors he no longer recognized; and yet he was the same man who but a short time before had marched across the battlefield shouting his marching chorus. A few active squadrons, and not a man would have escaped! Only he who has seen men in such circumstances, and observed their bearing, knows the dreadful imprint that their features leave upon the memory. Madness is there, the madness that arises from bodily exhaustion combined with the most abject terror. . . . I do not shrink," he adds, "from confessing that the fire of Mars-la-Tour affected my nerves for months."

If such are the results of ill-success, a whole army might be reduced to the condition of the 38th Brigade in the first month of the campaign, and it is thus perfectly clear that some small mistake in conduct, some trifling deficiency in preparation, an ill-conceived order, or a few hours' delay in bringing up a reinforcement, may have the most terrible consequences. That mistakes can be wholly avoided is to expect too much. But the state has every right to demand that to make our preparations complete, to ensure skilful leading, close co-operation, and resolute action, neither by statesman nor soldier should thought, labour, or expense be spared.

Naval and military force.

The importance, nay the necessity, that the people, as a governing body, should keep as watchful an eye on its armed forces and the national defences as on diplomacy or legislation is fully realized, naturally enough, only by those nations whose instincts of self-preservation, by reason of the configuration of their frontiers or their political situation, are strongly developed. So remote is the prospect that either British or American soldiers may suddenly be called upon to confront the trained hosts of continental Europe, that the efficiency of the army has comparatively little interest for the nation at large. Yet even to these maritime empires an efficient army is of the first necessity. Their land frontiers are vulnerable. They may have to deal with rebellion, and a navy is not all-powerful, even for the defence of coasts and commerce. It can protect, but it cannot destroy. Without the help of an army, it can neither complete the ruin of the enemy's fleet nor prevent its resuscitation. It can ward off attack, but counter-attack is beyond its scope. Without the help of an army it can hardly force a hostile Power to ask for terms. Exhaustion is the object of its warfare; but exhaustion, unless accelerated by crushing blows, is an exceedingly slow process. In the spring of 1861 the blockade was established along the coasts of the Southern Confederacy, and maintained with increasing stringency from month to month. Yet it was not till the spring of 1865 that the colours of the Union floated from the capitol of Richmond, and it was the army which placed them there. A state, then, which should rely on naval strength alone, could look forward to no other than a protracted war, and a protracted war between two great Powers is antagonistic to the interests of the civilized world. With the nations armed to the teeth, and dominated to a greater or smaller extent by a militant spirit; with commerce and finance dependent for health and security on universal peace, foreign intervention is a mere question of time. Nor would public opinion, either in Great Britain or America, be content with a purely defensive policy, even if such policy were practicable. Putting aside the tedium and the dangers of an interminable campaign, the national pride would never be brought to confess that it was incapable of the same resolute effort as much smaller communities. "An army, and a strong army," would be the general cry. Nor would such an army be difficult to create. Enormous numbers would not be needed. An army supported by an invincible navy possesses a strength which is out of all proportion to its size. Even to those who rely on the big battalions and huge fortresses, the amphibious power of a great maritime state, if intelligently directed, may be a most formidable menace; while to the state itself it is an extraordinary security. The history of Great Britain is one long illustration. Captain Mahan points out that there are always dominant positions, outside the frontiers of a maritime state, which, in the interests of commerce, as well as of supremacy at sea, should never be allowed to pass into the possession of a powerful neighbour. Great Britain, always dependent for her prosperity on narrow seas, has long been familiar with the importance of the positions that command these waterways. In one respect at least her policy has been consistent. She has spared no effort to secure such positions for herself, or, if that has been impracticable, at least to draw their teeth. Gibraltar, Malta, St Lucia, Aden, Egypt, Cyprus are conspicuous instances; but above all stands Antwerp. In perhaps the most original passage of Alison's monumental work the constant influence of Antwerp on the destinies of the United Kingdom is vividly portrayed. "Nature has framed the Scheldt to be the rival of the Thames. Flowing through a country excelling even the midland counties of England in wealth and resources, adjoining cities equal to any in Europe in arts and commerce; the artery at once of Flanders and Holland, of Brabant and Luxembourg, it is fitted to be the great organ of communication between the fertile fields and rich manufacturing towns of the Low Countries and other maritime states of the world." Antwerp, moreover, the key of the great estuary, is eminently adapted for the establishment of a vast naval arsenal, such as it became under Philip II. of Spain and again under the First Napoleon. "It is the point," continues the historian, "from which in every age the independence of these kingdoms has been seriously menaced. Sensible of her danger, it had been the fixed policy of Great Britain for centuries to prevent this formidable outwork from falling into the hands of her enemies, and the best days of her history are chiefly occupied with the struggle to ward off such a disaster." In ascribing, however, every great war in which Great Britain has been engaged to this cause alone he has gone too far. The security of India has been a motive of equal strength. Nevertheless, it was to protect Antwerp from the French that Charles II. sided with the Dutch in 1670; that Anne declared war on Louis XIV. in 1704; that Chatham supported Prussia in 1742; that Pitt, fifty years later, took up arms against the Revolution.

Interactions of naval and military operations.

The trophies of the British army in the great war with France were characteristic of the amphibious power. The troops took more battleships than colours, and almost as many naval arsenals as land fortresses. Many were the blows they struck at the maritime strength of France and her allies; but had the expedition which landed on the Isle of Walcheren in 1809 been as vigorously conducted as it was wisely conceived, it would have hit Napoleon far harder than even the seizure of the Danish fleet at Copenhagen. The great dockyard that the emperor had constructed on the Scheldt held the nucleus of a powerful fleet. Eight line-of-battle ships and ten frigates lay in mid channel. Twenty vessels of different classes were on the slips, and in the magazines and storehouses had been accumulated sufficient material to equip all these and twenty more. The destruction of Antwerp—and for a full week it was at Lord Chatham's mercy—would have freed scores of British frigates to protect British commerce; Wellington, in his great campaign of 1813, could not have had to complain that, for the first time, the communication by sea of a British army was insecure; the Americans, in the war which broke out in 1812, would have been more vigorously opposed; and Napoleon, who, while Antwerp was his, never altogether abandoned hope of overmastering Great Britain on her own element, might, on his own confession, have relinquished the useless struggle with the great sea Power. The expedition failed, and failed disastrously. But for all that, fulfilling as it did the great maxim that the naval strength of the enemy should be the first objective of the forces of the maritime power, both by land and sea, it was a strategical stroke of the highest order.

The predominant part played by the army under Wellington in Spain and Belgium has tended to obscure the principle that governed its employment in the war of 1793–1815. The army, in the opinion of the country, was first and foremost the auxiliary of the fleet; and only when the naval strength of the enemy had been destroyed was it used in the ordinary manner, *i.e.*, in the invasion of the hostile territory and in lending aid to the forces of confederate Powers. Events proved that these principles were absolutely sound. It was not in the narrow seas alone that the army rendered good service to the navy. Depriving France of her colonies, occupying her ports in foreign waters, ousting her from commanding posts along the trade routes, it contributed not only to her exhaustion, but to the protection of British commerce and to the permanent establishment of maritime supremacy. Few of these operations are of sufficient magnitude to attract much notice from the ordinary historian, yet it is impossible to overrate their effect. To the possession of the dominant positions that were captured by the army, Great Britain, in no small degree, is indebted for the present security of her vast dominions. The keynote of the fierce struggle with the French Empire was the possession of India. Before he became First Consul, Napoleon had realized that India was the throne of Asia; that whoever should sit on that throne, master of the commerce of the East, of the richest and most natural market for the products of the West, and of the hardiest and most enlightened nations of the golden hemisphere, would be master of more than half the globe. But his prescience was not surer than the instinct of the British people. Vague and shadowy indeed were their dreams of empire, yet the presentiment of future greatness, based on the foothold they had already gained in Hindustan, seems always to have controlled the national policy. They knew as well as Napoleon that Malta and Egypt, to use his own phrase, were merely the outworks of their stronghold in the East; and that if those outworks fell into the hands of France, a great army of warlike Mahommedans, led by French generals, stiffened by a French army corps, and gathering impetus from the accession of every tribe it passed through, might march unopposed across the Indus. So, from first to last, the least threat against Egypt and Malta sufficed to awaken their apprehensions; and in their knowledge that India was the ultimate objective of all his schemes is to be found the explanation of the stubbornness with which they fought Napoleon. It is not to be denied that in thwarting the ambition of their mighty rival, or perhaps in furthering their own, the navy was the chief instrument; but in thrusting the French from Egypt, in adding Ceylon, Mauritius, and Cape Colony to the outworks, the army, small as it was then, compared with the great hosts of the Continent, did much both for the making and the security of the British Empire.

But the scope of the military operations of a maritime state is by no means limited to the capture of colonies, naval arsenals, and coaling-stations. Timely diversions, by attracting a large portion of the enemy's fighting strength on the mainland, may give valuable aid to the armies of an ally. The Peninsular war is a conspicuous example. According to Napoleon, the necessity of maintaining his grip on Spain deprived him of 180,000 good soldiers during the disastrous campaign of 1813; and those soldiers, who would have made Dresden a decisive instead of a barren victory, were held fast by Wellington. Again, it was the news of Vittoria that made it useless for the emperor to propose terms of peace, and so escape from the coils that strangled him at Leipzig.

Nor is the reinforcement supplied by a small army based upon the sea to be despised. In 1793 a British contingent under the duke of York formed part of the allied forces which, had the British Government forborne to interfere, would in all probability have captured Paris. Twenty-two years later, under wiser auspices, another contingent, although numbering no more than 30,000 men, took a decisive part in the war of nations, and the blunders of the older generation were more than repaired at Waterloo. Nevertheless, the strength of the amphibious power has been more effectively displayed than in the campaign of 1815. Intervention at the most critical period of a war has produced greater results than the provision of a contingent at the outset. In 1782 the disembarkation of a French army on the Virginia Peninsula established the independence of the United States; and in 1878, when the Russian invaders were already in sight of Constantinople, the arrival of the British fleet in the Dardanelles, following the mobilization of an expeditionary force, at once arrested their further progress. Had the British Cabinet of 1807 realized the preponderating strength which even a small army, if rightly used, draws from the command of the sea, the campaign of Eylau would in all probability have been as disastrous to Napoleon as that of Leipzig. The presence of 20,000 men at the great battle would have surely turned the scale in favour of the allies. Yet, although the men were available, although a few months later 27,000 were assembled in the Baltic for the coercion of Denmark, his Majesty's ministers, forgetful of Marlborough's glories, were so imbued with the idea that the British army was too insignificant to take part in a Continental war, that the opportunity was let slip. It is a sufficiently remarkable fact that the successive Governments of that era, although they realized very clearly that the first duty of the army was to support the operations and complete the triumph of the navy, never seemed to have grasped the principles which should have controlled its use when the command of the sea had been attained. The march of the Allies on Paris, in 1793, was brought to a standstill because the British Cabinet considered that the contingent would be better employed in besieging Dunkirk. After the failure of the expedition under Sir John Moore to achieve the impossible, and in conjunction with the Spaniards drive the French from the Peninsula, the ministry abandoned all idea of intervention on the main theatre, although, as we have seen, had such intervention been well-timed, it might easily have changed the current of events. It is true that when the main theatre is occupied by huge armies, as was the case during the whole of the Napoleonic conflict, the value of a comparatively small force, however sudden its appearance, is by no means easily realized. For instance, it would seem at first sight that a British contingent of 100,000 men would be almost lost amid the millions that would take part in the decisive conflicts of a European war. It is remembered, however, that with enormous masses of men the difficulties of supply are very great. Steam has done much to lighten them, and the numbers at the point of collision will be far greater than it was possible to assemble in the days of Napoleon. Nevertheless, the lines of communication, especially railways, will require more men to guard them than heretofore, for they are far more vulnerable. The longer, therefore, the lines of communication, the smaller the numbers on the field of battle. Moreover, the great hosts of the Continent, not only for convenience of supply, but for convenience of manœuvre, will deploy several armies on a broad front. At some one point, then, a reinforcement of even one or two army corps might turn the scale.

Weakness of allied armies.

The objections, however, to intervention of this character are numerous. Between allied armies, especially if one is far larger than the other, there is certain to be friction, as was the case in the Crimea; and the question of supply is not easily settled. If, however, the decisive point is near the coast, as in the campaign of Eylau, the army of the maritime power, possessing its own base, can render effective aid without embarrassment either to itself or its ally. But, under all other conditions, independent operations of a secondary nature are distinctly to be preferred. Such was clearly the opinion of the British ministries during the war with France. They recognized that by giving vitality and backbone to popular risings even a small army might create useful diversions. But their idea of a diversion was a series of isolated efforts, made at far distant points; and even so late as 1813, they were oblivious of the self-evident facts that for a diversion to be really effective it must be made in such strength as to constitute a serious threat, and that it should be directed against some vital point. Fortunately for Europe, Wellington foresaw that the permanent occupation of Portugal, and the presence of a British army in close proximity to the southern frontier of France, would be a menace which it would be impossible for Napoleon to disregard. Yet with what difficulty he induced the Government to adopt his views, and how lukewarm was their support, is exposed in the many volumes of his despatches. In all history there are few more glaring instances of incompetent statesmanship than the proposal of the Cabinet of 1813, at the moment Wellington was contemplating the campaign that was to expel the French from Spain, and was asking for more men, more money, and more material, to detach a large force in the vague hope of exciting a revolution in southern Italy. Whether the improvement in communications, as well as the increase in the size of armies, have not greatly weakened the value of diversions on the mainland, it is difficult to say. Railways may enable the defender to concentrate his forces so rapidly that even the landing may be opposed, and with the enormous numbers at his command he may well be able to spare a considerable force from the main theatre. It is possible to conceive that a small army, even if it completed its embarkation, might find itself shut up in an entrenched position by a force little larger than itself. If, however, the diversion were made at a crisis of the campaign, the sudden appearance of a new army might be decisive of the war. Otherwise, the army would probably do more good if it refrained from landing and confined itself to threats. So long as it was hidden by the horizon, it would be invested with the terrors of the unknown. The enemy's knowledge that at any moment a well-equipped force, supported by a powerful fleet, might suddenly descend upon some prosperous port or important arsenal, would compel him to maintain large garrisons along the whole seaboard. The strength of these garrisons, in all probability, would be much larger in the aggregate than the force which menaced them, and the latter would thus exercise a far greater disintegrating effect on the enemy's armed strength than by adding a few thousand men to the hosts of its ally. On theatres of war which are only thinly populated or half civilized, a descent from the sea might easily produce a complete change in the situation. The occupation of Plevna, in close proximity to the Russian line of communications and to the single bridge across the Danube, brought the Russian advance through Bulgaria to a sudden stop, and relieved all pressure on Turkey proper. The deadlock which ensued is suggestive. Let us suppose that the invaders' line of communications had been a railway, and Plevna situated near the coast. Supplied from the sea, with unlimited facilities for reinforcement, Osman's ring of earthworks would have been absolutely impregnable; and had the ring been pushed so far inland as to secure scope for offensive action, the Russians, in all human probability, would never have crossed the Balkans. It is perfectly possible, then, that if an army lands within reach of a precarious line of communications it may compel the enemy, although far superior in numbers, to renounce all enterprises against distant points.

Railways.

Railways in war are good servants, but bad masters. In some respects they are far superior to a network of high-roads. Two trains will supply the daily needs of 100,000 men several hundred miles distant from their base. But the road-bed is easily destroyed; the convoy system is impracticable, and the regular course of traffic is susceptible to the slightest threat. So, when railways become the principal factors, as when an army finds itself dependent on a long and exposed line, a powerful aggressive combination becomes a matter of the utmost difficulty. The whole attention of the commander will be given to the security of his supplies, and even if he is not thrown on the defensive by the enemy's activity, his liberty of action will be exceedingly circumscribed. The relative values of the different kinds of communications have a most important bearing on the art of war. A great waterway, such as the Nile, the Mississippi, the Danube, or the Ganges, is safer and surer than a railway. But railways are far more numerous than navigable rivers, and a series of parallel lines is thus a better means of supplying a large army. But neither railways nor waterways as lines of supply or of operation are to be compared with the sea. Before the war of 1870, for instance, a study of the French railway system enabled Moltke to forecast, with absolute accuracy, the direction of Napoleon's advance, the distribution of his forces, and the extent of front that they would occupy. In a war, therefore, between two Continental powers, the staff on either side would have no difficulty in determining the line of attack; the locality for concentration would be at once made clear; and as the carrying capacity of all railways is well known, the numbers that would be encountered at any one point along the front might be easily calculated. But if the enemy's army, supported by a powerful fleet, were to advance across blue water, the case would be very different. Its movements would be veiled in the most complete secrecy. It would be impossible to do more than guess at its objective. It might strike at any point along hundreds of miles of coast, or it might shift from one point to another, perhaps far distant, in absolute security; it could bewilder the enemy with feints, and cause him to disperse his forces over the whole sea-board. Surprise and freedom of movement are pre-eminently the weapons of the power that commands the sea. Witness the War of Secession. McClellan, in 1862, by the adroit transfer of 120,000 men down the reaches of Chesapeake to the Virginia Peninsula, had Richmond at his mercy. Grant in 1864, by continually changing his line of communication from one river to another, made more progress in a month than his predecessors had done in two years. Sherman's great march across Georgia would have been impossible had not a Federal fleet been ready to receive him when he reached the Atlantic; and, throughout the war, the knowledge that at any moment a vast fleet of transports might appear off any one of the ports on their enormous sea-board prevented the Confederates, notwithstanding that the garrisons were reduced to a most dangerous extent, from massing their full strength for a decisive effort.

The sea as a line of operation.

Amphibious power.

Importance of strategy.

The power of striking like "a bolt from the blue" is of the very greatest value in war. Surprise was the foundation of almost all the grand strategical combinations of the past, as it will be of those to come. The first thought and the last of the great general is to outwit his adversary, and to strike where he is least expected. And the measures he adopts to accomplish his purpose are not easily divined. What soldier in Europe anticipated Marlborough's march to the Danube and Blenheim field? What other brain besides Napoleon's dreamt of the passage of the Alps before Marengo? Was there a single general of Prussia before Jena who foresaw that the French would march north from the Bavarian frontier, uncovering the roads to the Rhine, and risking utter destruction in case of defeat? Who believed, in the early June of 1815, that an army 130,000 strong would dare to invade a country defended by two armies that mustered together over 200,000 unbeaten soldiers? To what Federal soldier did it occur, on the morning of Chancellorsville, that Lee, confronted by 90,000 Northerners, would detach the half of his own small force of 50,000 to attack his enemy in flank and rear? The very course which appeared to ordinary minds so beset by difficulties and dangers as to be outside the pale of practical strategy has, over and over again, been that which led to decisive victory; and if there is one lesson more valuable than another as regards national defence, it is that preparation cannot be too careful or precautions overdone. Overwhelming numbers, adequately trained, commanded, and equipped, are the only means of ensuring absolute security. But a numerical preponderance, either by land or sea, over all possible hostile combinations, is unattainable, and in default the only sound policy is to take timely and ample precautions against all enterprises which are even remotely possible. There is nothing more to be dreaded in war than the combined labours of a thoroughly well trained general staff, except the intellect and audacity of a great strategist. The ordinary mind, even if it does not shrink from great danger, sees no way of surmounting great difficulties; and any operation which involves both vast dangers and vast difficulties it scoffs at as chimerical. The heaven-born strategist, on the other hand, "takes no counsel of his fears." Knowing that success is seldom to be won without incurring risks, he is always greatly daring; and by the skill with which he overcomes all obstacles, and even uses them, as Hannibal and Napoleon did the Alps, and as some great captain of the future may use the sea, to further his purpose and surprise his adversary, he shows his superiority to the common herd. It is repeated *ad nauseam* that in consequence of the vastly improved means of transmitting information, surprise on a large scale is no longer to be feared. It is to be remembered, however, that the means of concentrating troops and ships are far speedier than of old; that false information can be far more readily distributed; and also, that if there is one thing more certain than another, it is that the great strategist, surprise being still the most deadly of all weapons, will devote the whole force of his intellect to the problem of bringing it about.

Nor is it to be disguised that amphibious power is a far more terrible weapon than even in the days when it crushed Napoleon. Commerce has increased by leaps and bounds, and it is no longer confined within territorial limits. The arteries vital to the existence of civilized communities stretch over every ocean. States which in 1800 rated their maritime traffic at a few hundred thousand pounds sterling, value it now at many millions. Others, whose flags, fifty years ago, were almost unknown on the high seas, possess to-day great fleets of merchantmen; and those who fifty years ago were self-dependent, rely in great part, for the maintenance of their prosperity, on their intercourse with distant continents. There is no great Power, and few small ones, to whom the loss of its sea-borne trade would be other than a most deadly blow; and there is no great Power that is not far more vulnerable than when Great Britain, single-handed, held her own against a European coalition. Colonies, commercial ports, dockyards, coaling-stations, are so many hostages to fortune. Year by year they become more numerous. Year by year, as commercial rivalry grows more acute, they become more intimately bound up with the prosperity and prestige of their mother-countries. And to what end? To exist as pledges of peace, *auspicia melioris œvi*, or to fall an easy prey to the Power that is supreme at sea and can strike hard on land?

Value of unprofessional troops.

Even the baldest and briefest discussion of the vast subject of war would be incomplete without some reference to the relative merits of professional and unprofessional soldiers. Voluntary service still holds its ground in the Anglo-Saxon states; and both the United Kingdom and America will have to a great extent to rely, in case of conflicts which tax all their resources, on troops who have neither the practice nor the discipline of their standing armies. What will be the value of these amateurs when pitted against regulars? Putting the question of *morale* aside, as leading us too far afield, it is clear that the individual amateur must depend upon his training. If, like the majority of the Boers, he is a good shot, a good scout, a good skirmisher, and, if mounted, a good horseman and horsemaster, he is undeniably a most useful soldier. But whether amateurs *en masse*, that is, when organized into battalions and brigades, are thoroughly trustworthy, depends on the quality of their officers. With good officers, and a certain amount of previous training, there is no reason why bodies of infantry, artillery, or mounted infantry, composed entirely of unprofessional soldiers, should not do excellent service in the field. Where they are likely to fail is in discipline; and it would appear that at the beginning of a campaign they are more liable to panic, less resolute in attack, less enduring under heavy losses and great hardships, and much slower in manœuvre than the professionals. To a certain extent this is inevitable; and it has a most important bearing on the value of the citizen soldier. for, as we have already seen, the beginning of a campaign is a most critical phase. In short, troops who are only half-trained or have been hastily raised may be a positive danger to the army to which they belong; and the shelter of stout earthworks is the only place for them. Yet the presence of a certain number of experienced fighting men in the ranks may make all the difference; and, in any case, it is probable that battalions composed of unprofessional soldiers, the free citizens of a free and prosperous state, are little if at all inferior, as fighting units, to battalions composed of conscripts. But it is to be understood that the men possess the qualifications referred to above, that the officers are accustomed to command and have a good practical knowledge of their duties in the field. A mob, however patriotic, carrying small-bore rifles is no more likely to hold its own to-day against well-led regulars than did the mob carrying pikes and flint-locks in the past. A small body of resolute civilians, well-armed and skilful marksmen, might easily on their own ground defeat the same number of trained soldiers, especially if the latter were badly led. But in a war of masses, the power of combination, of rapid and orderly movement, and of tactical manœuvring is bound to tell. (G. F. R. H.)

II. Naval Strategy and Tactics.

Strategy.

Since the publication of the article on naval strategy in the ninth edition of this work, the subject has been treated by Captain Mahan of the United States navy in his three great works—*The Influence of Sea Power upon History* (1890), *The Influence of Sea Power on the French Revolution and Empire* (1892), and *The Life of Nelson, the Embodiment of the Sea Power of Great Britain* (1897)—in such a masterly and exhaustive manner that his books have been translated into the principal European languages, and are acknowledged to have thrown such a light on the value of sea power as to cause the Great Powers of Europe to make efforts to obtain it, almost regardless of expense. Previously to the publication of Mahan's works there was a general idea that a strong navy was of considerable importance to a country with maritime interests, but until the appearance of his masterly analysis of the effects of "sea power" on the rise and fall of nations, it was not realized that the command of the sea had played such an all-powerful part in moulding the world's history. So far as Great Britain and the British Empire are concerned, there is now no shadow of doubt as to what their prosperity is founded on. It is her sea power, or command of the sea, or naval supremacy, or whatever term may be used to indicate that preponderance in fighting power at sea which enables the country possessing it to keep the warships of her enemies blockaded in their ports, whilst her own warships sweep the seas, and ensure the safety of her merchant vessels, and if necessary of her troopships to transport armies in safety to any point upon the coast-line of any part of the globe. This freedom of action on the ocean is of vital importance to the very existence of the British Empire, and consequently it is British policy to spend the country's last shilling on the maintenance of a naval supremacy not only unrivalled in itself, but greater than that of any probable combination of Powers.

Connexion of policy and strategy.

National policy and naval strategy have always been closely interwoven, and in the days before the invention of the electric telegraph centralized all information at the seat of government, and largely deprived officers in command of fleets of their powers of initiative, the issues of peace or war not infrequently hung upon the decisions of an admiral, who perhaps suddenly found himself in the position of being called upon to attack the forces of a nation with which his own country was not formally at war. Thus Rooke at Cadiz, Nelson at Copenhagen, and Codrington at Navarino, all had to initiate hostilities against Powers with which Great Britain was nominally at peace. In each of these cases the responsibility of taking action was fraught with momentous consequences, and men with less force of character, less self-confidence, and weaker nerves, would probably have shrunk from it. Codrington, who had been ordered to resist certain movements of Ibrahim Pasha—"even if necessary by the use of cannon shot"—had the mortification of hearing his brilliant and successful action characterized in a speech from the Throne as an "untoward event." The responsibility for the attack on the Danish fleet and fortifications at Copenhagen was nominally Sir Hyde Parker's, but it was (as all the world knows) really Nelson's; and notwithstanding that it was the most desperate battle that great admiral ever fought, attended as it was by risks and dangers (beyond the ordinary risks of battle) such as would have appalled a weaker man, Nelson too had to suffer the mortification of seeing this brilliant action treated with marked coolness and a complete lack of appreciation of its far-reaching consequences. Of Rooke at Cadiz (the third case mentioned above), it is needless to say more than that he was sent on the ambiguous—not to say illogical—mission of trying to coerce the sturdy Andalusians (with whom Great Britain was not at war) into espousing the cause of the Austrian nominee to the Spanish throne, instead of that of the Bourbon prince whom they had already accepted and declared for; and that not even the bombardment of their fair city of Cadiz was successful in gaining their love for the former, notwithstanding that he was supported by all the moral and physical forces of the Grand Alliance.

The above cases—though many others might be mentioned—are sufficient to show the close connexion between naval strategy and international politics; and although it is unlikely that in the present days of rapid communication admirals will ever again be vested with such extensive opportunities of taking the initiative as occurred in the past, it is always possible that the break-down of a telegraph cable, or the capture of a cruiser carrying despatches, may to some extent temporarily restore the old order. Though the China-Japanese and the Spanish-American wars have not taught us any startling lessons in modern naval strategy, they are nevertheless likely to have momentous consequences on the balance of naval power in the world, insomuch that they may be said to have given rise to two new navies. The United States ever since it became a nation has had a small navy, varying in strength according to circumstances, though never comparable to that of Great Britain or France; but since the war with Spain it has launched forth on an ambitious programme of naval construction which bids fair to place it in a few years' time in the front rank of the naval Powers of the world. Its riches and resources are practically unlimited, and with distant colonies to protect (the result of the afore-mentioned war) it is certain to maintain a most powerful navy. Young and vigorous Japan, too, having revolutionized everything in the country (including naval architecture) from the forms and methods of mediæval times to those of the present day, with a marvellous rapidity, is completing a naval programme which includes battleships and armoured cruisers of the first rank, and in such numbers that there can be little doubt she will in a few years hold the balance of naval power in the Far East: in any quarrels about China, Japan has to be reckoned with; and she will never again allow herself to be robbed of the fruits of her victories through the want of a powerful navy. Thus future naval strategists will have to take account of the possibility of the United States or Japan becoming important factors in any naval war which may affect their honour or their interests.

Changes in the balance of naval power.

One other Power demands special mention. Russia, by her gigantic efforts to increase her war navy, bids fair to rival her ally France, and to take second place amongst the navies of the world; and as her present fleet of warships is already out of all proportion to her mercantile marine, and her coasts are practically inviolable from serious invasion, it seems obvious that this great war-fleet can only be intended for attack, and not for defence; and it thus becomes something very like a menace to the interests of those nations which depend largely for their prosperity on sea-borne commerce. The seizure of Port Arthur, and the large increase in the Russian navy, are facts which must at any rate profoundly affect naval strategy in that region of the world which is known as the Far East.

The "fleet in being."

Some recent writers on naval strategy have laid down the axiom that "a fleet in being" (*i.e.*, an undefeated though possibly inferior fleet of an enemy) is a sufficient menace to prevent territorial attack by a Power possessing a superior fleet. As a general principle, no doubt, naval history shows that the undefeated fleet of an enemy which is in a position to threaten the communications of the would-be invader has been considered a sufficiently serious threat to prohibit the embarkation of troops and the prosecution of military operations over-sea. But the rule does not seem to be of universal application, as the threat of the British squadron (which very nearly caught him at sea) did not prevent Napoleon from invading Egypt; though the subsequent destruction of the ships that carried his army of invasion is held by some critics to show that the invasion of Egypt in the circumstances was an act of false strategy. Another instance where the threat of an undefeated fleet in being did not prevent the embarkation of troops and the invasion of territory, was seen in the case of the British and French armies being transported across the Black Sea and landed on the coast of the Crimea, while a powerful Russian fleet lay in Sebastopol harbour, and was certainly in a position to cause serious opposition—if not absolute disaster—to the troops of their enemies while in the act of disembarkation, had that fleet been handled with skill and boldness. It is also thought by some historians that if the Russian fleet had attacked the fleets of the Allies at sea, hampered as they were by transports, and the French warships so crowded with troops as to be scarcely capable of fighting their guns, terrible havoc would have been made amongst them, and in all probability the invasion prevented.

In criticizing naval strategy it is not uncommon to judge entirely by events, and to come to the conclusion that if the general result of the combinations turns out to be successful, the strategy must necessarily have been sound, and *vice versâ*. But when it is remembered how largely the element of chance enters into all operations at sea, mainly on account of the variability of the weather, it must be obvious that if we only judge by results we shall not infrequently be in error, as a fog or a gale of wind (impossible to foresee) may be the pivot upon which success or failure turns.

If naval strategy has been modified by recent inventions, and by the great revolution which has taken place in naval war material, including the motive power of the ships themselves, there can be no doubt that the same causes have had a still wider effect on naval tactics. Strategy has been curtly described as the art of concentrating an effective fighting force, complete in all details, at a given place at a given time; and tactics as the art of using it to the best effect when there. A complete historical treatment of naval tactics is not necessary here. Suffice it to say that in the times called "ancient," and all through the period called the Middle Ages, when the Mediterranean Sea was the cockpit of the world, fighting-ships were mainly dependent on oars for their mobility, but as the area of civilization (and consequently of naval warfare) came to be extended, and all the great oceans were traversed by the ships of various nations seeking new territories and wider commerce, oars were found to be inadequate to propel ships of ever-increasing dimensions on longer voyages, and they were gradually displaced by sails. During the 17th and 18th centuries, and half of the 19th century, sails may be said to have been the sole method of locomotion for fighting-vessels of considerable size and sea-going capabilities; and all the great sea battles of modern times have been fought under sail or at anchor. The middle of the 19th century saw a great revolution in the art of naval warfare. This revolution still continues with unabated vigour, and he would be a bold prophet who would venture to predict what the state of affairs will be by the middle of the 20th century; but, for the present, steam remains the sole motive power of fighting-ships. Electricity, or some other force, may possibly take its place; but this is a mere speculative excursion into the unknown.

Tactics.

When the wind and sails constituted the motive power, the art of seamanship, in its generally accepted sense, was the main factor in naval warfare. The art of gunnery came next, and ere the close of the sail era it had assumed a most important position. In fact, its special votaries claimed for it first place. Now no one (save perhaps an enthusiastic torpedoist) would deny to gunnery the leading place—though both of these are dependent on and governed by the art of manœuvring ships under steam. In brief, modern naval tactics consist in the art of so manœuvring a ship or squadron as to bring the greatest amount of accurate gun and torpedo fire to bear upon an enemy. It is true that there still exists a small though diminishing school of naval officers who have faith in "ramming tactics"; and the terribly destructive effects of the ram in those cases where it has been accidentally brought into operation are quoted in support of the deliberate use of this weapon. Many practical seamen, however, have come to the conclusion that, considering the speed of modern ships, the ram will not be deliberately used in action, except perhaps to give the *coup de grâce* to a disabled enemy; but even this would appear to be the wanton destruction of a ship which might become a valuable prize, and a barbarous sacrifice of human life. Yet should a disabled enemy refuse to strike his colours, it might become necessary to put an end to him in this manner. It seems probable that when ramming does take place in action, it will more often be accidental than intentional. Two ships of from ten to fifteen thousand tons meeting end on at a speed of 28 knots (assuming the speed of each to be 14) would certainly produce mutual destruction, with loss of the lives of almost all on board; so that it is difficult to believe that any two men who still retain their reason would deliberately adopt such a suicidal method of fighting, even if it be possible to steer two large ships at high speed with such accuracy as to cause a direct end-on collision—a point which many practical seamen doubt. On the other hand, a ship striking another on the broadside, or at any angle approaching a right angle, would probably cause the destruction of the latter, though with grave injury to herself; but in order to place a ship in a position to strike such a blow (both ships being under way) she would herself have to assume a very critical situation; that is to say, she would have to expose her broadside, or in other words, she would have to place herself almost as much across the assumed path of her adversary as the adversary is across hers; in which position the miscalculation of a few seconds in time, a knot or two in speed, or even a small touch of the helm of either ship at the last moment, would turn the would-be rammer into the victim. It seems probable, therefore, that if ramming takes place in action, it will be more frequently by accident than design. Much has been made by the advocates of "ramming tactics" of the incident at the battle of Lissa, where the Austrian wooden ship *Ferdinand Max* rammed and sank the Italian ironclad *Re d' Italia;* but it has been stated on the best authority that the gallant Tegethoff himself disclaimed any design in the matter, further than that he suddenly saw through the smoke a grey object ahead of the *Ferdinand Max*, which he took to be an enemy's ship; that he ordered the engines of the *Ferdinand Max* to go full speed ahead, and the ship to be steered for the grey object; and that he then found he had rammed and sunk the *Re d' Italia.* Other cases of ramming, such as the *Vanguard* and *Iron Duke*, where the *Vanguard* was sunk; *Victoria* and *Camperdown*, where the *Victoria* was sunk, have been pointed to as illustrating the deadly effects of the ram, even at low speeds; but as a matter of fact nobody questions its deadly effect. What is doubted is the practical application of it without the extreme probability of self-destruction, and this mainly for the reasons given.

The importance of gunnery.

Ramming in action.

It is so impossible to simulate active war tactics at peace manœuvres with modern battleships, and the actual experiences of purely naval battles since the introduction of steam have been of such a very limited nature, with generally such one-sided results, that there may be said to be practically no established facts on which to found theories of modern naval tactics. This, however, has not prevented the admirals of the various nations from founding theories based on such knowledge of the manœuvring powers of modern warships as it has been possible to gain at peace manœuvres. During the period that fleets of warships were worked and fought under sail, all tactics were necessarily dependent on the wind. Ships could not move freely in all directions; if they wanted to get to windward, they had to do so by making a series of tacks, or zigzags, a slow and laborious process. Thus all commanders of squadrons on sighting an enemy manœuvred so as to get the "weather gauge"; but winds being frequently variable and unsteady, it not uncommonly happened that skill was frustrated by chance, and a sudden shift of wind might at any moment alter the whole aspect of a tactical problem, and give to the less skilful combatant an advantage which his adversary had fairly earned and deserved. All this has been completely changed by the introduction of steam: ships and squadrons being now independent of the wind, a discussion of the tactics of sailing days can only be of historical interest; though the guiding principle of seeking to concentrate an overwhelming force on a portion of the adversary's armaments, with the view of crushing that portion before succour can be afforded to it by its friends, remains the same with steam as it was with sails, and is common to both land and sea warfare.

Theories based on manœuvres.

It is generally assumed that in view of the large number of rapid-firing guns carried by modern warships, it will be almost—if not quite—impossible to make signals during an action; and if this is the case it becomes obvious that when once a battle has commenced, the admiral in command will practically lose control over the movements of all the ships of his squadron save his own flagship. There is, however, one formation which will enable him at any rate to keep his ships together, and prevent them from becoming a danger to each other, and this is the formation known as "single line ahead"—a very simple formation, which amounts practically to "follow my leader"; and it may be added that it is a formation in which a battle might be fought to the bitter end between two steam squadrons, if both sides accepted battle; but for a general chase, or a general retreat, it would be inadmissible—as in one case the leading ships, and in the other case the rearmost ships would be sacrificed. It is generally admitted that the numerous complicated tactical manœuvres which are practised in peace time by all the Powers possessing war navies are only intended for exercise, and to teach officers, by practical experience, what can be done with their ships in relation to speed, time, distance, and turning power, but that such manœuvres would never be attempted in battle. The Spanish-American war was (by sea) a contest so unequal that it failed to solve any of the numerous problems of modern naval tactics; and it seems scarcely possible that these can be solved until a *bonâ fide* maritime war shall have taken place between two first-class Powers.

Tactical value of torpedoes.

It remains to mention one more weapon, an instrument of unknown power, viz., the locomotive torpedo, commonly known as the "Whitehead." What effect this weapon will have upon the naval tactics of the future it is impossible to say. When first it was introduced as part of the equipment of warships, its special votaries claimed for it that it would cause a complete revolution in naval tactics; in short, that it would supersede the gun as the principal weapon of all warships. Its destructive effects (*when* it hits and explodes) are so terrible that the claim of the torpedoist seemed at first sight to be plausible. The artillerist, however, never admitted the claim—in fact, treated it with ridicule, and pointed out that the torpedo, moving in a far denser medium, a weapon of less accuracy, much shorter range, more dangerous to handle, costing far more money for each shot, and the supply being necessarily much more limited, could never become a serious rival to modern artillery, the power of which had lately been so greatly improved in all the important points of accuracy, penetration, range, rapidity of loading, ease of training, and absence of smoke to obstruct the view; whereas with the recent addition of the gyroscope—which has undoubtedly improved its accuracy—the torpedo appears for the present to have reached the limits of improvement. In short, the tactical value of torpedoes is not so highly estimated now as it was a few years ago. Its legitimate place appears to be in small vessels especially built for the purpose. In the latest designs for battleships the British Admiralty have wisely discarded all fittings above water for discharging torpedoes, and confined the torpedo equipment to four submerged broadside tubes only—a position in which this delicate and somewhat erratic weapon may at any rate be manipulated with reasonable safety to those using it; but it remains for future naval battles to prove whether a locomotive torpedo, when used from battleships or large cruisers, will produce a governing, or indeed any decided influence on naval tactics. There is another locomotive torpedo in use, known as the "Brennan"; but as it is unsuitable for use in ships, and its proper place appears to be the guarding of comparatively narrow channels, it does not claim notice under the heading of naval tactics.

Submarine boats.

The French constructors, with their well-known ingenuity, perseverance, and special genius for mechanical invention, have for some years past been devoting much attention to the perfecting of submarine boats, and should their efforts be crowned with success, they hope thereby to adjust the balance of naval power as between France and Great Britain, which is now considerably in favour of the latter, and perhaps sweep her battleships from the sea, and thus pave the way for an invasion of England—a vision of conquest and glory which appears to possess a special and absorbing fascination for many French soldiers, sailors, and statesmen. The British Admiralty, after watching for some years the development of the submarines, built half a dozen in 1902, more for experimental purposes, it would appear, than from any firm belief in their utility as practical engines of warfare. Some were also built for the American navy. The fact is, that no maritime Power can afford to ignore any invention of the sort which offers even a remote prospect of success, lest her rivals steal a march upon her, as the Prussians did upon the Austrians with the needle-gun, and pick a quarrel with her before she is ready. Least of all can Great Britain afford to do so, as her very existence depends upon her maritime supremacy.

No seaman would venture to predict that submarine navigation would never become a practical factor in naval warfare, though it is certainly not the general opinion that it has become so at present. The French have been working most assiduously at the problem, and they claim (1902) to have achieved considerable success (in mimic warfare) by torpedoing some of their own battleships. The conditions, however, do not appear to have much relation to those which exist in actual warfare. The limitations of the submarine, both as to navigability and radius of action, are considerable. Some of them may, of course, be removed in process of time; and with each improvement the submarine must become more formidable. One of the greatest difficulties which stand in the way of the development of the submarine appears to be the lack of stability, and specially of longitudinal stability, to which all totally immersed bodies are necessarily subject.

Wireless telegraphy.

Wireless telegraphy is one of the latest inventions of science which seems destined to have some effects on naval tactics, and possibly even on strategy. It is not possible—with our present experience—to assign a limit to the effect which it may have, but it opens up a vision of such a revolution in the hitherto recognized methods of communication at sea, promising as it does to put a power into the hands of an admiral to communicate with distant ships and squadrons which he did not previously possess, that it cannot fail to have far-reaching consequences, more especially as we may reasonably look for improvement in an art of such recent birth. (C. C. P. F.)

War, Laws of.—The law of war does not apply to all armed conflicts, but only to such conflicts as, by the usage of states, constitute war. War exists when the organized armed forces of one state are opposed to the organized armed forces of another state. War also exists within the bounds of a single state when organized armed forces, of sufficient power to make the issue doubtful, place themselves in opposition to the armed forces of

Civil war as distinguished from rebellion.

the existing government. If the disaffected forces are in a state of flagrant inferiority in comparison with those of the existing government, there is not a state of war but of rebellion. The combatants in civil war are entitled to treatment in accordance with the law of war. Rebels, as outlaws, have no rights. In the South African campaign (1899–1902) the question arose whether the manifest inferiority of the Boer forces, the possession by the British forces of the seats of government, and their practical occupation of the whole country, did not put an end to the state of war and constitute the Boer fighting forces rebels against a new existing government which had proclaimed annexation of the conquered states and was obviously in a position to retain its conquest. The action of the British commanders is a precedent in favour of the view that the fighting forces of an invaded state are entitled to belligerent rights, though in a state of hopeless inferiority, so long as they remain in the field in organized bands. In this, as in many cases which have formed international usage, the danger of reprisals more than the logic of principles has dictated a different line of conduct from that which the strict principles of law suggested. A somewhat similar, but more complicated situation, arose out of the cession by Spain to the United States of the Philippine Islands. The insurgents being in possession of them at the time, Spain ceded what she did not in fact possess. Thus it has been contended that the position of the insurgents became that of belligerents defending their country against conquest by invading forces.

Neutral interest.

Wars have been classed in different ways—wars of intervention, wars of conquest, wars of defence, wars of independence, just wars, unjust wars, and so on—but the law of war applies to them all without distinction. States do not sit as judges over each other, but treat war, subject to their own interest, as a fact. Interest, however, with the increasing development of international relations is becoming a more important factor in the determination of the attitude of the neutral onlooker (see NEUTRALITY).

War with barbarous peoples.

In the Chino-Japanese war the Japanese had to decide whether the Chinese were entitled to treatment under the European law of war. Japan acceded to the Geneva Convention (see below) in 1886, and to the Declaration of Paris (see below) in 1887. China was a party to neither, and observed the provisions of neither. Japan, nevertheless, as related by her learned judicial advisers, Professors Ariga and Takahashi, observed towards the Chinese forces, combatant and non-combatant, all the rules of European International Law without resorting to the reprisals to which Chinese barbarities provoked her.

Neutral position towards insurgents.

The position of neutral governments towards insurgent forces is always a delicate one. If they are not recognized as belligerents by the state against which they are arrayed, the state in question theoretically accepts responsibility for the consequences of their acts in respect of neutral states. A neutral state may be satisfied with this responsibility, or it may recognize the belligerent character of the insurgents. If it does not, however, do so, the insurgent forces cannot exercise rights of war against neutral property without exposing themselves to treatment as outlaws and pirates. A case of such treatment occurred in September 1902 in connexion with a pending revolution in Hayti, a German cruiser, the *Panther*, having treated an insurgent gunboat, the *Crête-à-Pierrot*, as a pirate vessel,[1] and sunk her for having stopped and confiscated arms and ammunition among the cargo of the German steamer *Markomannia* on the ground of their being contraband destined for the armed forces of the existing Haytian Government. The *Crête-à-Pierrot* had for some years formed part of the Haytian navy, and was commanded by Admiral Killick, who had been an admiral of that navy. There had been no recognition of the belligerency of the insurgents. No state seems to have made any observations on the incident, which may be taken to be in accordance with current international usage.

British recognition of the Confederates.

A well-known instance of a neutral government recognizing insurgent forces as belligerents, in spite of the denial of that character to them by the state against which they are carrying on hostilities, occurred in the North American civil war. The right asserted by Great Britain to recognize the belligerency of the Confederate forces was based on the contention that British commercial interests were very largely affected by the blockade of the Southern ports. It is agreed, however, among international jurists that, where the interests of neighbouring states are not affected, the recognition of an insurgent's belligerency is needless interference.[2]

Effect of recognition of belligerency.

The recognition of belligerency does not entail recognition of the belligerent as a sovereign state. The recognition of belligerency goes no farther than its immediate purpose. The belligerent armies are lawful combatants, not bandits; supplies taken from invaded territory are requisitions, not robbery. The belligerent ships of war are lawful cruisers, not pirates; and their captures, made in accordance with maritime law, are good prize; and their blockades if effectual, must be respected by neutrals. But this does not suffice to invest the belligerent with the attributes of independent sovereignty for such objects as negotiation of treaties, and the accrediting of diplomatic and consular agents. This was the attitude of Great Britain and France towards the Confederates in the American civil war.

The position of a vassal state or a colony carrying on foreign war without the consent of the suzerain or parent state might involve still more complicated issues.[3]

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[1] *The Times*, 9th September 1902.

[2] It is also agreed that, as the existence of belligerency imposes burdens and liabilities upon neutral subjects, a state engaged in civil war has no right, in endeavouring to effect its warlike objects, to employ measures against foreign vessels, which, though sanctioned in time of peace, are not recognized in time of war. In other words, it cannot enjoy at one and the same moment the rights of both peace and war. Thus, in 1861, when the Government of New Grenada, during a civil war, announced that certain ports would be closed, not by blockade, but by order, Lord John Russell said, "That it was perfectly competent to the government of a country in a state of tranquillity to say which ports should be open to trade, and which should be closed. But in the event of insurrection or civil war in that country, it was not competent for its government to close ports which were *de facto* in the hands of the insurgents, and that such a proceeding would be an invasion of international law relating to blockade." (*Hansard*, clxiii., 1846). Subsequently the Government of the United States proposed to adopt the same measure against the ports of the Southern States, upon which Lord John Russell wrote to Lord Lyons that "Her Majesty's Government entirely concur with the French Government in the opinion that a decree closing the Southern ports would be entirely illegal, and would be an evasion of that recognized maxim of the law of nations that the ports of a belligerent can only be closed by an effective blockade." (*State Papers*, North America, No. 1, 1862.) In neither case was the order carried out. When in 1885 the President of Colombia, during the existence of civil war, declared several ports to be closed without instituting a blockade, Mr Bayard, Secretary of State of the United States, in a despatch of 24th April of that year, fully acknowledged the principle of this contention by refusing to acknowledge the closure.

[3] In the Servo-Bulgarian war of 1885 the Sultan, though suzerain of Bulgaria, was unmoved by the invasion of his vassal's dominions.

Regular forces and civilians.

Civilized warfare, the text-books tell us, is confined, as far as possible, to disablement of the armed forces of the enemy; otherwise war would continue till one of the parties was exterminated. "It is with good reason," observes Vattel, "that this practice has grown into a custom with the nations of Europe, at least with those that keep up regular standing armies or bodies of militia. The troops alone carry on war, while the rest of the nation remain in peace" (*Law of Nations*, iii. 226). Modern notions of patriotism do not, however, view this total and unconditional abstention of the civilian population as any longer possible. They have found, to some extent, expression in the following Articles of The Hague War-Regulations:[1]—

> "Art. 1. The laws, rights, and duties of war apply not only to armies, but also to militia and volunteer corps fulfilling the following conditions: (*a*) To be commanded by a person responsible for his subordinates; (*b*) to have a fixed distinctive emblem recognizable at a distance; (*c*) to carry arms openly; and (*d*) to conduct their operations in accordance with the laws and customs of war. In countries where militia or volunteer corps constitute the army, or form part of it, they are included under the denomination 'army.'
>
> "Art. 2. The population of a territory which has not been occupied, who, on the enemy's approach, spontaneously take up arms to resist the invading troops without having time to organize themselves in accordance with Article 1, shall be regarded as belligerent if they respect the laws and customs of war."[2]

By these provisions, irregular combatants whom both the Government of the United States in the American civil war, and the German Government in the Franco-German war refused to regard as legitimate belligerents, are now made legally so.[3] It may be contended that the second Article covers the irregularities of the Boer Army.

Enemy property on invaded territory.

Connected with the position of private persons in time of war is that of their property in invaded territory, a subject which has often been misunderstood. Assertions as to its immunity from capture in warfare on land have been made which are historically inaccurate and are not borne out by contemporary usage. No doubt contemporary usage is an improvement on older usage. An invading army, before the practice of war became more refined, lived by foraging and pillage in the invaded country; pillage, in fact, being one of the inducements held out to the adventurers who formed part of the fighting forces either as officers or as common soldiers, and this continued down to comparatively recent times. Attenuations followed from the rise of standing and regular armies, and the consequent more marked distinction between soldier and civilian. They have now taken the form of systematic requisitions and contributions, the confining of the right of levying these to generals and commanders-in-chief, the institution of quittances or bills drawn by the belligerent invader on the invaded power and handed in payment to the private persons whose movable belongings have been appropriated or used, and of war indemnities. These are methods of lessening the hardships of war as regards the private property on land of the subjects of belligerent states. Their object and effect have by no means been to arrive at immunity, but to develop an organized system by which damage and losses to individuals, whom the fortune of war has brought into immediate contact with the enemy, are spread over the whole community. There is thus no immunity of private property in warfare on land, and The Hague War-Regulations, far from declaring the contrary, have ratified the right of appropriation of private property in the following Article:—

> "Neither requisitions in kind nor services can be demanded from communes or inhabitants *except for the necessities of the army of occupation.* They must be in proportion to the resources of the country, and of such a nature as not to involve the population in the obligation of taking part in military operations against their country.
>
> "These requisitions and services shall only be demanded on the authority of the Commander in the locality occupied.
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> "The contributions in kind shall, *as far as possible*, be paid for in ready money; *if not, their receipt shall be acknowledged*" (Article 52).

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[1] To distinguish between the three Conventions adopted at the Peace Conference at The Hague, all of which bear the same date, we shall refer to the Convention described as "for the pacific settlement of international disputes" as "The Hague Arbitration Convention," to that described as "with respect to the laws and customs of war by land" as "The Hague War Convention," the regulations provided for therein as "The Hague War-Regulations," and to that "for adapting to maritime warfare the principles of the Geneva Convention of 22nd August 1864" as "The Hague (Red Cross) Maritime Convention."

[2] The preamble of the Convention refers specially to Articles 1 and 2 in the following terms:—"In the view of the High Contracting Parties, these provisions, the wording of which has been inspired by the desire to diminish the evils of war so far as military necessities permit, are destined to serve as general rules of conduct for belligerents in their relations with each other and with populations;

"It has not, however, been possible to agree forthwith on provisions embracing all the circumstances which occur in practice;

"On the other hand, it could not be intended by the High Contracting Parties that the cases not provided for should, for want of a written provision, be left to the arbitrary judgment of the military commanders;

"Until a more complete code of the laws of war is issued, the High Contracting Parties think it right to declare that in cases not included in the Regulations adopted by them, populations and belligerents remain under the protection and empire of the principles of international law, as they result from the usages established between civilized nations, from the laws of humanity, and the requirements of the public conscience;

"They declare that it is in this sense especially that Articles 1 and 2 of the regulations adopted must be understood."

[3] The instructions for the government of armies of the United States in the field, issued in 1863, provided:—

> "Men or squads of men who commit hostilities, whether by fighting or inroads for destruction or plunder, or by raids of any kind, without commission, without being part and portion of the organized hostile army, and without sharing continuously in the war, but who do so with intermitting returns to their homes and avocation, or with the occasional assumption of the semblance of peaceful pursuits, divesting themselves of the character or appearance of soldiers—such men or squads of men are not public enemies, and therefore, if captured, are not entitled to the privileges of prisoners of war, but shall be treated summarily as highway robbers or pirates."

Germany seven years later declined to recognize the irregular bands of Franc-tireurs unless each individual member of them had been personally called out by legal authority, and wore a uniform or badge, irremovable and sufficient to distinguish him at a distance. The older publicists were, on the whole, strongly opposed to the legalization of irregular troops. Halleck settles the question in a summary way by calling those who engage in partisan warfare, robbers and murderers; and declaring that when captured they are to be treated as criminals (*International Law*, chap. xviii. s. 8). It is easy to understand the unfavourable opinion of partisan bands usually expressed by the military authorities when the enormous power for damage of modern arms is considered. At the Brussels Conference of 1874 the representatives of the great military Powers of the Continent naturally desired to keep spontaneous movements within the narrowest possible bounds, while the delegates from the secondary states, who have to rely for their defence chiefly upon the patriotism of their people, endeavoured to widen the right of resistance to an invader. Finally the Conference adopted the provisions which were later formally recognized at The Hague Conference (see *British State Papers Miscellaneous*, No. 1, 1875, pp. 252–257). It is noteworthy that both at the Brussels and The Hague Conferences, the British delegate ranged himself on the side of the smaller states in favour of the recognition of guerilla bands. At The Hague Conference Sir John Ardagh gave notice of his intention to propose an additional Article, to the effect that nothing in the Regulations should "be considered as tending to diminish or suppress the right which belongs to the population of an invaded country patriotically to oppose the most energetic resistance by every legitimate means." The upshot of this notice was to cause the insertion of a proviso in the preamble of the Convention denying the right of military commanders to act according to their own arbitrary judgment (*Parliamentary Papers*, No. 1, 1899, c. 9534).

In another Article provision, moreover, is made for the utilization of property in kind belonging to private persons:—

> "An army of occupation can only take possession of the cash, funds, and property liable to requisition belonging strictly to the state, depôts of arms, means of transport, stores and supplies, and, generally, all movable property of the state which may be used for military operations.
>
> "Railway plant, land telegraphs, telephones, steamers, and other ships, apart from cases governed by maritime law, as well as depôts of arms, and, generally, all kinds of war material, *even though belonging to companies or to private persons*, are likewise material which may serve for military operations, but they must be restored at the conclusion of peace, and indemnities paid for them" (Article 53).

And utilizable neutral rolling-stock is not excepted, Article 54 only providing that the

> "plant of railways coming from neutral states, whether the property of those states, or of companies, or of private persons, shall be sent back to them as soon as possible."

Enemy property at sea.

Enemy property at sea is subject to different rules from those which govern it on land. It is liable to capture and confiscation wherever found on the high seas or in enemy waters. The United States has made strenuous efforts to get this rule of maritime warfare altered, and immunity from capture accepted as the law of the sea. It has even made this a condition of its accession to the Declaration of Paris (see NEUTRALITY). But thus far other Powers have shown no disposition to agree to any alteration. At The Hague Conference the United States raised the question again, but it was not taken into consideration, though somewhat vaguely reserved for a future conference. And, in fact, the considerations which have led mankind to systematize the practice of war in regard to private property on land do not arise in the same form in connexion with private property at sea. Here there is no question of seizing the live-stock, or the bedding, or the food, or the utensils of the private citizen. If ship and cargo are captured, it may be hard upon the merchant, but such captures do not directly deprive him of the necessaries of life. Yet, as in the case of war on land, its hardships have been attenuated, and progress has been made by developing a more systematic procedure of capture of private property at sea. Thus exemption from capture is now allowed by belligerents to enemy merchant ships which, at the outbreak of war, are on the way to one of their ports, and they also allow enemy merchantmen in their ports at its outbreak a certain time to leave them. A somewhat similar practice exists as regards pursuit of merchant ships which happen to be in a neutral port at the same time with an enemy cruiser. Lastly, there has grown up, on grounds similar to those which have led to the indulgence shown to private property on land, a now generally recognized immunity from capture of small vessels engaged in the coast fisheries, provided they are in no wise made to serve the purposes of war. This has all been done with the object of making the operations of war systematic, and enabling the private citizen to estimate his risks and take the necessary precautions to avoid capture, and of restricting acts of war to the purpose of bringing it to a speedy conclusion.

We have seen that the only immunity of private property yet known to the laws of war is a limited one at sea. War, by its very nature, prevents the growth of any such immunity. The tendency in war on land has been to spread its effects over the whole community, to keep a faithful record on both sides of all confiscations, appropriations, and services enforced against private citizens; beyond this, protection has not yet been extended. There is good reason for this. The object of each belligerent being to break the enemy's power and force him to sue for peace, it may not be enough to defeat him in the open field; it may be necessary to prevent him from repairing his loss both in men and in the munitions of war. This may imply crippling his material resources, trade, and manufactures. It has been contended that "to capture at sea raw materials used in the manufacturing industry of a belligerent state, or products on the sale of which its prosperity, and therefore its taxable sources depend, is necessarily one of the objects, and one of the least cruel, which the belligerents pursue. To capture the merchant vessels which carry these goods, and even to keep the seamen navigating them prisoners, is to prevent the employment of the ships by the enemy as transports or cruisers, and the repairing from among the seamen of the mercantile marine of losses of men in the official navy."[1]

The question of reform of the existing practice would naturally be viewed in different countries according to their respective interests. The United States has obviously an interest in the exemption of its merchant vessels and cargoes from capture, a small official navy being sufficient for the assertion of its ascendency on the American continent. It may also be presumed to be in the interest of Italy, who, in a treaty with the United States in 1871, provided for mutual recognition of the exemption.

In the Austro-Prussian war of 1866 the principle of inviolability was adhered to by both parties. Germany proclaimed the same principle in 1878, but afterwards abandoned it.

Whether it is expedient for Great Britain at the present day to agree to the immunity of private property at sea from capture, must be dictated by the circumstances of the particular war in which she engages. It is quite conceivable that different considerations would weigh with her in a war with the United States from those which would arise in a war with France or Germany. In the case of the United States it might be in the interest of both parties to localize the operations of war, and to interfere as little as possible, perhaps for the joint exclusion of neutral vessels, with the traffic across the Atlantic. In the case of a war with France or Germany, Great Britain might consider that the closing of the high sea to all traffic by the merchantmen of the enemy would be very much in her own interest.

Enemy subjects—their property on hostile territory.

The converse subject of the treatment of enemy subjects who remain in the country of the other belligerent also was not dealt with at The Hague. British practice in this matter has always been indulgent, the protection to the persons and property of non-combatant enemies on British soil dating back to Magna Charta (s. 48), and this is still the law of England. The practice on the continent of Europe varies according to circumstances, to which no doubt, in the event of the invasion of Great Britain, British practice would also have to adapt itself.

Prisoners of war.

The Hague War-Regulations deal fully with the treatment of prisoners, and though they add nothing to existing practice, such treatment is no longer in the discretion of the signatory Powers, but is binding on them. They provide as follows:—

> Prisoners of war are in the power of the hostile government, but not in that of the individuals or corps who captured them. They must be humanely treated. All their personal belongings, except arms, horses, and military papers, remain their property (Article 4). Prisoners of war may be interned in a town, fortress, camp, or any other locality, and bound not to go beyond certain fixed limits; but they can only be confined as an indispensable measure of safety (Article 5). The state may utilize the labour of

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[1] Barclay, "Proposed Immunity of Private Property at Sea from Capture by Enemy," *Law Quarterly Review*, January 1900.

prisoners of war according to their rank and aptitude. Their tasks shall not be excessive, and shall have nothing to do with the military operations. Prisoners may be authorized to work for the public service, for private persons, or on their own account. Work done for the state shall be paid for according to the tariffs in force for soldiers of the national army employed on similar tasks. When the work is for other branches of the public service or for private persons, the conditions shall be settled in agreement with the military authorities. The wages of the prisoners shall go towards improving their position, and the balance shall be paid them at the time of their release, after deducting the cost of their maintenance (Article 6). The government into whose hands prisoners of war have fallen is bound to maintain them. Failing a special agreement between the belligerents, prisoners of war shall be treated, as regards food, quarters, and clothing, on the same footing as the troops of the government which has captured them (Article 7). Prisoners of war shall be subject to the laws, regulations, and orders in force in the army of the state into whose hands they have fallen. Any act of insubordination warrants the adoption, as regards them, of such measures of severity as may be necessary. Escaped prisoners, recaptured before they have succeeded in rejoining their army, or before quitting the territory occupied by the army that captured them, are liable to disciplinary punishment. Prisoners who, after succeeding in escaping, are again taken prisoners, are not liable to any punishment for the previous flight (Article 8). Every prisoner of war, if questioned, is bound to declare his true name and rank, and if he disregards this rule, he is liable to a curtailment of the advantages accorded to the prisoners of war of his class (Article 9). Prisoners of war may be set at liberty on parole if the laws of their country authorize it, and, in such a case, they are bound, on their personal honour, scrupulously to fulfil, both as regards their own government and the government by whom they were made prisoners, the engagements they have contracted. In such cases, their own government shall not require of nor accept from them any service incompatible with the parole given (Article 10). A prisoner of war cannot be forced to accept his liberty on parole; similarly the hostile government is not obliged to assent to the prisoner's request to be set at liberty on parole (Article 11). Any prisoner of war who is liberated on parole and recaptured, bearing arms against the government to whom he had pledged his honour or against the allies of that government, forfeits his right to be treated as a prisoner of war, and can be brought before the courts (Article 12).

Journalists.

An interesting addition assimilates individuals who follow an army without directly belonging to it, such as newspaper correspondents and reporters, sutlers, contractors, who fall into the enemy's hands, to prisoners of war, provided they can produce a certificate from the military authorities of the army they were accompanying.

Information office as to prisoners.

A new departure is made by a provision in the Regulations providing for the institution of a bureau for information relative to prisoners of war. This is to be created at the commencement of hostilities, in each of the belligerent states and, when necessary, in the neutral countries on whose territory belligerents have been received. It is intended to answer all inquiries about prisoners of war, and is to be furnished by the various services concerned with all the necessary information to enable it to keep an individual return for each prisoner of war. It is to be kept informed of internments and changes, as well as of admissions into hospital and deaths. It is also the duty of the information bureau to receive and collect all objects of personal use, valuables, letters, &c., found on the battlefields or left by prisoners who have died in hospital or ambulance, and to transmit them to those interested. It is, moreover, to have the privilege of free postage. Letters, money orders, and valuables, as well as postal parcels destined for the prisoners of war or despatched by them, are to be free of all postal duties, both in the countries of origin and destination, as well as in those they pass through. Gifts and relief in kind for prisoners of war are to be admitted free of all duties of entry and others, as well as of payments for carriage by the government railways.

Relief societies.

Furthermore, relief societies for prisoners of war, regularly constituted with the object of charity, are to receive every facility, within the bounds of military requirements and administrative regulations, for the effective accomplishment of their task. Delegates of these societies are to be admitted to the places of internment for the distribution of relief, as also to the halting-places of repatriated prisoners, "if furnished with a personal permit by the military authorities, and on giving an engagement in writing to comply with all their regulations for order and police."

Sick and wounded.

The obligations of belligerents with regard to sick and wounded on land are governed by the Geneva Convention of 1864. By this convention ambulances and military hospitals, their medical and administrative staff and chaplains are invested with a neutral character. Certain immunities are granted to the tenants of any private houses in which wounded men are cared for, and a uniform flag and arm-badge bearing a red cross were provided as a distinguishing mark of their neutral character. A convention, accepted at the Peace Conference, has now adapted the principles of this convention to maritime warfare. The new (Red Cross) Maritime Convention provides :—

That military hospital-ships, that is to say, ships constructed or assigned by states specially and solely for the purpose of assisting the wounded, sick, or shipwrecked, and the names of which have been communicated to the belligerent powers at the commencement or during the course of hostilities, and in any case before they are employed, are to be respected and cannot be captured while hostilities last.

As regards hospital-ships, equipped wholly or in part at the cost of private individuals or officially recognized relief societies, they likewise are to be respected and exempt from capture, provided the belligerent or neutral power to which they belong shall have given them an official commission and notified their names to the hostile power at the commencement of or during hostilities, and in any case before they are employed.

The belligerents have the right to control and visit them; they can refuse to help them, order them off, make them take a certain course, and put a commissioner on board; they can even detain them, if important circumstances require it.

The religious, medical, or hospital staff of any captured ship is inviolable, and its members cannot be made prisoners of war.

Lastly, neutral merchantmen, yachts, or vessels, having, or taking on board, sick, wounded, or shipwrecked of the belligerents, cannot be captured for so doing.

Arms and projectiles.

Under the Declaration of St Petersburg (1868), to which most European states were parties, a minimum weight was fixed for projectiles. The Hague War-Regulations, which, by the way, do not refer to the St Petersburg Declaration, contain provisions forbidding the use of poisoned arms or the employment of arms, projectiles, or material of a nature to cause superfluous injury. The following agreements, to which Great Britain is not a party, were also adopted :—

"1. To prohibit the launching of projectiles and explosives from balloons or by other similar new methods.

"2. To prohibit the use of projectiles, the only object of which is the diffusion of asphyxiating or deleterious gases.

"3. To prohibit the use of bullets which expand or flatten easily in the human body, such as bullets with a hard envelope, of which the envelope does not entirely cover the core, or is pierced with incisions."[1]

The following prohibitions are also placed by The Hague Regulations on the means of injuring the enemy :—

Injuring enemy, sieges, bombardments.

To employ poison or poisoned arms.

To kill or wound treacherously individuals belonging to the hostile nation or army.

To kill or wound an enemy who, having laid down arms, or having no longer means of defence, has surrendered at discretion.

To declare that no quarter will be given.

To employ arms, projectiles, or material of a nature to cause superfluous injury.

To make improper use of a flag of truce, the national flag, or military ensigns and the enemy's uniform, as well as the distinctive badges of the Geneva Convention.

To destroy or seize the enemy's property, unless such destruction or seizure be imperatively demanded by the necessities of war; to attack or bombard towns, villages, habitations, or buildings which are not defended.

To pillage a town or place, even when taken by assault.

Ruses of war and the employment of methods necessary to obtain information about the enemy and the country, on the contrary, are considered allowable.

In sieges and bombardments all necessary steps are to be taken to spare as far as possible buildings devoted to religion, art, science, and charity, hospitals, and places where the sick and wounded are collected, provided they are not used at the same time for military purposes; but the besieged are to indicate these buildings or places by some particular and visible signs, and notify them to the assailants.

A spy is one who, acting clandestinely, or on false pretences, obtains, or seeks to obtain, information in the zone of operations of a belligerent, with the intention of communicating it to the hostile party (The Hague War Convention, Art. 29). Thus, soldiers not in disguise who have penetrated into the zone of operations of a hostile army to obtain information are not considered spies.

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[1] The texts of these Declarations will be found in Parliamentary Paper, "Miscellaneous, No. 1, 1899." C. 9534.

Spies. Similarly, the following are not considered spies: soldiers or civilians, carrying out their mission openly, charged with the delivery of despatches destined either for their own army or for that of the enemy. To this class belong likewise individuals sent in balloons to deliver despatches, and generally to maintain communication between the various parts of an army or a territory (*ib.*) A spy taken in the act cannot be punished without previous trial, and a spy who, after rejoining the army to which he belongs, is subsequently captured by the enemy, is a prisoner of war, and not punishable for his previous acts of espionage.[1]

Occupation of hostile territory.

Territory is considered as occupied when it is actually under the authority of the hostile army. The authority having passed into the hands of the occupant, the latter takes all possible steps to re-establish public order and safety. Compulsion of the population of occupied territory to take part in military operations against its own country, and pressure to take the oath to the hostile power are prohibited. Private property must be respected, save in case of urgent military necessity (Arts. 47 and 23). The property of the communes, that of religious, charitable, and educational institutions, and of art and science, even when state property, are assimilated to private property, and all seizure of, and destruction, or intentional damage done to such institutions, to historical monuments, works of art or science, is prohibited.

Boer war and Hague Regulations.

As regards Continental criticism of the conduct of the Boer war by the British commanders, who are alleged to have frequently violated these provisions of The Hague War-Regulations, it would be carping to contend that, as the Boer Republics were not parties to the convention, they were not entitled to its benefits.[2] The criticism, however, was irrelevant, The Hague War-Regulations relating only to "occupation" by a hostile army and not to the military establishment of a conquering state in possession of *annexed* territory, to which international regulations can have no application.

Declaration of war. Contemporary practice as regards declarations of war varies.

The Franco-Prussian war of 1870 was preceded by a deliberate declaration. In the war between Japan and China there was no declaration. (See Ariga, *La Guerre Sino-Japonaise*, Paris, 1896).

Modern practice. The delivery of an ultimatum specifying those terms, the compliance with which is demanded within a specified time, is practically a conditional declaration of war which becomes absolute in case of non-compliance. Thus the note communicated by the United States to Spain on 20th April 1898 demanded the "immediate withdrawal of all the land and sea forces from Cuba," and gave Spain three days to accept these terms. On the evening of 22nd April the United States seized several Spanish vessels, and hostilities were thus opened. In the case of the Transvaal war, the declaration also took the form of an ultimatum. (See as to the formal notification of the existence of a state of war, NEUTRALITY.)

Future of law of war.

Too much confidence must not be placed in regulations concerning the conduct of war. Military necessity, the heat of action, the violence of the feelings which come into play will always at times defeat the most skilfully-combined rules diplomacy can devise. Still, such rules are a sign of conditions of public opinion which serve as a restraint upon the commission of barbarities among civilized peoples. The European operations in China consequent on the "Boxer" rising show how distance from European criticism tends to loosen that restraint. On the other hand, it was significant that both the United States and Spain, who were not parties to the Declaration of Paris, found themselves, in a war confined to them, under the necessity of observing provisions which the majority of civilized states have agreed to respect. (T. BA.)

Warburton, Colonel Sir Robert (1842–1899), Anglo-Indian soldier and administrator, was the son of an artillery officer who was taken prisoner at Kabul in 1842, and who escaped through the good offices of an Afghan princess. He married this lady, and she transmitted to their son that power of exercising influence over the tribes of the north-west frontier which stood him in good stead during his long service in India. Warburton entered the Royal Artillery in 1861, took part in the Abyssinian war of 1867–68, and then joined the Bengal Staff Corps. He served with distinction in the expedition against the Utman Khels in 1878 and in the Afghan war of 1878–80. Very soon after the British Government had made permanent arrangements for keeping open the Khaibar Pass, Warburton was appointed to take charge of it as political officer. This post he held, discharging its duties with conspicuous ability, between 1879 and 1882 with intervals of other duty, and continuously from 1882 until 1890. He turned the rude levies which formed the Khaibar Rifles into a fine corps, ready to serve the Indian Government wherever they might be required. He made the road safe, kept the Khaibar Afridis friendly, and won the thanks of the Punjab Government, expressed in a special order upon his retirement, for his good work. When the Afridis began to cause anxiety in 1897, Colonel Warburton was asked by the Government of India if he would assist in quieting the excitement amongst them. He declared himself ready to do so, but in the meantime the trouble had come to a head. Colonel Warburton took part in the campaign which followed; at its close his active career ended. He occupied his leisure in retirement by writing his memoirs, which, under the title of *Eighteen Years in the Khyber*, were published by Murray in 1900. He died at Kensington on 22nd April 1899.

Ward, Adolphus William (1837– ——), historian and man of letters, was born at Hampstead, 2nd December 1837, and was educated in Germany and at the University of Cambridge. In 1866 he was appointed professor of history and English literature in Owens College, Manchester, and was principal from 1890 to 1897, when he retired. He took an active part in the foundation of Victoria University, of which he was vice-chancellor from 1886 to 1890 and from 1894 to 1896. In 1897 the freedom of the city of Manchester was conferred upon him, and in 1900 he was elected Master of Peterhouse. His most important work is his standard *History of English Dramatic Literature to the Age of Queen Anne* (1875), re-edited after a thorough revision in 1899. He has also written *The House of Austria in the Thirty Years' War* (1869), and the volumes on Chaucer and Dickens in the "English Men of Letters" series edited by Mr John Morley, and has translated Curtius's *History of Greece*, 1868–73. He has also been an extensive contributor to high-class periodical literature.

Ward, Elizabeth Stuart Phelps (1844– ——), American authoress, was born in Boston, Massachusetts, 13th August 1844. Her father was Austin Phelps, who became, soon after her birth, professor in Andover Theological Seminary, and was the author of *The Still Hour* and other popular works on the spiritual life. Miss Phelps began her literary career by the production of juvenile tales of no special significance, but in 1868 appeared *The Gates Ajar*, a realistic study, in the form of fiction, of the possibilities of the life after death, which attained immediate popularity, and was followed by the similar *Beyond the Gates* (1883) and *The Gates Between* (1887). Her other numerous writings fall under the divisions of novels, short stories, tales for children, personal reminiscences, religious books, hints on dress reform, and verse; the most significant being the novel, *Doctor Zay* (1882); such strong tales as *The Tenth of January* (a narrative of the falling and burning of a cotton-mill in Lawrence, Massachusetts, in 1860, which appeared in *The Atlantic Monthly* for March 1868); and the Gloucester tragedy entitled *Jack the Fisherman* (1887); the "Trotty" stories for children, one of the best features of *Our Young Folks* magazine between 1865 and 1873; and the readable *Chapters from a Life*, reprinted from a monthly periodical in 1896, and giving a characteristic record of certain passing phases of religio-social life in New England in the middle of the 19th century. In 1888 Miss Phelps married Herbert Dickinson Ward, a Congregational minister and writer, with whom she collaborated in some of her less important works of fiction.

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[1] See as to *Flags of Truce*, Art. 32 of The Hague Regulations.

[2] Art. 2. The provisions contained in the Regulations mentioned in Art. 1 are only binding on the contracting powers in case of war between two or more of them.

Ward, John Quincy Adams (1830-——), American sculptor, was born in Urbana, Ohio, 29th June 1830. His education was received in the village schools. In 1850 he entered the studio of Henry K. Browne, where he remained as student and assistant until 1857. Between that date and 1861, when he opened a studio in New York, he executed busts of Joshua R. Giddings, Alexander H. Stephens, and Hannibal Hamlin; prepared the first sketch for the "Indian Hunter," and made studies among the Indians themselves for the work. In 1863 he became a member of the National Academy of Design (New York), and was elected its president in 1872. Among his best-known statues are the "Indian Hunter," finished in 1864 (Central Park, New York); Washington, heroic size (on the steps of the U.S. Sub-Treasury, Wall Street, New York); Henry Ward Beecher (Brooklyn); an equestrian statue of General George H. Thomas (Washington); Israel Putnam (Hartford); and the seated statue of Horace Greeley, the founder of the New York *Tribune*, in front of the office of that newspaper. In 1896 he was elected president of the newly organized National Sculpture Society (New York). Unlike his fellow-countryman, W. W. Story, he acquired his training, his inspiration, and his themes from his own country.

Ward, William George (1812–1882), English Roman Catholic theologian, was born 21st March 1812. His career is extremely interesting as illustrating the development of religious opinion at a remarkable crisis in the history of English religious thought. Ward is described by his son and biographer as somewhat unequally gifted by nature. For pure mathematics he had a special gift—almost a passion. For history, applied mathematics—for anything, in fact, outside the exact sciences—he felt something approaching to contempt. He was endowed with a strong sense of humour and a love of paradox carried to an extreme. He went up to Christ Church, Oxford, in 1830, but his father's subsequent pecuniary embarrassments compelled him in 1833 to try for a scholarship at Lincoln College, which he succeeded in obtaining. His examination for mathematical honours exhibited some of the peculiarities of his character and mental powers. Four out of his five papers on applied mathematics were sent up absolutely blank. Honours, however, were not refused him, and in 1834 he obtained an open fellowship at Balliol. In the previous year the Tractarian movement had commenced, and Ward's relations with that movement were as original as the rest of his life. He was attracted to it by his hatred of moderation and what he called "respectability" in any shape—a characteristic of which some amusing instances have been handed down. He was repelled from it by the conception he had formed of the character of Newman, whom he regarded as a mere antiquary. When, however, he was at length persuaded by a friend to go and hear Newman preach, he at once became a disciple. But he had, as Newman afterwards said of him, "struck into the movement at an angle." He had no taste for historical investigations. He treated the question at issue as one of pure logic, and disliking the Reformers, the right of private judgment which Protestants claimed, and the somewhat prosaic uniformity of the English Church, he flung himself into a general campaign against Protestantism in general and the Anglican form of it in particular. He nevertheless took deacon's orders in 1838 and priest's orders in 1840. In 1839 he became the editor of the *British Critic*, the organ of the Tractarian party, and he excited suspicion among the adherents of the Tractarians themselves by his violent denunciations of the Church to which he still belonged. In 1841 he urged the publication of the celebrated "Tract XC.," and wrote in defence of it. From that period Ward and his associates worked undisguisedly for union with the Church of Rome, and in 1844 he published his *Ideal of a Christian Church*, in which he openly contended that the only hope for the Church of England lay in submission to the Church of Rome. This publication brought to a height the storm which had long been gathering. The University of Oxford was invited, on 13th February 1845, to condemn "Tract XC.," to censure the *Ideal*, and to degrade Ward from his degrees. The two latter propositions were carried, and "Tract XC." only escaped censure by the *non placet* of the proctors Guillemard and Church. The condemnation precipitated an exodus to Rome. Ward left the Church of England in September 1845, and was followed by many others, including Newman himself. After his reception into the Church of Rome Ward gave himself up to ethics, metaphysics, and moral philosophy. He wrote articles on Free Will, the Philosophy of Theism, on Science, Prayer, and Miracles for the *Dublin Review*. He also dealt with the condemnation of Pope Honorius, carried on a controversial correspondence with John Stuart Mill, and took a leading part in the discussions of the Metaphysical Society founded by Mr James Knowles, of which Tennyson, Huxley, and Martineau were also prominent members. He was a vehement opponent of Liberal Catholicism. In 1851 he was made professor of moral philosophy at St Edmund's College, Ware, and was advanced to the chair of dogmatic theology in 1852. In 1868 he became editor of the *Dublin Review*. He gave a vigorous support to the promulgation of the dogma of Papal Infallibility in 1870. After his admission into the Roman Catholic Church he had, rather to the dismay of his friends, entered the married state, and for a time had to struggle with poverty. But his circumstances afterwards improved. He died 6th July 1882. (J. J. L*.)

Wardha, a town and district of British India, in the Nagpur division of the Central Provinces, which take their name from the Wardha river. The town is situated 48 miles south-west of Nagpur by rail. It was laid out in 1866, shortly after the district was first constituted. Population (1881), 5816; (1891), 8322. There are two steam factories, pressing 153,000 maunds of raw cotton.

The district of WARDHA has an area of 2428 square miles; population (1881), 387,221; (1891), 400,854, showing an increase of 4 per cent.; average density, 165 persons per square mile. In 1901 the population was 385,483, showing a decrease of 4 per cent. The land revenue and rates were, Rs. 7,31,292, the incidence of assessment being R.0–7–5 per acre; cultivated area (1897–98), 916,854 acres, of which 3149 were irrigated from wells; number of police, 389; boys at school, 6115, being 20 per cent. of the male population of school-going age; registered death-rate (1897), 58·37 per 1000. The principal crops are cotton, millet, wheat, and oil-seeds. This region has given its name to the cotton known in the market as

Hinganghat. There are two cotton-mills at Hinganghat and Pulgaon, and eight steam cotton presses. The district is traversed by the Nagpur line of the Great Indian Peninsula Railway, with five stations. A branch runs from Wardha town past Hinganghat to the Warora coal-field in the district of Chanda.

Ware, a town of Hampshire county, Massachusetts, U.S.A. It comprises an area of 28 square miles of hill country, in the central part of the state, containing several villages, the largest of which bears the same name as the town, and is on the Ware river, and on the Boston and Albany and the Boston and Maine railways, at an altitude of 488 feet. It is irregularly laid out, and has an excellent water-supply. Its chief industry is the manufacture of cotton and woollen goods. Population of the town (1880), 4817; (1890), 7329; (1900), 8263, of whom 3263 were foreign-born.

Wareham, a municipal borough of Dorsetshire, England, 17 miles south-east of Dorchester, near Poole Harbour, with a station on the London and South-Western Railway. It formerly sent two members to Parliament, but in 1832 its representation was merged in that of the county. In the ancient church of St Mary is a chapel said to be the burial-place of the Anglo-Saxon kings. The town and neighbourhood have been long noted for their lime and cement, and large quantities of potters', pipe, fire, and other kinds of clay are sent to Staffordshire and to foreign countries. Population (1891), 2141; (1901), 2003.

Warminster, a market town and railway station in the Westbury parliamentary division of Wiltshire, England, 21 miles west-north-west of Salisbury. The restoration of the church of St Denys has been completed, and the missionary college provided with new buildings. There is a technical and industrial institute. Area of parish (an urban district), 6564 acres. Population (1891), 5563; (1901), 5547.

Warner, Charles Dudley (1829–1900), American author, was born at Plainfield, Massachusetts, 12th September 1829. He graduated at Hamilton College, Clinton, New York, 1851; became a lawyer, and practised in Chicago 1856–60; but in 1861 removed to Hartford, Connecticut, as editor of the *Press* (merged in the *Courant* in 1867). There he continued to reside, engaged in editorial work upon that journal and *Harper's Magazine*, in lecturing, in such public services as prison reform, city park supervision, &c., and in literary work. Of his numerous volumes the first was *The Book of Eloquence* (1853), a collection of extracts for declamation; but his place in American literature dates from the appearance of the humorous and reflective sketches entitled *My Summer in a Garden*, first published in his newspaper, and reissued in a small volume in 1870. Their literary style was midway between the formal sentiment of Irving and the brisk paradoxes of Mark Twain; and the pleasure they gave to the reader was due to their delicacy of touch, kindly suggestiveness, and humorous wholesomeness of tone. Their general method of entertaining comment on things and men was afterwards applied by the author to many successive collections of sketches of travel, life, &c., such as *Saunterings* (in western Europe, 1872), *Baddeck and That Sort of Thing* (Nova Scotia, &c., 1874), and *Back-Log Studies* (1872). A more descriptive and on the whole a less jocose style was adopted in *Mummies and Moslems* (1876), *In the Levant* (1877), *On Horseback* (in the Southern states, 1888), and *Our Italy* (southern California, 1891). Warner also wrote a book of reminiscences of childhood, and biographies of Captain John Smith and Washington Irving (the first semi-humorous and the second wholly serious). He edited the "American Men of Letters" series, and a large "Library of the World's Best Literature"; but his chief contributions to literature, apart from the books named and the graceful little collection of *Harper's Magazine* essays under the titles of *As We Were Saying* (1891) and *As We Go* (1893), are his novels, *The Gilded Age* (in collaboration with Mark Twain, 1873), *Their Pilgrimage* (1886), *A Little Journey in the World* (1889), *The Golden House* (1894), and *That Fortune* (1899). The first of the novels is a broad satire on American "shiftiness"; the others, like Howells's *Their Wedding Journey*, combine topographical description with quiet character-study—the author's expression of the society in which he has lived. The three last named form a trilogy on the general subject of money-making and money-losing. Warner died at Hartford, Connecticut, 20th October 1900.

Warnsdorf, a town in the government district of Rumburg, in Bohemia, near the Saxon frontier. The chief industries comprise cotton spinning, weaving, and calico printing, the manufacture of cloth, woollen and linen stuffs, satin and velvet, machinery, cement, colours, &c. The ecclesiastical edifices include an old-Catholic church, and there is a monument to the imperial reformer, Joseph II. Population (1890), 18,268; (1900), 21,150.

Warora, a town of British India, in the Chanda district of the Central Provinces, with a railway station. Population (1881), 8022; (1891), 10,018. Warora gives its name to a coal-field. The colliery, which is worked by the Government, employs about 1500 persons. In 1897–98 the output was 115,652 tons, of which 56,070 tons were sold to the railway; total expenditure, Rs.3,97,594, being Rs.3.7.0 per ton; total receipts, Rs.5,40,749, showing a profit of 7·7 per cent. on the capital outlay. A fireclay industry under the same management raised 2065 tons of iron-clay in 1897, and sold bricks and tiles to the value of Rs.34,948. Warora is connected with Wardha on the Great Indian Peninsula Railway by a state line 45 miles in length.

Warren, a city of Ohio, U.S.A., capital of Trumbull county, on the Mahoning river, and on the Pennsylvania, the Erie, and the Pittsburg and Western railways, in the north-eastern part of the state, at an altitude of 872 feet. It is in a region of coal and iron mining, and has rolling-mills, machine-shops, and other manufactures. Population (1880), 4428; (1890), 5973; (1900), 8529, of whom 1161 were foreign-born and 137 negroes.

Warren, a borough of Pennsylvania, U.S.A., capital of Warren county, on the Allegheny river, and the Dunkirk, Allegheny Valley and Pittsburg, the Pennsylvania, and the Western New York and Pennsylvania railways, in the north-western part of the state, at an altitude of 1189 feet. It is in the oil region, and most of its industries are directly connected with the production, refining, and distribution of oil. Population (1880), 2810; (1890), 4332; (1900), 8043, of whom 1529 were foreign-born.

Warrensburg, a city of Missouri, U.S.A., capital of Johnson county, on the Black river, and on the Missouri Pacific Railway, in the western part of the state, at an altitude of 831 feet. Its site is hilly, its street plan regular, it has a good water-supply, and is divided into four wards. It is surrounded by a rich farming region, for which it serves as a shipping and supply point. Population (1880), 4049; (1890), 4706; (1900), 4724, of whom 127 were foreign-born and 556 negroes.

Warrington, a municipal, county, and parliamentary borough and market town, in the Newton parliamentary division of Lancashire, England, 18 miles west-south-west of Manchester, on the river Mersey, with stations on several railways. Parr Hall, opened in 1895, was built at a cost of £10,000, and a county court-house was erected in 1897. Victoria Park and Queen's Gardens were opened in 1897. Population (1891), 52,288; (1901), 64,241.

Warrnambool, a seaport town, Victoria, Australia, in the county of Villiers, 166 miles south-west of Melbourne, and its nearest port on the western seaboard. A viaduct and breakwater pier, 2400 feet in length, have been constructed. Dairy produce is exported to the value of about £150,000 annually. Race meetings are held, the steeplechase course being said to be the best in the colony. Luxurious sea-baths have been fitted up by the corporation. The summer climate is the coolest in the Australian states. Population (1881), 4839; (1891), 6582; (1901), 6410.

Warsaw, a government of Russian Poland, occupying a narrow strip of land on the left bank of the Vistula and the lower Bug down to the Prussian frontier. It has an area of 5623 square miles, and its population, which was 971,730 in 1885, in 1897 numbered 1,933,689 (domiciled only), of whom 949,794 were women, and 791,746 lived in towns, chiefly in the city of Warsaw. The inhabitants are mostly Poles, Jews (about 225,000), and Germans (about 90,000). The government is divided into thirteen districts, the chief towns of which are Warsaw, Błonie (2981), Gostynin (6455), Grójec (5800), Kutno (11,213), Łowicz (12,434), Neszawa (2573), Novo-Minsk (7978), Płonsk (7907), Radzymin (3629), Skierniewice (9846), Sochaczew (5968), and Włocławek (23,065). In spite of an unfertile soil, agriculture is prosecuted with considerable success. The total area under cereal crops in 1900 was 1,605,800 acres. The average yield in 1895–99 was: wheat, 1,701,000 cwt.; rye, 5,371,000 cwt.; barley, 863,000 cwt.; oats, 2,044,000 cwt.—all cereals, 10,559,000 cwt.; also potatoes, 15,430,000 cwt. Cattle-breeding is also widely engaged in, and there were in the province in 1898 119,970 horses, 339,800 horned cattle, 453,600 sheep, and 171,300 pigs. Manufacturing industries have greatly developed. In 1898 the aggregate returns of all factories amounted to 106,316,000 roubles, as compared with 54,700,000 roubles in 1885, thus making Warsaw the fifth industrial province in Russia in Europe. The principal establishments are machinery and sugar works, flour-mills, and factories for plated silver, carriages, carpets, woollen cloth, boots and shoes, and ready-made clothing.

Warsaw (Polish, *Warszawa*), the chief town of the above government and the capital of Poland, on the left bank of the Vistula. It is an important railway junction, from which five railways radiate to Danzig in Prussia, St Petersburg (700 miles), Moscow (870 miles), *viâ* Siedlce and Brest Litovsk, Kieff and south-west Russia, *viâ* Lublin, Berlin (404 miles), and Vienna, *viâ* Skierniewice. It has continued to develop, and had in 1897 a population of 638,208. About one-third of these are Jews; Germans form an important element, and the Russian garrison numbers some 31,000; the rest are Poles. The abolition of the central administration of the lieutenancy of Poland and of the administrative autonomy of the Polish provinces has in no wise diminished the national importance of the city, nor has the fact that in all the educational institutions but two instruction is given in Russian. On the contrary, it acquires every year more and more importance as an intellectual centre—literary, dramatic, and musical—for all Polish-speaking peoples, and as an industrial centre both for Poland and the western portion of the Russian Empire. From a military point of view Warsaw remains the chief stronghold for the military defence of Poland; the Alexander Citadel has been much improved, and the bridge across the Vistula is defended by a strong fort, Sliwicki. Many large and handsome buildings have been erected, and several empty spaces have been converted into gardens and beautiful squares; improvements have been made in the Saxon Garden, and the "Uyazdovsk" boulevards have been planned in imitation, on a small scale, of the Champs Elysées of Paris. The iron and steel industry has greatly developed. The principal steel works now produce annually no less than 100,000 tons of steel goods, half of which are rails, and some of the establishments rank among the largest of their kind, though out of 368 factories registered in 1895, 100 employed less than 16 workers each, 175 from 16 to 50, and only 34 more than 100. The machinery works have suffered to some extent from competition with those of southern Russia, and find the high price of land a great obstacle in the way of extension. But the manufactures of plated silver, carriages, boots and shoes (annual turnover 80,000,000 roubles), millinery, hosiery, gloves, and all sorts of small artistic house decorations retain their importance, chiefly owing to the skill of the workers. There are altogether more than 50,000 artisans in the city. Trade is principally in the goods enumerated above, but the city is still a centre for trade in corn, leather, coal, and sugar, and its two fairs (wool and hops) have a great reputation throughout western Russia. (P. A. K.)

Warthe, or WARTHA, a river of Poland and Prussia. It rises on the north slope of the mountains north of Cracow, flows north as far as Radomsk, then west, then north again past Sieradz, until it reaches Kolo, where it again turns west, crosses the frontier into the Prussian province of Posen, wheels north again to beyond the town of Posen, then once more bends west, and flowing past Schwerin and Landsberg, enters the Oder, from the right, at Küstrin. Its total length is 440 miles, of which 210 are in Poland and 230 in Prussia; it is navigable up to Konin in West Poland, a distance of 265 miles. Its banks are mostly low and flat, its lower course especially running through marshes (drained and cultivated). It is connected with the Vistula through the Netze (its own right-hand tributary) and the Bromberg canal. The area of its drainage basin is 17,240 square miles.

Warwick, a midland county of England, bounded on the W. by Worcester, on the N.W. by Stafford, on the N.E. and E. by Leicester and Northampton, and on the S. by Oxford and Gloucester.

Area and Population.—The area of the ancient county is 577,462 acres, or 902 square miles, with a population in 1881 of 737,339; in 1891 of 805,072, of whom 388,261 were males and 416,811 females; and in 1901 of 897,678, the number of persons per square mile being 995, and of acres to a person 0·64. The area of the administrative county, as given in the census tables of 1891, was 562,797, with a population of 307,193, or, including the county boroughs of Birmingham and Coventry, 578,595 acres, with a population of 838,039. Since 1891, however, various changes have been made in the administrative area. In 1895 the part of the parish of Drayton Bassett in Warwick was transferred to Stafford, and the parish of Stoneton was transferred from Northampton to Warwick; and in 1896 the part of the parish of Batsford in Warwick was transferred to Gloucester, and the parish of Oldberrow from Worcester to Warwick. The area of the registration county is 621,833 acres, with a population in 1891 of 801,738 and in 1901 of 906,451, of whom 439,177 were males and 467,274 were females. Within the registration area the increase of population between 1881 and 1891 was 9·75 per cent., and between 1891 and 1901, 13 per cent. The excess of births over deaths between 1881 and 1891 was 106,685, and the actual increase of resident population was 71,223.

The following table gives the numbers of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1898:—

Year.	Marriages.	Births.	Deaths.	Illegitimate Births.	
				Males.	Females.
1880	5174	25,975	14,481	509	592
1890	6643	24,567	15,971	481	475
1898	8064	28,123	16,199	476	422

In 1899 the number of marriages was 8009, of births 28,586, and of deaths 16,843.

The following table gives the marriage-, birth-, and death-rates per thousand of the population, with the percentage of illegitimate births, for a series of years:—

	1870–79.	1880.	1880–89.	1890.	1888–97.	1898.
Marriage-rate .	16·7	14·3	14·9	16·7	16·6	18·9
Birth-rate . .	37·4	35·8	33·5	30·8	31·5	32·9
Death-rate . .	22·2	20·0	19·0	20·1	19·2	19·0
Percentage of illegitimacy . .	4·2	4·2	4·1	3·9	3·7	3·2

Both the birth-rate and the death-rate are high, but the percentage of illegitimacy is much below the average. The number of Scots in the county in 1891 was 3453, of Irish 7084, and of foreigners 2591.

Constitution and Government.—The county contains six municipal boroughs: Birmingham (522,182), Coventry (69,377), Royal Leamington Spa (26,888), Stratford-on-Avon (8310), Sutton Coldfield (14,264), and Warwick (11,889). Birmingham and Coventry are county boroughs. The following are urban districts: Aston Manor (77,310), Bulkington (1548), Erdington (16,366), Kenilworth (4544), Nuneaton and Chilvers Coton (24,995), and Rugby (16,838). Warwickshire is in the midland circuit, and assizes are held at Warwick. The boroughs of Birmingham, Coventry, Royal Leamington Spa, Stratford-upon-Avon, Sutton Coldfield, and Warwick have separate commissions of the peace, and the boroughs of Birmingham and Warwick have, in addition, separate courts of quarter sessions. The ancient county, which is mostly in the diocese of Worcester, contains 276 entire ecclesiastical parishes or districts, with parts of 14 others.

Education.—Birmingham is the seat of a university and other important educational institutions, and Rugby of one of the most famous of English public schools. There is a day training college for schoolmasters and schoolmistresses in connexion with Mason University College, Birmingham. In Birmingham there are two board deaf schools, a general institution for the blind, and the royal institution for the deaf and dumb. At Aston there is a board deaf school. The total number of elementary schools on 31st August 1899 was 415, of which 120 were board and 295 voluntary schools, the latter including 243 National Church of England schools, 4 Wesleyan, 36 Roman Catholic, and 12 "British and other." The average attendance at board schools was 77,952, and at voluntary schools 58,332. The total school board receipts for the year ended 29th September 1898 were £356,656. The income under the Agricultural Rates Act was over £1878.

Agriculture.—About five-sixths of the total area is under cultivation, and of this about two-thirds is in permanent pasture. About 2500 acres are under orchards and 21,000 under woods. The acreage under corn crops has greatly diminished, the decrease being chiefly in that under wheat, which amounts to about one-third of the wheat acreage. Wheat is, however, still grown on about two-fifths of the corn acreage, while barley occupies less than one-third and oats only about one-seventh. More than half the acreage under green crops is occupied by turnips, swedes, and mangold, much attention being paid to cattle-rearing and dairy-farming. The following table gives the acreages of the larger main divisions of the cultivated area at intervals from 1885:—

Year.	Total Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885	496,850	110,426	31,784	41,857	298,352	14,430
1890	495,490	10,101	29,283	35,175	317,502	10,108
1895	494,680	92,829	29,894	37,836	324,703	8,922
1900	495,284	92,513	28,349	33,174	334,583	6,115

The following table gives particulars regarding the principal live-stock during the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or in Calf.	Sheep.	Pigs.
1885	20,630	114,296	38,432	296,867	41,348
1890	20,695	104,360	35,425	306,913	45,835
1895	22,273	95,305	32,249	272,856	46,498
1900	22,482	108,592	35,958	272,189	36,405

Industries and Trade.—According to the report for 1898 of the chief inspector of factories (1900), the total number of persons employed in factories and workshops in 1897 was 192,444, as compared with 182,302 in 1896. Of these only 5110 were employed in textile factories, woollen and worsted industries, &c., employing 1396, and silk (including ribbons at Coventry and Nuneaton) 2427. Non-textile factories employed 156,008, the percentage of increase between 1895 and 1896 being 17·6, while between 1896 and 1897 it was 5·6. As many as 60,731 persons were employed in the manufacture of machines, appliances, conveyances, and tools, 16,354 in the founding and conversion of metals, 14,718 in the manufacture of jewellery, plate, instruments, and fancy articles (Warwickshire ranking in this respect next to London), 12,140 in furniture-making, 7180 in the manufacture of paper, &c., 6618 in the galvanizing and finishing of metals, 3792 in clothing industries, 1739 in clay and stone industries, 1605 in the manufacture of glass, 1869 in indiarubber and gutta-percha manufactures, and 1051 in the manufacture of chemicals. Of the 31,326 persons employed in workshops, 6387 were engaged in clothing industries, 6236 in jewellery, &c., industries, 4270 in furniture-making, 3873 in the manufacture of machines, &c., and 1179 in the manufacture of paper, &c. The total number of persons employed in connexion with mines and quarries in 1899 was 10,440. In the same year 651,433 tons of clay were raised, 227,959 tons of limestone, 116,440 tons of sandstone, 139,352 tons of igneous rocks, 41,405 tons of gravel and sand, and 5709 tons of iron pyrites; 27,354 tons of fireclay, valued at £5471, were raised in 1899, as compared with 35,299 tons, valued at £7069, in 1890. Iron ore, of which 10,981 tons, valued at £5490, were obtained in 1885, has been mined in increasing quantities, 30,497 tons, valued at £3176, having been obtained in 1899. The following table gives the output from coal-mines in 1890 and 1898:—

Year.	Coal.	
	Tons.	Value.
1890	1,744,174	£697,670
1898	2,873,098	969,671

AUTHORITIES.—BURGESS. *Early Earthworks in Warwickshire.* Birmingham, 1884.—DEAKIN. *Sketches in Shakespeare Villages.* Birmingham, 1885.—TIMMINS. *History of Warwickshire* (Popular County History series). London, 1889.—BURGESS. *Historic Warwickshire.* Birmingham, 1892–93.—HANNET. *The Forest of Arden.* Birmingham, 1894.—NUTHALL. *Warwickshire Word Book.* (English Dialect Society.) London, 1897.

(T. F. H.)

Warwick, a municipal and parliamentary borough and county town of Warwickshire, England, on the Avon, 98 miles north-west by west of London by rail. The King's School was founded during the reign of Edward the Confessor. Upon the same foundation are the high school for girls and the King's Middle School. There is a free library and a museum. There are iron-works and a gelatine factory. Area of municipal borough, 5613 acres. Population (1891), 11,903; (1901), 11,889.

Warwick, a town of Queensland, Australia, in the county of Merivale, 169 miles by rail north-west of Brisbane. The district is a wheat- and maize-growing one. Vine-culture has also been successfully tried, and is extending. The town has substantial public and private buildings, and two large parks besides smaller recreation grounds. The water-supply from the Condamine is excellent and unlimited. Coal is found in various parts of the district, as are also excellent building stone and brick-clay. Mean rainfall (12 years), 32·13 inches. Population (1891), 3402; (1901), 3836.

Warwick, a town of Kent county, Rhode Island, U.S.A., comprising an area of 44 square miles of level country, fronting on Narragansett Bay, and traversed by a line of the New York, New Haven, and Hartford Railroad. Its population is scattered among more than a score of small villages, whose chief industry is the manufacture of cotton goods. Warwick was settled in 1642, and incorporated five years later. Population (1880), 12,164; (1890), 17,761; (1900), 21,316, of whom 7792 were foreign-born and 183 negroes.

Wasa. See Vasa.

Washburne, Elihu Benjamin (1816–1887), American statesman, was born in Livermore, Me., on the 23rd of September 1816. He was one of seven brothers, of whom four sat in Congress from as many different states. After a common school education he was admitted to the bar; in 1840 he removed to Galena, Ill. He was elected to Congress in 1852, where, first as a Whig and afterwards as a Republican, he represented his district without intermission till 1869. He contributed much to aid General Grant early in the Civil War, and the latter on becoming President made Washburne Secretary of State. Prevented by ill-health from serving in this position, he was appointed minister to France, where during the Franco-German war and the Commune he won much distinction as protector of German and other foreign citizens in Paris. In 1877 he retired from public life, and died in Chicago, Ill., 22nd October 1887.

Washington, one of the states of the American Union, occupying the extreme north-western portion of the country. Wholly within it lies Puget Sound, on the shores of which cities have grown up within a few years that carry on a large share of American trade with the Orient. It was organized as a territory in 1853, and was admitted as a state in 1889.

Population.—The population has rapidly increased from 11,594 in 1860 to 349,390 in 1890 and 518,103 in 1900, an increase of 48·3 per cent. during the decade 1890–1900. The density per square mile had increased during the same period from 5·2 to 7·7. In 1890 the three principal cities contained 28·27 per cent. of the population. Between 1890 and 1900 Seattle increased from 42,837 to 80,671, Tacoma from 36,006 to 37,714, and Spokane from 19,922 to 36,848. The three then contained about 30 per cent. of the population. There were in 1900 ninety incorporated places, of which only twenty had a population of more than 2000. The urban population (including under this head all persons in cities of more than 4000 inhabitants) increased from 33·8 per cent. of the total population in 1890 to 36·4 per cent. in 1900. In the latter year the population comprised 304,178 males (58·7 per cent.) and 213,925 females (41·3 per cent.) The foreign-born numbered 111,364 (21·5 per cent.) and the coloured 22,799 (4·2 per cent.). The coloured population included 2514 negroes, 3629 Chinese, 6617 Japanese, and 10,039 Indians.

Railways.—Until the advent of railways, settlement progressed slowly. Since the construction of the trans-continental lines, commercial development has been more marked than increase of population. Three trans-continental systems cross or enter Washington. The Great Northern and Northern Pacific traverse its entire length from east to west, and the Canadian Pacific has access by traffic arrangements on lines passing from the international boundary to Seattle. There are railways from Seattle and Tacoma south to the Oregon line, from Walla Walla in the south-eastern corner to Spokane, and from Spokane north to British Columbia. Numerous branches tap agricultural and mineral regions, and many extensions are under construction. In 1880, when the first railway was built, the mileage was 289. This increased to 2012 in 1890 and 2914 in 1900.

Commerce.—The official statement of the Puget Sound customs shows that the exports have grown from $3,184,908 in 1885 to $20,678,829 in 1901, and the imports from $238,036 in 1885 to $6,721,060 in 1901. The exports have been largely wheat, flour, and lumber; the imports tea, silks, and other Oriental products. Large quantities of iron, cotton, and other merchandise from the middle west now take this route to China and Japan, while return traffic, heretofore carried by way of the Suez Canal, is being diverted to the eastward passage and the Pacific coast. So extraordinary has been the demand for ocean carriage that the Great Northern Railway is now (1902) finishing several steamers (of more than 20,000 tons each) for the Pacific trade.

Lumber.—First in importance of the natural resources of Washington at the present time are its forests. The department of geography and forestry of the United States Geological Survey estimates the timber standing in the state at 114,778,000,000 feet, of which 71,000,000,000 are fir, 18,000,000,000 cedar, 17,278,000,000 hemlock, and 8,500,000,000 spruce. Practically all of this is on the western side of the Cascade Mountains, the fir and cedar being in the north-western portion of the state, and the hemlock and spruce in the south-western part. It is estimated by the Government that, since lumbering began in the state, 40,000,000,000 feet have been destroyed by fire and 36,000,000,000 handled by the mills. The total standing timber in western Washington is estimated at 103,504,276,000 feet. There are 533 saw and shingle mills, and 344 logging camps. The grand total output for all the mills for 1901 was 1,450,000,000 feet. In 1901, 52,337 cars of lumber and shingles were shipped east, an increase of 9651 cars over the best previous record. The total lumber shipments (by cargo and rail) were 889,500,046 feet, and of shingles 4,485,600,000 pieces. While the main timber supply is drawn from the forests between the summit of the Cascades and the Pacific, there is a considerable growth on the eastern slope of the range and north of the Columbia river. The timber in this region consists mostly of white and yellow pine, with some red fir. Washington lumber is shipped to California, Australia, South America, Hawaii, China, Alaska, South America, Mexico, and the Philippines, and to all principal European ports. A large demand for this lumber from the middle western states is growing with the decrease of the pine forests of Minnesota, Wisconsin, and Michigan. Large forest areas have been set aside in the state, by executive proclamation under Acts of Congress, as permanent forest reserves (see Forestry).

Fisheries.—The principal item in the fishing industry is the canning of salmon. In the Puget Sound district the official report for 1901 shows twenty-four canneries employing 8657 men, and putting upon the market 1,410,444 cases of salmon, valued at $5,641,776. With the addition of fresh, salt, and smoked fish of other varieties, and of shellfish, the total product of the district for the year aggregated $6,817,041. Large canneries are still being built. The total salmon packed for the state of Washington for 1901 was 1,584,650 cases, valued at over $6,335,000. This is over one-third of the total pack of the Pacific coast, which was 5,024,538 cases, valued at over $20,000,000. The largest cannery in the world is situated at Fairhaven. The salmon supply is re-inforced by the work of fish hatcheries supported and conducted by the state. Twenty-one of these in 1901 gave an output of 57,156,500 young salmon.

Minerals.—The coal-fields are of wide area, lying mostly on the western side of the Cascades in the north-western part of the state. The product is bituminous and lignite, no anthracite having been found thus far. There are twenty-one coal mines, whose total output for 1900 was 2,418,034 tons, having an average value at the mine of $1.83 per ton. Mines have been conducted principally in Kittitas, King, Pierce, Whatcom, and Snohomish counties. From the bituminous coals, the best quality of coke is produced, the fixed carbon ranging from 50 to 60 per cent. There has been little deep prospecting for coal, the measures that have been opened having been developed from the outcrop. The increasing demand for Washington coal, both for the growing manufacturing industry of the state, and for the large fleets of steamers from Puget Sound, encourages prospecting, and new measures are being discovered. Coal is shipped in considerable quantities to San Francisco, and some to Honolulu. The value of the total output is over $4,000,000 a year, and some 4338 men find work in the mines. There are extensive deposits of iron ore in various parts of the state that have not been developed commercially owing to the absence of a market. Much of the ore is of good Bessemer quality. The Skagit valley has iron-fields covering an area of 5 to 6 miles wide, by 15 to 18 miles long. The ore is found in veins varying from 6 to 60 feet in width, and assays 5 per cent. to 11 per cent. manganese, 38 per cent. to 50 per cent. of iron, 38 per cent. to 55 per cent. of silica, with small percentage of silver and phosphorus. Red hæmatite is found in the Lake Cushman district, running 40 per cent. to 50 per cent. iron. Hæmatite iron, carrying $5 to $7 in gold and 50 per cent. iron, exists in the Clugston Creek district. Other deposits of iron are found on the Snohomish, Cedar, Chewelah, Icicle, Green, and Snoqualmie rivers, and in Mason and Thurston counties. Placer mining exists on the Columbia, Palouse, Skagit, and other rivers, although the deposits are not especially rich. The famous republic district in the northern part of the state which was opened in 1898, has become one of the notable gold-mining camps in the country. In the main range of the Kettle river, gold, silver, and copper are found, and along the Okanogan river there are deposits of free gold and gold-copper. Free gold and concentrating ores exist in the Slate Creek and Mount Baker districts. Dry silver is found in the Colville district. Index has gold and copper; Monte Cristo, low grade galenas in large bodies; Peshastin, free gold and concentrating ores; Cle-Elum, gold and copper. The total value of the gold and silver produced in 1900 was $1,008,463. The gold production for the year 1900 increased to 95,432 fine ounces, valued at $718,200; and the silver production to 148,300 fine ounces, with a coinage value of $290,263. In connexion with the mining of the precious metals, there was a yield in 1898 of 857,555 pounds of lead, valued at $32,416. At the Government Assay Offices established at Seattle there were received from the date of their establishment, 15th July 1898 to 31st December 1901, gold deposits amounting to $55,973,856.07; of which $508,600.63 was from the mines of Washington, $43,967,275.38 from Alaska, the Klondike, and adjacent districts, and $2,315,950.11 from British Columbia.

Agriculture.—Of the 44,796,160 acres included in the area of Washington, 11,756,785 acres are still unappropriated and unreserved. While a considerable portion of these tracts is mountainous and unfit for cultivation, there is much good agricultural land, and a large area which needs only irrigation to make it extremely productive. In eastern Washington there are millions of acres of good farm land, and in western Washington a large amount adapted to the raising of oats, barley, and vegetables, and to dairying. The tide marsh lands when dyked produce 100 bushels of oats, 80 bushels of barley, 60 bushels of wheat, and 14 tons of hay per acre. In the western portion of the state the wooded slopes stretching down to meadows and river banks, the abundance of pure water, the mildness of the climate, and the extreme coolness of the nights during the entire year are favourable to the making of high-grade dairy products. In 1900 there were 33,202 farms with an acreage of 8,499,297, of which 3,465,960 were improved. The total value of farm property was $144,040,547.

Education, &c.—Ample provision is made for public education. In 1900 Washington had 2060 school districts, and of 139,097 census children, 122,104 were enrolled in the common schools. The teachers numbered 3784. The total expenditure for school purposes was $1,818,060.05, of which $977,632.25 was paid to teachers. Of the population over ten years of age in 1890, 4·3 per cent. were illiterates. Among 195,572 adult males in 1900, 6635 were illiterate (unable to write), of whom 3989 were foreign-born. The State University at Seattle has 600 students and 40 instructors. There are three state normal schools, with 675 pupils in all, and a flourishing agricultural college, with an attendance of 638. School revenues are derived from the sales and leases of school lands, and from general and special taxes. When the state was admitted, 622,000 acres of public lands were granted for public buildings and state institutions. The school for defective youth at Vancouver includes departments for the deaf, the blind, and the feeble-minded.

Marine Interests.—Though the native woods are well adapted to shipbuilding, high wages have prevented the prosecution of the industry on an extensive scale. Most of the boats built are sailing craft. One yard at Port Blakely turned out 100 vessels in the decade 1890–1900, registering an average of more than 500 net tons. The Government despatch-boat *Seward* was built at Seattle, the torpedo-boat *Rowan* was launched there in 1899, and there is now (1902) under construction at that city the first-class battleship *Nebraska*. The largest dry dock is located at Port Orchard. A canal is under construction by the Federal Government from Puget Sound to Lakes Union and Washington. These will constitute a fresh-water harbour for the largest ocean-going vessels. Another fresh-water harbour is being constructed at the mouth of the Snohomish river at Everett.

Coast Defences.—The entrance to Puget Sound is defended by heavy fortifications upon which over a million dollars have been expended. At three points—Point Wilson, Admiralty Head, and Marrowstone Point—these works have been constructed and provided with modern guns of the heaviest calibre. The forts are arranged in a triangle so that their fire could be concentrated upon any point in the channel, and no fleet could pass the entrance. In addition to this, the cities of Seattle and Tacoma and the navy yard at Port Orchard are defended by strong fortifications in their immediate vicinities.

Finances.—On 30th September 1900 the outstanding warrants on the general fund of the state amounted to $600,719.67, the military funds warrants to $2039.22, and the state bonds to $817,671.72; making a total state indebtedness of $1,418,391.39. The assessed valuation of real estate as equalized for the year 1901 was $188,816,920; of personal property, $54,890,300; and of railway trackage, $16,473,514; making a total valuation of $260,180,734. The state tax was $676,464, and the state school tax, $1,300,902. Since the close of the period of depression in 1893, the banking interest of the state has increased rapidly. The total deposits of the forty-two national and state banks in the autumn of 1901 amounted to $29,198,129, or more than $56 per caput. Of this sum $24,255,000 was in the national institutions, the capital stock of which was $3,155,000, and the loans and discounts, $15,078,000. The state banks had a total capital stock of $1,602,800, and the capital, surplus, and undivided profits and individual deposits amounted to $5,945,210, and the total resources to $9,533,859. The deposits of the national banks increased from $7,009,614 in 1893. For the calendar year 1901 the bank clearings of the three principal cities were: Seattle, $144,634,367; Spokane, $58,856,221; Tacoma, $59,622,548. Savings banks are few, and no statistics with regard to them are available.

Politics: Woman's Suffrage.—The territorial legislature in 1883 passed an Act extending the suffrage to women, and it was declared valid by a decision of the Supreme Court in the following year. In 1886 it was amended, and under this law women voted at all general and municipal elections, and served on grand and petty juries. In 1887 the Supreme Court again reviewed the law, and declared it void on account of a technical defect in the title. The law was re-enacted in 1888 to cure the defect, and was this time overthrown by the Court on the ground that women were not "citizens of the United States" within the meaning of the Organic Act. When the constitution prepared for the state of Washington was submitted to the voters, women's suffrage was embodied in a section which was voted upon separately and defeated. Continued efforts were made to secure another vote on the question, and it was brought before the people again in the election of 1898, when a suffrage amendment was voted upon and lost by some 9000 votes. Under the constitution of the state, the state legislature consists of a senate of 34 members and a house of representatives of 80 members. The governor holds office for four years. The total vote of the state for governor was 58,543 in 1889, and 89,897 in 1892, in both of which years a Republican was elected; in 1900 it was 103,907, when a Democrat was elected with a plurality of 2084 votes. In the presidential election of 1896 the Democratic candidate received a plurality of 12,493, and in 1900 the plurality of the Republican nominee was 12,623.

(J. G. P.)

Washington, a city and the capital of the United States of America. It is on the north bank of the Potomac river, at the head of tide and navigation. The statue on the Capitol dome is in 38° 53′ 23·25″ N. and 77° 00′ 33·55″ W. The city is commonly regarded as identical in area and population with the District of Columbia, since the entire District is under one government, and no distinction, except in matters of taxation, is made between urban and rural portions. Owing to the rapid growth and extension of the city, the area of the District, 60 square miles of land surface, is already in great part covered by urban population. That part of its site lying below the cliffs has become entirely occupied, and urban settlement has extended upon the plateau above the cliffs to the boundaries of the District in several directions.

Washington is one of the best paved cities of the world. More than one-half of its street area is paved with sheet asphalt, while a smaller part, including those streets subjected to heavy traffic, is paved with granite blocks, and altogether about five-sixths of its street area is paved. Its street car service is equally satisfactory: after a long struggle the overhead electric trolley has been banished from the central portions of the district, and the underground trolley adopted on all the urban lines, comprising some 50 miles of double track. The suburban lines are run by overhead trolley. Besides the numerous circles and parks, large and small, which are scattered throughout the city, there are several large parks in its neighbourhood. Among them is the soldiers' home park, north of the centre of the city, comprising an area of 523 acres, in which are the buildings of the national home for soldiers of the regular army. The Zoological Park, on Rock Creek, north-west of the city, comprises an area of 167 acres. Its site is very picturesque, and the collection of animals makes it a popular resort. North of this, and extending to the boundary of the district, and including both banks of Rock Creek, with its wild and picturesque beauty, is a tract of 1600 acres, known as Rock Creek Park, which has been purchased by the Government and as yet is largely unimproved. On the opposite side of the Potomac, in Virginia, is Fort Myer, a military post, with ample grounds, and adjoining it, Arlington, formerly the estate of the Lee family and now a National Cemetery, in which lie buried 16,000 Union soldiers and many distinguished officers. Among the fine buildings recently erected is the new city post office, which occupies an entire square on Pennsylvania Avenue. It is a steel and stone structure, nine storeys in height, with a tower. It houses not only the city post office, but the entire department of the General Post Office, which has been removed from the old post office building on 7th Street.

The libraries of the city are rich and numerous. First in order of mention is the library of Congress, now housed in its new building just east of the Capitol, probably the finest building of its kind in the world. Its dimensions are 470 by 340 feet, thus covering nearly 4 acres. It is of granite, three storeys in height, surmounted by a dome. The interior decorations are exceedingly ornate, many American artists having furnished mural paintings. It was erected between 1888 and 1897 at a cost exceeding $6,000,000, and contains 800,000 books and 250,000 pamphlets. The free city library, housed in a new building on Mount Vernon Square, contains 20,000 volumes. Besides these, several of the Government departments and bureaus maintain libraries, some of which, being on technical subjects, are both valuable and exhaustive. The fine arts are well represented. Many of the smaller parks and circles are embellished with statues of men prominent in American history; the Capitol contains many others, besides noteworthy paintings. The Corcoran Gallery of Art, founded and largely maintained by private endowment, contains a most noteworthy collection of paintings and statuary. It occupies a beautiful new marble building near the state, war, and navy building. The city contains numerous clubs, the principal of which are the Cosmos (scientific and literary), the Metropolitan, the Army and Navy, and the Washington Club. The last is composed of ladies. The rapid growth of the scientific element among the people is illustrated by its scientific societies, ten in number, with a total membership of about 4000. There are in the city numerous hospitals and homes for the dependent. Among the former are Providence Hospital, Garfield Hospital, Columbia Hospital, National Homœopathic Hospital, Freedmans Hospital, and the Emergency Hospital. Among the latter are the Louise Home, industrial home school, reform school, House of the Good Shepherd, home for the aged, children's hospital, and several orphan asylums.

The city contains many educational institutions, including an excellent public school system, private schools and seminaries, and six colleges besides the Carnegie Institution, which was founded by Mr Carnegie in 1902 to "encourage investigation, research, and discovery," and to which he gave $10,000,000. The colleges are as follows:—Columbian University, a Baptist institution, opened in 1821, which in 1899 had a faculty of 173 professors and was attended by 1041 students, including 118 women; Georgetown College, a Jesuit institution, opened in 1891, which had in 1899 a faculty of 113 and was attended by 634 students; Gonzaga College, a Roman Catholic institution, opened in 1821, which had in 1899 a faculty numbering 15 and was attended by 151 students. Gallaudet College, a Government institution for the education of deaf mutes, was opened in 1865; in 1899 its faculty numbered 18 and the attendance was 103, including 39 women; the Catholic University of America, opened in 1889, and intended for graduate students only, had ten years later a faculty numbering 34 and an attendance of 168; the buildings of the American Methodist University are in course of erection.

Washington has in proportion to its population little manufactures or commerce, its industries being mostly such as are required to supply the needs of its inhabitants. The city exists almost wholly for the machinery of government, and contains few other interests. In 1900 it had 2754 manufacturing establishments, with a total capital of $41,981,245. They employed 24,693 hands, and paid in wages $14,643,714. The raw materials used were valued at $19,369,571, and the product was $47,667,622.

The assessed valuation of assessable real and personal property of the District in 1900 was $189,761,256. The non-assessable property, most of which was the property of the general Government, had a value of very nearly the same amount. The net debt of the District was $14,553,874. The rate of taxation for urban property was $15·00 per $1000, for farm lands $10·00. The income of the District was $7,835,680, and the expenditure for maintenance and operation $5,018,211. Because of its large property holdings, the United States Government assumes one-half of the expense of carrying on the District government and one-half of the District debt. The death-rate of the total population of the city in 1890 was 23·7; in 1900 it was 22·8, that of the coloured element being 31·0, and that of the whites 19·1. Population (1890), 230,392; (1900), 278,718, of whom 191,532 were white and 87,186 coloured, including 86,702 negroes. (H. G*.)

Washington, a city of Indiana, U.S.A., capital of Davies county, at the intersection of the Baltimore and Ohio South-Western, the Evansville and Indianapolis, and the Southern Indiana railways, in the south-western part of the state, at an altitude of 510 feet. It is in a coal-mining region, and has a large business in the shipment of coal. Population (1880), 4323; (1890), 6064; (1900), 8551, of whom 391 were foreign-born and 255 negroes.

Washington, a city of Fayette county, Ohio, U.S.A. It is at the intersection of the Baltimore and Ohio, the Cincinnati and Muskingum Valley, the Cincinnati, Hamilton, and Dayton, and the Ohio Southern railways, south-west of the centre of the state, at an altitude of 970 feet. It is a railway centre of importance, and is in a rich farming region, for which it serves as a shipping-point. Population (1880), 3798; (1890), 5742; (1900), 5751, of whom 135 were foreign-born and 708 negroes.

Washington, a borough of Pennsylvania, U.S.A., capital of Washington county, on the Baltimore and Ohio, the Pittsburg, Cincinnati, Chicago and St Louis, and the Waynesville and Washington railways, in the south-western part of the state, at an altitude of 1049 feet. It is in a region of coal and natural gas, and has manufactures of iron, steel, brass, and glass. It is the seat of Washington and Jefferson College, a Presbyterian institution, opened in 1802. In 1899 it had a faculty numbering 16 and was attended by 345 students. Population (1880), 4292; (1890), 7063; (1900), 7670, of whom 465 were foreign-born and 984 negroes.

Wasmes, a town of Belgium, in the province of Hainaut, 7 miles south-west of Mons by rail. It is one of a series of mining towns in the rich coal district known as Le Borinage. Population (1890), 13,105; (1900), 14,538.

Watches.—The most important modern development in watch manufacture is the application of machinery. This was proposed in 1848 by Aaron L. Dennison of Boston, Mass., U.S.A., and two years later, in partnership with Howard and Curtis, a factory was opened at Roxbury, Mass., which was subsequently removed to Waltham, Mass. In 1900 the Waltham factory produced 2500 watches per day, and employed 1400 women and 800 men. The number of separate pieces in a Waltham watch is 160, and in their manufacture and assemblage 3750 different operations are involved. Blanks of sheet metal for wheels are punched out at the rate of 25,000 a day. Fifty or more are strung upon a mandrel, and the teeth are cut by a rotary cutter. For pinions three cutters operate in succession, giving a true epicycloidal shape to the teeth. The microscopic screws are cut and shaped by 41 machines, with a capacity of 175,000 screws per day. There is no attempt to evade necessary operations. Thus the hands require three separate punchings to give them shape, after which they are polished while resting on a rocking support to give the proper rounded contour.

The success of machine-made watches and the possibilities of the factory system led to the manufacture of cheap watches. By the suppression of the fusee and chain a very great reduction had already been brought about in the number of pieces, which was to be still further diminished. The Waterbury watch, the pioneer in the field, had originally fifty-four pieces, less than one-half the number usually found even in a chainless watch. To secure even running the mainspring was made four times as long as usual, or fully nine feet, and the entire movement rotated in the case once every hour. The objectionable feature was the time required to wind the watch. About 1891–92 the "long-wind" construction was discarded. Previous to 1879 the cheapest "short-wind" watch was a Swiss one, costing £3. The modern short-wind watch is composed of forty-seven machine-made parts, and costs but a small fraction of this price. One of the leading manufactories of such watches employs from 500 to 800 operatives. To meet American competition the Swiss have introduced the factory system, together with schools of watch-making, which are most exacting in their curriculum. In England the most expensive watches contain from one hundred and fifty to over one thousand pieces. Yet the factories of the United States produce watches of the finest as well as the cheapest qualities, and some remarkable results in the way of accuracy have been attained with American factory-made watches. But in spite of their success, watch factories in the United States have suffered great vicissitudes. Since 1860 twenty have gone out of existence. A new method for marking dials accurately has been introduced at the watch factory at Elgin, Illinois. A standard plate is engraved with the complete design of the dial. Black enamel powder is dusted over it and wiped off, leaving the material in the lines of the engraving. Collodion solution is then poured over the plate, and, saturating the powder, forms a film, which is floated off in water, and as it floats is picked up upon the blank enamelled watch face. After drying, the face is fired in an enameller's furnace, the collodion burns away, and the enamel of the design fuses. A most accurate dial is the result. A recent innovation is a movement in which the hands rotate in the reverse direction. Such watches are made for sale in the East, and are designed to correspond with the right to left text prevalent in some Oriental countries. Phonographic watches naming the hour are another curiosity in watch-making.

The trials instituted at Kew Observatory in 1884 under the auspices of the Royal Society, and now carried out by the National Physical Laboratory, have had a decided effect in maintaining and improving the quality of English hand-made watches. Three classes of certificates are granted, known respectively as A, B, and C. The A test is by far the most severe. It extends over 45 days, divided into 8 periods of 5 days each, with 4 intermediate and extra days, during which the watch is not rated. During the first three periods the watch is kept at a temperature of 60°–65° F., in a vertical position, the pendant being up in the first period, to the right in the second, and to the left in the third. Then after a day of rest the watch is placed in a refrigerator at a temperature of about 40° F. with the dial up. Having remained there for 5 days, it is kept for a further 5 days with the dial in the same position at about 65° F., and then it is removed, still with the dial up, to an oven having a temperature of about 90° F. In the seventh period it remains for 5 days in a horizontal position, with dial downwards, in a temperature of about 65° F., and finally it spends its eighth period, as at the beginning, in a vertical position with the pendant up. The conditions it must fulfil during the test, in order to gain a certificate, are: (1) The average of the daily departures from the mean daily rate during the same stage of trial must not exceed 2 seconds in any one of the 8 stages; (2) the mean daily rate while in the pendant-up position must differ from the mean daily rate in the dial-up position by less than 5 seconds, and from that while in any other position by less than 10 seconds; (3) the mean daily rate must be affected by change of temperature to an amount less than ⅓ second per degree F.; (4) the mean daily rate must not exceed 10 seconds while in any position. An absolutely perfect watch passing through these trials would receive a total of 100 marks, made up of 40 marks in respect of absence of daily variation of rate, 40 marks for absence of change of rate with change of position, and 20 marks for absence of change of rate with change of temperature. But no watch is absolutely perfect, and those that are sent in are deprived of marks in a regular proportion as they fall short of perfection—in temperature, for instance, for each ·015 second by which the watch departs from zero, that is from no variation, it loses one mark. Watches that obtain 80 marks or more are classed as "especially good." In spite of the severity of the tests applied, the number which gains this distinction shows a distinct tendency to increase in comparison with the number which are awarded simply the class A certificate, and the percentage in 1901, viz., 36·5 per cent., was the highest on record, though the total sent in for trial was much smaller than in many preceding years. The highest number of marks, viz., 91·3, ever gained by a watch was also reached in 1901. Even the most elaborate watches are now made to pass the class A tests with the highest distinction; thus a London firm obtained 83·8 marks for a watch which is probably the most complicated ever produced, being a clock watch striking the hours with minute repeater, minute and seconds and split seconds chronograph, and perpetual calendar, showing day of the week and month and phases of the moon. Non-magnetizable watches, *i.e.*, watches that can be exposed to a strong magnetic field, such as is produced by a dynamo, without injury to their time-keeping qualities, are also now constructed to pass class A tests. Watches which are candidates for B or C certificates have to pass much less severe tests than those which aspire to be ranked in class A, the trials for the former lasting for 31 days and for the latter only 16 days.

Waterbury, a town and city of New Haven county, Connecticut, U.S.A. The town contains an area of 29 square miles of hilly country, situated west of the centre of the state. The city, which includes most of the population of the town, is situated on the Naugatuck river. It is regularly laid out, its streets are poorly paved, and it derives an excellent water-supply from the surrounding hills. It is on a line of the New York, New Haven, and Hartford Railroad, and is at an altitude of 260 feet. Waterbury is a prominent manufacturing centre.

In 1900 it contained 404 manufacturing establishments, with a total capital of $23,421,140. They employed 14,914 hands, and the products were valued at $33,778,905. These consisted in great part of brass goods, which were manufactured to the value of $13,239,031. Buttons, foundry and machine-shop products, and stamped ware were items of secondary importance. In 1900 the assessed valuation of real and personal property was $11,619,908, the net debt of the city was $1,386,302, and the rate of taxation per $1000 was $32·00. Population (1890) of the town, 33,202; of the city, 28,646; (1900) of the town, 51,139; of the city, 45,859, of whom 15,368 were foreign-born and 540 negroes.

Waterford, a maritime county of Ireland, province of Munster, bounded on the N. by counties Tipperary and Kilkenny, on the E. by county Wexford, on the W. by county Cork, and on the S. by the Atlantic. The area of the county in 1900 was 452,743 acres, of which 77,016 were tillage, 245,465 pasture, 19,455 plantation, 1347 turf bog, 15,410 marsh, 75,140 barren mountain, and 18,910 roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, comprises the old judicial county except one electoral division, now added to Kilkenny, and the portions of Clonmel and Carrick-on-Suir formerly situated in Waterford. The population in 1881 was 112,768; in 1891, 98,251; and in 1901, 87,030, of whom 42,905 were males and 44,125 females, divided as follows among the different religions: Roman Catholics, 82,494; Protestant Episcopalians, 3645; Presbyterians, 312; Methodists, 214; and other denominations, 365. The decrease of population between 1881 and 1891 was 12·87, and between 1891 and 1901 9·1 per cent. The average number of persons to an acre in 1891 was ·21, and of the total population 72,136 persons inhabited the rural districts, being an average of 147 to each square mile under crops and pasture.

The following table gives the degree of education in 1891 (excluding the city of Waterford):—

	Males.	Females.	Total.	Percentage.			
				R. C.	Pr. Ep.	Presb.	Meth.
Read and write	22,053	22,149	44,202	61·5	92·9	92·9	94·3
Read only . .	3,154	3,300	6,454	9·4	3·2	5·3	1·2
Illiterate . .	9,363	10,396	19,759	21·9	3·9	1·8	4·5

The percentage of illiterates among Roman Catholics in 1881 was 40·6. In 1891 there were 8 superior schools with 477 pupils (Roman Catholics, 442, and Protestants, 35), and 150 primary schools with 11,447 pupils (Roman Catholics, 11,046, and Protestants, 401). The number of pupils on the rolls of the National schools on 31st December 1900 was 12,921, of whom 12,467 were Roman Catholics and 454 Protestants. The following table gives the number of births, deaths, and marriages in various years:—

Year.	Births.	Deaths.	Marriages.
1881	3154	2771	494
1891	2207	1891	441
1900	1889	1809	407

In 1901 the birth-rate per 1000 was 21·7, the death-rate 20·8, and the rate of illegitimacy 4·5 per cent. of the total births. The total number of emigrants who left the county between 1st May 1851 and 31st December 1900 was 100,147, of whom 53,983 were males and 46,164 females. The chief towns in the county are Waterford, Dungarvan, and Tramore.

Administration.—The county is divided into two parliamentary divisions, East and West, the number of registered electors in 1901 being respectively 4665 and 4724. The rateable value in 1900 was £314,339. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the grand jury were transferred to a county council, urban and rural district councils were established, and under that Act the county now comprises one urban and seven rural sanitary districts. The city of Waterford constitutes a separate county.

Agriculture.—The following tables show the total extent of land under crops, including meadow and clover, and the amount of live stock, in 1881, 1891, 1895, and 1901. The figures for 1901 are for the new administrative county.

Year.	Wheat.	Oats.	Barley, Rye, &c.	Potatoes.	Turnips.	Other Green Crops.	Meadow and Clover.	Total.
1881	8553	30,043	1383	14,453	6933	3852	20,979	86,196
1891	1170	28,167	1333	13,165	6274	4384	23,209	77,702
1895	388	29,159	1762	11,875	7058	4432	23,024	77,698
1901	387	29,331	1572	10,177	6472	5806	24,628	78,373

In 1900 the total value of the cereal and other crops was estimated at £525,398, the smallest amount of any county in Munster. The number of acres under pasture in 1881 was 236,888, in 1891 239,670, and in 1900 245,465.

Year.	Horses and Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	13,447	4220	97,839	49,600	42,719	4892	276,793
1891	15,763	5105	108,803	85,137	44,795	6790	273,003
1895	17,699	5524	105,668	62,213	44,763	5734	293,843
1901	15,982	5938	112,516	72,140	31,860	7467	344,094

The number of milch cows in 1891 was 39,307, and in 1901 39,557. It is estimated that the total value of cattle, sheep, and pigs for 1901 was £1,621,965. In 1900 the number of agricultural holdings not exceeding 1 acre was 2956; between 1 and 5, 1216; between 5 and 15, 1427; between 15 and 30, 1387; between 30 and 50, 1284; between 50 and 100, 1660; between 100 and 200, 825; between 200 and 500, 221; and above 500, 26; total, 11,002. The number of loans issued (the number of loans being the same as the number of tenants) under the Land Purchase Acts, 1885, 1891, and 1896, up to 31st March 1901 was 1144, amounting to £949,210. The number of loans for agricultural improvements sanctioned under sect. 31 of the Land Act, 1881, between 1882 and 1901 was 170, and the amount issued, £12,288. The total amount issued on loan for all classes of works under the Land Improvement Acts from the commencement of operations in 1847 to 31st March in 1901 was £90,591.

Fisheries.—The number of vessels registered in the deep-sea and coast fishery district of Waterford in 1900 was 88, employing 279 hands. The number of persons employed in the salmon fishing districts of Waterford and Lismore in the same year was 2281, and the licence duty paid amounted to £1542. (W. H. Po.)

Waterford, a maritime city, county and parliamentary borough (returning one member), on the river Suir, 97 miles south-south-west of Dublin by rail. Waterford is the second most important port on the south coast of Ireland, vessels of 4000 tons being able to discharge at the quays. In all 1827 vessels of 480,900 tons entered in 1900, and 1427 of 396,764 tons cleared. The value of the imports, which included 792,900 cwts. of maize, amounted to £364,851. In the same year the number of vessels registered in the port was 32 of 4927 tons. The salmon fishery district is extensive, and in 1900 1412 persons were employed. Eighty-eight vessels were registered in the same year in the deep-sea and coast fishery district, employing 279 hands. There is considerable inland navigation, and the junction of the river Barrow with the Grand Canal allows barges to be worked through from Dublin to Waterford. The trade of the town is almost entirely agricultural. In 1898 Waterford was constituted one of the six county boroughs which have separate county councils. The rateable value in 1901 was £48,300. Population (1891), 20,852; (1901), 27,947, the increase being largely due to the extension of the municipal area.

Waterford, a town of Saratoga county, New York, U.S.A. It is situated in 42° 48′ N. and 73° 41′ W., on the west bank of the Hudson, just above the mouth of the Mohawk, and opposite Lansingburg, on the Delaware and Hudson Railroad, in the eastern part of the state. It has excellent water-power, and a variety of manufactures. Population (1880), 4328; (1890), 5286; (1900), 6157, of whom 474 were foreign-born.

Waterhouse, Alfred (1830-——), English architect, was born at Liverpool on 19th July 1830, and passed his professional pupilage under Richard Lane in Manchester. His earliest commissions were of a domestic nature, but his position as a designer of public buildings was assured as early as 1859 by success in the open competition for the Manchester assize courts. This work marked him not only as an adept in the planning of a complicated building on a large scale, but also as a champion of the Gothic cause. Nine years later, in 1868, another competition secured for Waterhouse the execution of the Manchester town hall, where he was able to show a firmer and perhaps more original handling of the Gothic manner. The same year brought him the rebuilding of part of Caius College, Cambridge, not his first university work, for Balliol, Oxford, had been put into his hands in 1867. At Caius, out of deference to the Renaissance treatment of the older parts of the college, the Gothic element was intentionally mingled with classic detail, while Balliol and Pembroke, Cambridge, which followed in 1871, may be looked upon as typical specimens of the style of his mid-career—Gothic tradition (European rather than British) tempered by individual taste and by adaptation to modern needs. Girton College, Cambridge, a building of simpler type, dates originally from the same period (1870), but has been periodically added to by further buildings. Two important domestic works were undertaken in 1870 and 1871 respectively—Eaton Hall for the Duke, then Marquis, of Westminster, and Heythrop Hall, Oxfordshire, the latter, a restoration, being of a fairly strict classic type. Iwerne Minster for Lord Wolverton was begun in 1877. In 1865 Waterhouse had removed his practice from Manchester to London, and he was one of the architects selected to compete for the Royal Courts of Justice. He received from the Government, without competition, the commission to build the Natural History Museum, South Kensington, a design which marks an epoch in the modern use of terra-cotta. The New University Club—a Gothic design—was undertaken in 1866, to be followed nearly twenty years later by the National Liberal Club, a study in Renaissance composition. Waterhouse's series of works for Victoria University, of which he was made LL.D. in 1895, date from 1870, when he was first engaged on Owens College, Manchester. Yorkshire College, Leeds, was begun in 1878; and Liverpool University College in 1885. St Paul's School, Hammersmith, was begun in 1881, and in the same year the Central Technical College in Exhibition Road, London. Waterhouse's chief remaining works in London are the Prudential Assurance Company's offices in Holborn (1876 to present time); University College Hospital, now in progress; the National Provincial Bank, Piccadilly, 1892; the Surveyors' Institution, Great George Street, 1896; and the Jenner Institute of Preventive Medicine, Chelsea, 1895. For the Prudential Company he has designed many provincial branch offices, while for the National Provincial Bank he also designed premises at Manchester. The Liverpool infirmary is Waterhouse's largest hospital; and St Mary's Hospital, Manchester, the Alexandra Hospital, Rhyl, and extensive additions at the general hospital, Nottingham, have also engaged him. Among works not already mentioned are the Salford gaol; St Margaret's School, Bushey; the Metropole Hotel, Brighton; Hove town hall; Alloa town hall; St Elizabeth's church, Reddish; the Weigh House chapel, Mayfair; and Hutton Hall, Yorks.

Waterhouse became a fellow of the Royal Institute of British Architects in 1861, and president from 1888 to 1891. He obtained a Grand Prix for architecture at the Paris Exposition of 1867, and a "Rappel" in 1878. In the same year he received the Royal Gold Medal of the Royal Institute of British Architects, and was made an associate of the Royal Academy, of which body he became a full member in 1885 and treasurer in 1898. He is a member of the Academies of Vienna (1869), Brussels (1886), Antwerp (1887), Milan (1888), and Berlin (1889), and a corresponding member of the Institut de France (1893). Since 1886 he has been constantly called upon to act as assessor in architectural competitions, and was a member of the international jury appointed to adjudicate on the designs for the west front of Milan Cathedral in 1887. In 1890 he served as architectural member of the Royal Commission on the proposed enlargement of Westminster Abbey as a place of burial. From 1891 to 1902, when he retired, his work was conducted in partnership with his son, Paul Waterhouse.

Waterloo, a city of Iowa, U.S.A., capital of Blackhawk county, on the Cedar river, and the Burlington, Cedar Rapids, and Northern, the Chicago Great Western, and the Illinois Central railways, in the eastern part of the state, at an altitude of 841 feet. It is in a rich agricultural region, for which it serves as a shipping and supply point, and it has varied manufactures. Population (1895), 8490; (1900), 12,580, of whom 1334 were foreign-born.

Water Motors.—The most notable developments in the use of water power since the date of the article on HYDROMECHANICS in vol. xii. of this Encyclopædia have been in the supply of high-pressure water from central power stations in large cities like London, Manchester, Glasgow, Liverpool, Antwerp, Melbourne, &c., and the extraordinary increased employment of turbines in the United States, Switzerland, Sweden, and other countries possessing suitable natural water-supplies. The subject of hydraulic transmission of power having already been treated in vol. xxxi. (POWER TRANSMISSION: *Hydraulic*), the present article will be confined to water motors.

Hydraulic Lifts.—The direct-acting lift is perhaps the simplest of all machines using pressure-water, but as the height of the lift increases, certain problems in construction become exceedingly difficult to cope with, notably those due to the great increase in the weight and displacement of the ram. In fact, with a simple ram it is not possible to lift beyond a certain height with a given pressure and load. It becomes, therefore, necessary to balance in some way the varying displacement of the ram if economy is to be secured in the working: this is often done by the use of counterweights attached to chains travelling over head sheaves, but this largely destroys the simplicity and safety of the direct-acting lift, and hence some form of hydraulic balancing is more satisfactory and more certain. In one form, shown in Fig. 1, the lift cylinder is in hydraulic connexion with a pair of short cylinders placed one above the other, the pistons working in them being connected together by a common rod. Below the piston of the upper cylinder is an annular space E (surrounding the common piston rod) with a capacity equal to the maximum displacement of the lift ram, while the corresponding annular area C of the piston of the lower cylinder is just large enough when subjected to the working water-pressure to enable the work of lifting the net load to be done and any friction to be overcome. The area B of the top side of the upper piston is proportioned in such a way that when under the full water pressure the dead weight of the ram and cage is just balanced when the former is at the bottom of its stroke. With this arrangement the lift ram and the two balance pistons are always in equilibrium, or, in other words, the ever-changing displacement of the lift-ram is automatically in balance. To work the lift, pressure-water is admitted to the annular space C above the lower of the two balance pistons (the space B above the upper one is always in communication with the pressure-water), and the combined pressure on the two pistons is sufficient to lift the cage, ram, and load. As the ram ascends it apparently increases in weight, but this is balanced by the greater pressure on the two balance pistons as they descend, owing to the increase of the head of water acting on them. To allow the lift-ram to descend, the pressure-water in C above the lower balance piston is discharged through the exhaust into the drain, while that above the upper piston is simply pushed back into the pressure main. As an illustration of the economy of this system, it may be mentioned that in one lift having a 6-inch ram with a lift of 90 feet, the working load being 1 ton and the maximum working speed 180 feet a minute, the quantity of pressure-water used per journey of 90 feet was reduced from 109 to 24½ gallons by the use of this method of balancing.

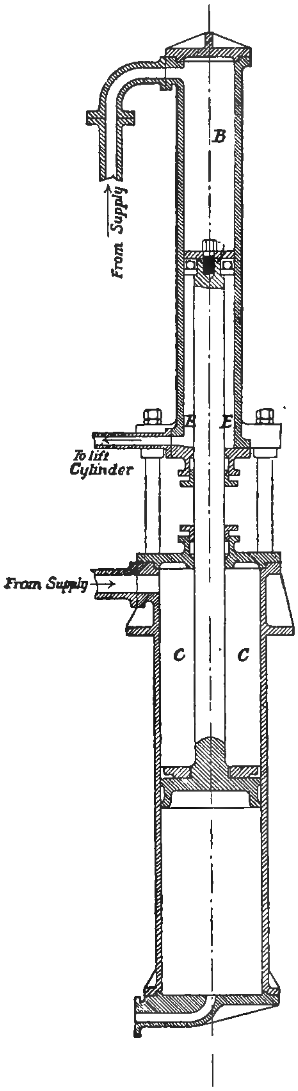

Fig. 1.—Hydraulic Balancing.

In another system of hydraulic balance (Fig. 2) the ram A has an annular area so proportioned that when it is connected with the water in an elevated tank (usually placed somewhere in the roof of the building), the hydraulic pressure upon it just balances the weight of the ram and cage. Here again, since the intensity of the pressure on A becomes greater as it descends owing to the increased head, the apparent increase of weight of the lift-ram as it rises is automatically balanced; water from the high-pressure system is admitted down the hollow ram B and does the work of lifting the live load.

Since the introduction of deep-level electric railways in London and elsewhere, hydraulic passenger lifts on a large scale have been brought into use for conveying passengers up and down from the street level to the underground stations.

Direct-acting Water Motors.—Owing to the difficulty of securing a durable motor with a simple and trustworthy means of automatically regulating the quantity of water used to the power needed at various times from the motor, not much advance has been recently made in the use of water motors with reciprocating rams or pistons. Probably the most successful one has been a rotary engine invented by Mr Arthur Rigg.[1] In this engine the stroke, and therefore the amount of water used, can be varied either by hand or by a governor while it is running; the speed can also be varied, very high rates, as much as 600 revolutions a minute, being attainable without the question of shock or vibration becoming troublesome. The cylinders are cast in one piece with a circular valve, and rotate about a main stud S (Fig. 3), while their plungers are connected to a disc crank which rotates above the point O, which is the centre of the main crank; O S being the crank length or half stroke of the engine, any variation in its length will vary the power of the engine and at the same time the quantity of water used. The movement of S is obtained by means of a relay engine, in which there are two rams of different diameters; a constant pressure is always acting on the smaller of these when the motor is at work, while the governor (or hand-power if desired) admits or exhausts pressure-water from the face of the other, and the movements to and fro thus given to the two rams alter the position of the stud S, and thus change the stroke of the plungers of the main engine. Fig. 4 gives an outside view of a 30 H.P. engine capable of using water at a pressure of 700 ℔ per square inch; the governor is carried within the driving pulley shown at the right-hand end, while the working revolving cylinders are carried inside the boxed-in flywheel at the left-hand end, the relay cylinder and its attachments being fixed to the bed-plate in front of the flywheel. On a test one of these engines gave an efficiency or duty of 80 per cent.

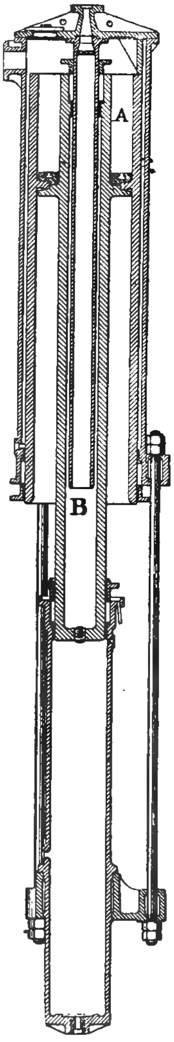

Fig. 2.—Hydraulic Balancing.

Water Wheels.—The Pelton water wheel (Fig. 5) has proved a most successful motor when very high heads are available, heads of 2000 feet having been used occasionally. Such machines have been extensively employed in America, and have also lately been used in Great Britain, worked by the high-pressure water

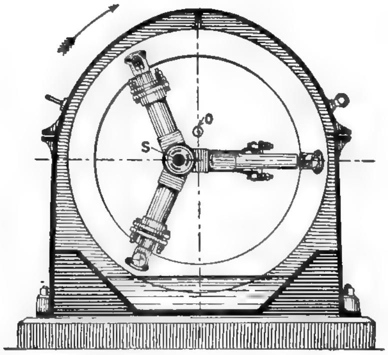

Fig. 3. Section of Rigg's Water-Engine.

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[1] This engine was fully described in *Engineering*, vol. xlv. p. 61.

supplied in large towns. The wheel carries a series of cups placed at equal distances around the circumference. A jet or jets of water impinge on the cups, the interiors of which are shaped in such a way that the jet is discharged parallel to its original direction. If the linear velocity of the cups in feet a second is V_1, and the linear velocity of the jet is V_2, then the velocity of the jet relative to the cup is $V_2 - V_1$ feet a second, and if the whole energy of the water is to be given up to the cups, the water must leave the cup with zero absolute velocity. But its velocity relative to the cup, as it passes backwards, is $-(V_2 - V_1)$, and since the forward velocity of the cup is V_1, the absolute velocity of the water is $-(V_2 - V_1) + V_1$ or $2V_1 - V_2$. This will become zero if V_1 is $\frac{1}{2}V_2$, that is, if the linear velocity of the cup-centres is one-half that of the jet of water impinging upon them. The theoretical efficiency of the wheel would then be 100 per cent. The actual efficiency of these wheels when used with high falls is from 80 to 86 per cent.; when used in connexion with high-pressure water in London an efficiency of 70 per cent. has been obtained, and when a dynamo is driven directly by them about 66 per cent. of the hydraulic energy has been converted into electric energy.

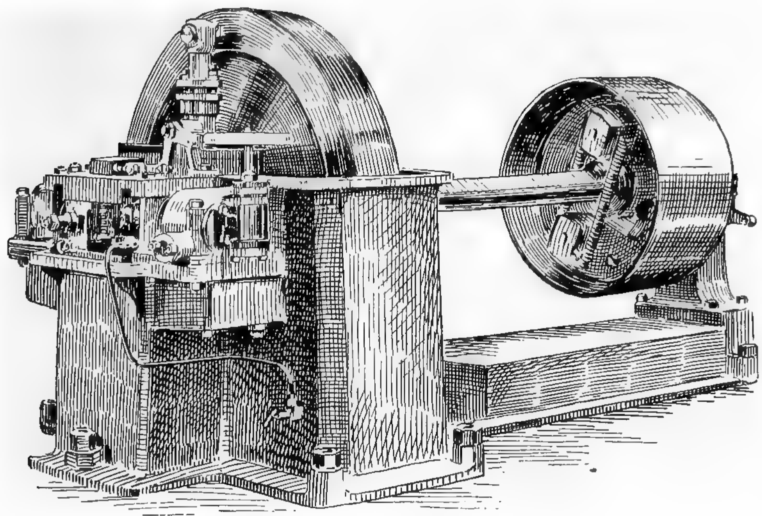

Fig. 4.—External View of Rigg's Water-Engine.[1]

Pelton wheels are very sensitive to variation of load, and considerable trouble was experienced at first in securing adequate governing when they were used to generate electric energy; but this difficulty has been overcome, and they have been rendered most efficient machines for use with high falls, where ordinary turbines would be difficult to manage owing to the excessive speed at which they would run. In a small installation in the United States water is brought in a 36-inch pipe a distance of 1800 feet, and supplies six Pelton wheels each 28 inches in diameter, running at 135 revolutions a minute under a head of 130 feet. The total power developed is 600 H.P., and though the load factor varies very greatly in this case, the differential type of governor used secures perfect control of the running of the wheels.

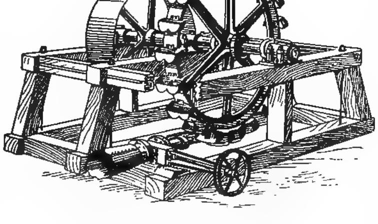

Fig. 5.—Pelton Wheel.

Turbines.—The turbine has now become one of the most efficient of the prime movers employed by man, and in the United States of America and on the Continent of Europe[2] its use has enormously increased of recent years. Though no radical changes have been made in the design of turbines for some years, an immense amount of skill and ingenuity has been shown in perfecting and improving details, and such machines of great size and power are now constantly being made, and give every satisfaction when in use. In the "Hercules" turbine, shown in Fig. 6, the flow is what is called mixed, that is, it is partly a radial inward and partly an axial flow machine. On entering, the water flows at first in a radial direction, and then gradually, as it passes through the wheel, it receives a downward component which becomes more and more important. Professor Thurston has published the results of a test of one of these, which gave an efficiency of 87 per cent. at full load and 70 per cent. at about three-fifths full load.

Another turbine of the mixed flow type is the "Victor," which consists of three parts —the outer guide case, and, inside this, the register gate, and the wheel. The gate regulates the speed of the wheel by varying the quantity of water; when fully open it merely forms a continuation of the guide passages, and thus offers no obstruction to the flow of the water, but by giving it a movement through a part of a revolution the passages are partly blocked and the flow of water is checked. This form of regulation is fairly efficient down to three-quarter opening. Turbines of this type may also be used on horizontal shafts, and are very useful in the case of low falls where there is a large amount of water and the head is fairly constant. At Massena, in the United States, 75,000 H.P. is to be developed from fifteen sets of these turbines working under a head of 40 feet. Each generator can develop 5000 H.P. at a potential of 2200 volts, and is driven by three horizontal double turbines on the same shaft; when working under a minimum head of 32 feet at 150 revolutions, each turbine will have a nominal horse-power of 1000.

Probably the most important application of turbines to the generation of power on a great scale is that at Niagara Falls. The water is tapped off from the river Niagara about a mile above the falls and brought by a canal to the power-house. The wheel-pit is 180 feet in depth, and is connected with the river below the falls by

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[1] This and some of the other drawings have been taken from Blaine's *Hydraulic Machinery*.

[2] The following statistics of turbine construction in Switzerland are taken from *Schweizerische Bauzeitung*, 1901, p. 128, which, in the same volume at p. 53, contains a valuable article on the most important improvements in turbines and their regulation shown in the Paris Exhibition of 1901:—

Period.	Number of Turbines.	Total H.P.	Average H.P.
1844–1869 . .	767	36,894	48
1869–1879 . .	1006	66,688	66½
1879–1889 . .	1840	133,579	72½
1889–1899 . .	2231	400,474	179½
Totals .	5844	637,635	...

a tail-race, consisting of a tunnel 21 feet high and 18 feet 10 inches wide at its largest section. The original turbines were of the "Fourneyron" type, and a pair were mounted on each vertical shaft, the two being capable of giving out 5000 H.P. with a fall of 136 feet. Each pair of wheels is built in three storeys, and the outflow of the water is controlled by a cylindrical gate or sluice, which is moved up and down by the action of the governor. As the pair of wheels and the big vertical shaft (which is of hollow steel 38 inches in diameter) with the revolving part of the dynamo mounted on the upper end of the shaft weigh about 152,000 ℔, a special device, since adopted in other similar power plants, was designed to balance in part this dead weight. The water passes from the penstock through the guide blades of the upper wheel, and in doing so acts in an upward direction on a cover of the upper wheel, which thus becomes, as it were, a balance-piston. The total upward pressure on this piston is calculated to be equal to 150,000 ℔; hence the shaft-bearings are practically relieved from pressure when the wheels are running. Another turbine which has come into extensive use is the "Francis," an exceedingly efficient turbine on a low fall with large quantities of water. At Schaffhausen two of them with a fall of 12½ feet developed 430 H.P., when the older turbines only gave 260 H.P., the efficiency of the Francis turbine being in this case 86 per cent. at full load and 77 per cent. at half load.

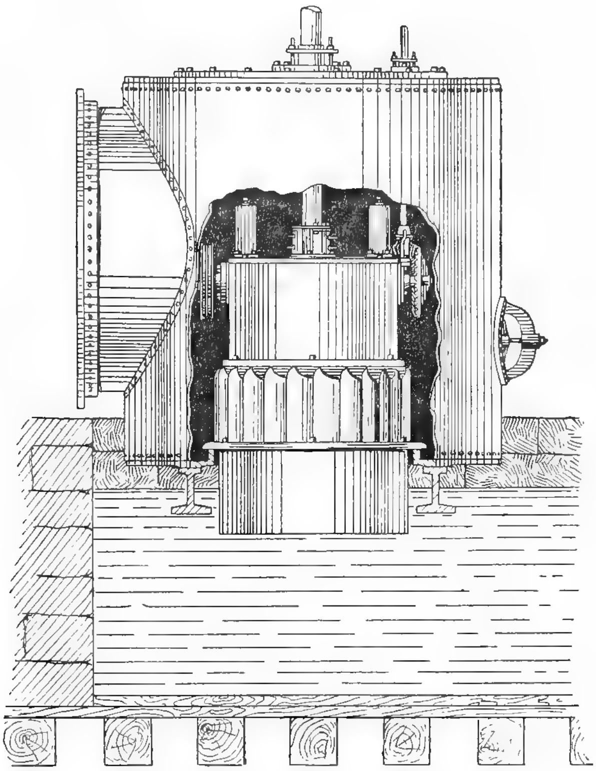

Fig. 6.—"Hercules" Turbine.

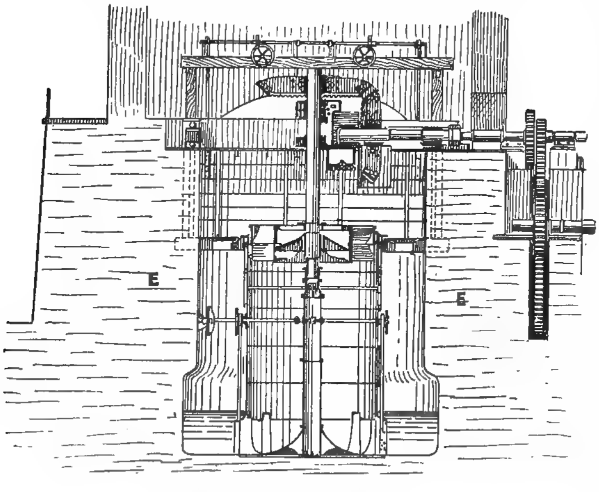

Fig. 7.—Jonval Turbine.

A recent form of the Jonval turbine is shown in Fig. 7. This turbine was designed to give 1250 H.P. with a fall of 25 feet and an efficiency of 77 per cent. It is fitted with a suction pipe and a circular balanced sluice for admitting and cutting off the water-supply. The wheel is 12 feet 3½ inches in diameter, and has a speed of fifty revolutions per minute, and the power generated is transmitted through bevel-gearing to a horizontal shaft from which the power is taken off for various purposes. When complete the turbine weighed about 140 tons. There is a regulating arrangement, by which one-half of the guide-passages can be shut off in pairs from the water, and at the same time air is freely admitted into these unused passages by pipes which pass through the hinges of the controlling shutter. Tests of a turbine of this slow-moving type showed an efficiency of 82 per cent. at full gate, and one of 75 per cent. when half of the passages in the guide-blades were closed by the shutters, as described above.

As an illustration of the use of water-power, even at a considerable distance from a town, the case of Lausanne may be described. The town has secured the right of using a waterfall of 113 to 118 feet high, by impounding the Rhône near Saint Maurice. In dry seasons this will supply 6000 H.P., and for quite ten months in an ordinary year 14,000 H.P. The plant in 1902 consisted of five turbines, having horizontal axles, and each developing 1000 H.P. when running at 300 revolutions a minute. They drive electric generators, and the current so produced is taken at a pressure of 22,000 volts on overhead wires a distance of 35 miles to Lausanne, the loss being estimated not to exceed 10 per cent. in the long transmission. Near the town is a station for reducing the voltage, and current is distributed at 125 volts for lighting purposes and at 500 volts for use on the tramways and for other power purposes.

For further information concerning the construction and employment of water motors, the reader is referred to the following papers and text-books:—*Proc. Inst. Mech. Eng.*, 1882, p. 119; 1889, p. 350; 1895, p. 353. (These papers contain full accounts of recent forms of lifts.)—*Engineering*, vol. lxvii. pp. 91, 128, 160 ("Power Station at Niagara"); vol. lxxii. pp. 391–767 ("Governing of Water Wheels").—*Proc. Inst. Civil Eng.*, vol. lxxxvi. p. 60 ("Mersey Railway Lifts"); vol. xciii. p. 596 ("Experiments on Jonval and Girard Turbines at Alching"); vol. xcvi. p. 182 ("Hydraulic Canal Lifts"); vol. cii. p. 154 ("Keswick Water-Power Electric Station"); vol. cxii. p. 410 ("Hydraulic Works at Niagara"); vol. cxviii. p. 537 ("A 12-Mile Transmission of Power Generated by Pelton Wheels"); vol. cxxiii. p. 530 ("The Pelton Water Wheel"); vol. cxxiv. p. 223 ("The Niagara Power Works"); vol. cxxvi. p. 494 ("The Rheinfelden Power Transmission Plant"); vol. cxli. p. 269 ("Electric Transmission Plants in Transvaal"), p. 307 ("Turbines"); vol. cxlii. p. 451 ("Electrical Installations at Lausanne"); vol. cxlv. p. 423 ("Water Power at Massena"); vol. cxlvii. p. 467 ("Some Large Turbine Installations").—Wood. *Theory of Turbines.*—Bovey. *Hydraulics.*—Björling. *Hydraulic Motors.*—Blaine. *Hydraulic Machinery.*—Bodmer. *Hydraulic Motors.*—Unwin. "Water Motors." (Lectures on Hydro-Mechanics, *Inst. Civil Eng.*, 1885.) (T. H. B.)

WATER SUPPLY.

WATER, parted by evaporation from its impurities, condensed into cloud or vapour, returned to the earth as rain, dew, snow, or hoar frost, and once more gathering impurities on its way to the sea, is artificially collected and sold in England to the value of more than seven millions sterling annually. Collected, purified, and delivered at the home of the consumer, and forced to the top of his house, it costs him commonly about 2d. per ton; but the difficulty of obtaining it is increasing, and the cost is increasing also in a much higher ratio than the population. Nor can we at any future time hope for assistance from other countries in this particular necessary of life. The problem is everywhere of the first importance, and in the future of the British Isles it is a most serious, if not an alarming one.

Nomadic and scattered tribes seem to have set the example of preferring springs or wells to streams, and perennial springs have determined the sites of many ancient cities; but it is doubtful whether, except when navigable, the presence of a river has ever done so. Where towns or villages are situated even upon mountain rivers or streams the preference for natural springs or artificial wells is very marked. The brightness and freedom from colour of most underground waters has led to a general assumption, not always justified, of their comparative wholesomeness. In times of flood open water courses are discoloured with both organic and inorganic matter which may be perfectly harmless, while the brilliancy of a spring is no security whatever against the presence of pathogenic bacteria thriving more readily alone than among their harmless relatives in the river water. When chemistry was in its infancy and bacteriology unknown, it was never suspected that the waters of a turbid river were often perfectly wholesome, while the pellucid spring might contain the germs of disease.

COLLECTING GROUNDS.

Surface Waters.—The whole area from which water, flowing over the surface of the ground, will naturally pass a given point in any natural water-course is commonly known in Europe as the "hydrographic basin" above that point. In English it has been called indifferently the "catchment basin," the "gathering ground," the "drainage area," and the "watershed." The latter term, though originally equivalent to the German *Wasserscheide*—"water-parting"—is perhaps least open to objection. The water-parting is the line bounding such an area and dividing it from other watersheds. The banks of a river or sides of a valley are distinguished as the right or left bank respectively, the spectator being understood to have his back to the source of the stream.

When no reservoir exists, the volume of continuous supply from the surface of any watershed area is evidently limited to the minimum flow of the stream draining that area. This cannot be determined from the rainfall; it entirely depends upon the power of the soil and rock to store water in the particular area under consideration. Mountain areas of 10,000 acres and upwards, partly covered with moorland, upon nearly impermeable rocks with few water-bearing fissures, yield in temperate climates, towards the end of the driest seasons, from a fifth to a quarter of a cubic foot per second per 1000 acres; in the case of the river Severn, the head-waters of which are chiefly supplied from such formations, this rate does not materially change even down to the city of Worcester, past which the discharge flows from 1,256,000 acres. But in smaller areas, which on the average are necessarily nearer to the water-parting, the limits are much wider, and the rate of minimum discharge is generally smaller.

Thus, for example, on 1000 acres or less, it commonly falls to one-tenth of a cubic foot, and upon an upland Silurian area of 940 acres, giving no visible sign of any peculiarity, the discharge fell, on the 21st September 1893, to one-thirty-fifth of a cubic foot per second per 1000 acres. In this case, however, some of the water probably passed through the beds and joints of rocks to an adjoining valley lying at a lower level, and had both streams been gauged the average would probably have been considerably greater. The Thames at Teddington, fed largely from cretaceous areas, fell during ten days in September 1898 (the artificial abstractions for the supply of London being added) to about one-sixth of a cubic foot per second per 1000 acres; while since 1880 the discharge has occasionally fallen, in each of six other cases, to about one-fifth of a cubic foot per second per 1000 acres. Owing, however, to the very variable permeability of the strata, the tributaries of the Thames, when separately gauged, yield the most divergent results. It may be taken as an axiom that the deviation of minimum surface-discharges from their mean increases as the separate areas diminish. In the eastern and south-eastern counties of England even greater variety of dry weather flow prevails than in the west, and upon the chalk formations there are generally no surface streams, except such as burst out after wet weather and form the so-called "bournes."

Rainfall.

When, however, a reservoir is employed to equalize the flow during and before the period of dry weather, the first essential in determining the yield is to ascertain the rainfall. For this purpose, if there are no rain gauges on the drainage area in question, we can only form an estimate from the records of numerous gauges throughout the country, most of which are published in *British Rainfall* by the successors of the late Mr G. J. Symons, F.R.S.; but even in the hands of those who have spent years in such investigations, this method may lead to most incorrect conclusions. If any observations exist upon the drainage area itself they are commonly only from a single gauge, and this gauge, unless the area is very level, may give results widely different from the mean fall on the whole area. Reliance upon single gauges in the past has been the cause of serious errors in the estimated relation between rainfall and flow off the ground.

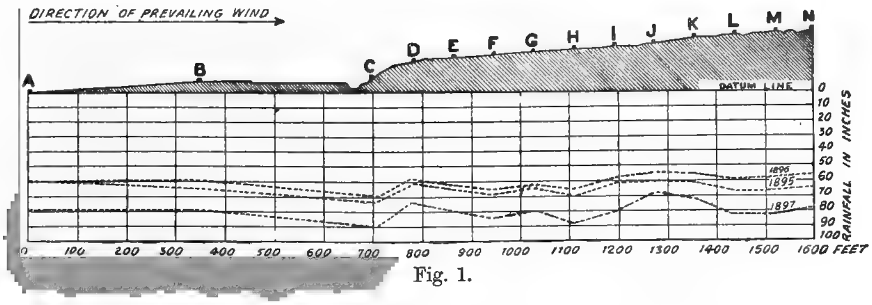

Fig. 1.

The uncertainties are illustrated by the following actual example. A battery of fourteen rain gauges, in the same vertical plane, on ground having the natural profile shown by the section (Fig. 1), gave during three consecutive years the respective falls shown by the depth of the dotted lines below the datum line. Thus on the average, gauge C recorded 20 per cent. more than gauge D, only 70 feet distant. The prevailing winds are along the section from left to right, between A and N; their direction is therefore necessarily inclined upwards, and a large proportion of the drops are thus thrown clear of the gauge D to augment the fall in the gauges F to I. Then comes the curious depletion at gauge J, an effect of the wind eddy caused by the obstruction between C and D. At C in 1897 the rainfall was actually 30 per cent. greater than at J, only 187 yards distant. At the place where these observations were made the average rainfall is about 70 inches, and the altitude exceeds 1400 feet above the sea. In less exposed positions such extreme variations would not occur, but it is nevertheless essential everywhere to guard against the perturbations which apparently slight irregularities of the surface may cause. It has been commonly stated that the rainfall increases with the altitude. This is broadly true. A rain-cloud raised vertically upwards expands, cools, and tends to precipitate; but in the actual passage of rain-clouds over the surface of the earth other influences are at work. In Fig. 2 the thick line represents the profile of a vertical section crossing two ranges of hills and one valley. The arrows indicate the directions of the prevailing winds. At the extreme left the rain-clouds are thrown up, and if this were all, they would precipitate a larger proportion of the moisture they contained as the altitude increased. But until the clouds rise above the hill there is an obvious countervailing tendency to compression, and in steep slopes this may reduce or entirely prevent precipitation until the summit is reached, when a sudden fall of pressure must occur. Very high mountain ranges usually consist of many ridges, among which rain-clouds are entangled in their ascent, and in such cases precipitation on the windward side of the main range, though on the leeward sides of the minor ridges of which it is formed, may occur to so large an extent that before the summit is reached the clouds are exhausted or nearly so, and in this case the total precipitation is less on the leeward than on the windward side of the main range; but in the moderate heights of the United Kingdom it more commonly happens from the causes explained that precipitation is prevented or greatly retarded until the summit of the ridge is reached. The following cause also contributes to the latter effect. Imagine eleven raindrops A to K to fall simultaneously and equi-distantly from the horizontal plane A M. A strong wind is urging the drops from left to right. The drops A and K may be readily conceived to be equally diverted by the wind, and to fall near the tops of the two hills respectively. Not so drop C, for directly the summit is passed the wind necessarily widens out vertically and, having a greater space to fill, loses forward velocity. It may even eddy backwards, as indicated by the curved arrows, and it is no uncommon thing, in walking up a steep hill in the contrary direction to the flight of the clouds, to find that the rain is coming from behind. Much the same tendency exists down to E, but at F the wind has begun to accommodate itself to the new régime and to assume more regular forward motion, and as J is approached, where vertical contraction of the passage through which the wind must pass takes place, there is an increasing tendency to lift the raindrops beyond their proper limits. The general effect is that the rain falling from between G and K is spread over a greater area of the earth G′ K′ than that falling from the equal space between B and F, which reaches the ground within the smaller area B F. From this cause also, therefore, the leeward side of the valley receives more rain than the windward side. In the United Kingdom the prevailing winds are from the south-west, and some misapprehension has been caused by the bare, but perfectly correct, statement that the western slope is wetter than the eastern. Over the whole width of the country from coast to coast, or of the Welsh mountain ranges only, this is so; but it is nevertheless true that the leeward side of an individual valley generally receives more rain than the windward side, and also that the leeward side of an individual ridge receives more rain than the windward side. Successive abstraction of rain-drops as the rain-clouds pass over ridge after ridge causes a gradually diminishing precipitation, but this is generally insufficient to reverse the local conditions, which tend to the contrary effect in individual ranges. The neglect of these facts has led to many errors in estimating the mean rainfall on watershed areas from the fall observed at gauges in particular parts of those areas.

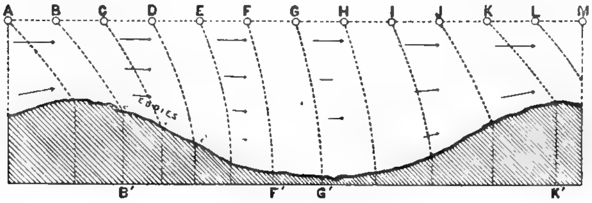

Fig. 2.

On large watersheds at least two rain gauges to every thousand acres have been found necessary to determine the annual rainfall with sufficient accuracy, and on smaller areas the proportion necessary for equal accuracy must be greater. In the simplest case of a single valley we ought at least to know the rainfall at five points, three being in the axis of the valley, and one near the point of intersection of that axis with the watershed. Then, in order to connect with these the effect of the right- and left-hand slopes, there should be at least one gauge on each side about the middle height, and approximately in a line perpendicular to the axis of the valley passing through the central gauge. The relative depths recorded in the several gauges depend mainly upon the direction of the valley and steepness of the bounding hills. The gauge in the bottom of the valley farthest from the source will generally record the least rainfall, and one of those on the south-west side the highest. Much will depend upon the judicious placing of the gauges. Each gauge should have for 10 or 15 yards around it an uninterrupted plane fairly representing the general level or inclination, as the case may be, of the ground for a much larger distance around it. The earliest records of such gauges should be carefully examined, and if any apparently anomalous result is obtained, the cause should be traced, and when not found in the gauge itself, or in its treatment, other gauges should be used to check it. The central gauge is useful for correcting and checking the others, but in such a perfectly simple case as the straight valley above assumed it may be omitted in calculating the results, and if the other four gauges are properly placed, the arithmetical mean of their results will probably not differ widely from the true mean for the valley. But such records carried on for a year or many years would afford no knowledge of the worst conditions that could arise in longer periods, were it not for the existence of much older gauges not far distant and subject to somewhat similar conditions. The nearer such long-period gauges are to the local gauges the more likely are their records to rise and fall in the same proportion. The work of Mr James Glaisher, F.R.S., of the late Mr G. J. Symons, F.R.S., of the Meteorological Office and of the Royal Meteorological Society has resulted in the establishment of a vast number of rain gauges in different parts of the United Kingdom, and it is generally, though not always, found that the mean rainfall over a long period can be determined, for an area upon which the actual fall is known only for a short period, by assigning to the missing years of the short-period gauges rainfalls bearing the same proportion to those of corresponding years in the long-period gauges that the rainfalls of the known years in the short-period gauges bear to those of corresponding years in the long-period gauges. In making such comparisons, it is always desirable if possible to select as standards long-period gauges which are so situated that the short-period district lies between them. Where suitably placed long-period gauges exist, and where care has been exercised in ascertaining the authenticity of their records and in making the comparisons, nearly correct results may thus be obtained in carrying back the records of the local gauges.

Rainfall is proverbially uncertain; but it would appear from the most trustworthy records that observations of a single gauge, extending over 50 years, will probably not vary more than 1 or 2 per cent. from the true mean, while the records of any period of 25 years will generally be found to fall within 3½ per cent. of the mean of 50 years. It is equally satisfactory to know that there is a nearly constant ratio, at any given place, between the true mean annual rainfall, the rainfall of the driest year, the two driest consecutive years, and any other groups of driest consecutive years. Thus if from a period of 50 years the two or three driest are selected, their rainfalls will generally be found to differ but little, while the rainfall of the driest will be about 63 per cent. of the mean for the 50 years.

That of the two driest consecutive years will be about 72 per cent. of the mean for the 50 years.

That of the three driest consecutive years will be about 77 per cent. of the mean for the 50 years.

That of the four driest consecutive years will be about 80 per cent. of the mean for the 50 years.

That of the five driest consecutive years will be about 82 per cent. of the mean for the 50 years.

That of the six driest consecutive years will be about 83¾ per cent. of the mean for the 50 years.

As a single rain gauge only represents the actual rainfall upon an exceedingly small area of the earth's surface, its annual records are subject to greater perturbations than can occur when the mean of several gauges near together is used for the determination. Hence the fact that isolated gauges occasionally show somewhat greater deviations in particular years from the true mean does not vitiate the general trustworthiness of the results. But if, instead of regarding only the mean rainfall over a series of years, we compare the relative falls in short intervals of time among gauges yielding the same general averages, the discrepancies prove to be enormous, and it follows that the maximum possible intensity of discharge from different areas rapidly increases as the size of the watershed decreases. Extreme cases of local discharge are due to the phenomena known in America as "cloud-bursts," which occasionally occur in Great Britain and result in discharges of far greater intensity than anything yet recorded by rain gauges. The periods of such discharges are so short, their positions so isolated, and the areas affected so small, that we have little or no exact knowledge concerning them, though their disastrous results are well known. They do not directly affect the question of supply, but may very seriously affect the works from which that supply is given.

Evaporation and absorption.

Where in this article the term "evaporation" is used alone, it is to be understood to include absorption by vegetation. Of the total quantity of rainfall a very variable proportion is rapidly absorbed or re-evaporated. Thus in the western mountain districts of Great Britain, largely composed of nearly impermeable rocks more or less covered with pasture and moorland, the water evaporated and absorbed by vegetation is from 13 to 15 inches out of a rainfall of 80 inches, or from 16 to 19 per cent., and is nearly constant down to about 60 inches, where the proportion of loss is therefore from 22 to 25 per cent. The Severn down to Worcester, draining 1,256,000 acres of generally flatter land largely of the same lithological character, gave in the dry season from the 1st July 1887 to 30th June 1888 a loss of 17·93 inches upon a rainfall of 27·34 inches, or about 66 per cent.; while in the wet season, 1st July 1882 to 30th June 1883, the loss was 21·09 inches upon a rainfall of 43·26 inches, or only 49 per cent. Upon the Thames basin down to Teddington, having an area of 2,353,000 acres, the loss in the dry season from 1st July 1890 to 30th June 1891 was 17·22 inches out of a rainfall of 21·62 inches, or 79 per cent.; while in the wet season, 1st July 1888 to 30th June 1889, it was 18·96 out of 29·22 inches, or only 65 per cent. In the eastern counties the rainfall is lower and the evaporation approximately the same as upon the Thames area, so that the percentage of loss is greater. But these are merely broad examples and averages of many still greater variations over smaller areas. Again, with the same rainfall in two different seasons the evaporation may vary greatly. An inch falling in a single day on a saturated mountain area will nearly all reach the rivers, but if it falls during a drought seven-eighths may be lost so far as the period of the drought is concerned. In such a case most of the water is absorbed by the few upper inches of soil, only to be re-evaporated during the next few hours or days, and the small proportion which sinks into the ground probably issues in springs many months later. Thus the actual yield of rainfall to the streams depends largely upon the mode of its time-distribution. Without a knowledge of this it is impossible to anticipate the yield of a particular rainfall, and in judging of the minimum annual flow of a stream we must not only assume the incidence of a minimum rainfall, but also that its distribution will be such that a maximum re-evaporation and absorption of that rainfall will occur. In estimating the evaporation to be deducted from the rainfall, for the purpose of determining the flow into a reservoir, it is important to bear in mind that the loss from a constant water surface is nearly twice as great as from the intermittently saturated land surface. A simple and safe rule is to add the mean water surface of the reservoir (between the limits of high and low water) to the total area, including the reservoir, over which the rainfall and evaporation are calculated.

Variation of discharge.

Even neglecting the isolated and local discharges due to excessive and generally unrecorded rainfall, the variation in the discharge of all streams, and especially of mountain streams, is very great. We have seen that the average flow from mountain areas in Great Britain towards the end of a dry season does not exceed one-fifth of a cubic foot per second per 1000 acres. Adopting this general minimum as the unit, we find that the flow from such areas up to about 5000 acres, whose mean annual rainfall exceeds 50 inches, may be expected occasionally to reach 1500 such units; while from similar areas of 20,000 or 30,000 acres with the same mean rainfall the discharge sometimes reaches 1200 or 1300 such units. It is well to compare these results with those obtained from much larger areas but with lower mean rainfall. The Thames at Teddington has been continuously gauged by the Thames Conservators since 1883, and the Severn at Worcester by the writer, on behalf of the corporation of Liverpool, during the 10 years 1881 to 1890 inclusive. The highest flood, common to the two periods, was that which occurred in the middle of February 1883. On that occasion the Thames records gave a discharge of 7·6 cubic feet per second per 1000 acres, and the Severn records a discharge of 8·6 cubic feet per second per 1000 acres, or 38 and 43 respectively of our units; while in February 1881, before the Thames gaugings were commenced, the Severn had risen to 47 of such units, and subsequently in May 1886 rose to 50 such units, though the Thames about the same time only rose to 13. But in November 1894 the Thames rose to about 80 such units, and old records on the Severn bridges show that that river must on many occasions have risen to considerably over 100 units. In both these cases the natural maximum discharge is somewhat diminished by the storage produced by artificial canalization of the rivers.

Compensation water.

These illustrations of the enormous variability of discharge serve to explain what is popularly so little understood, namely, the advantage which riparian owners, or other persons interested in a given stream, may derive from works constructed primarily for the purpose of diverting the water of that stream—it may be to a totally different watershed—for the purposes of a town supply. Under modern legislation no such abstraction of water is usually allowed, even if limited to times of flood, except on condition of an augmentation of the natural dry-weather flow, and such a condition at once involves the construction of a reservoir. The water supplied to the stream from such a reservoir is known as "compensation water," and is generally a first charge upon the works. This water is usually given as a continuous and uniform flow, but in special cases, for the convenience of mill-owners, as an intermittent one. In the manufacturing districts of Lancashire and Yorkshire it generally amounts to one-third of the whole so-called "available supply." In Wales it is usually about one-fourth, and elsewhere still less; but in any case it amounts to many times our unit of one-fifth of a cubic foot per second per 1000 acres. Thus the benefit to the fisheries and to the riparian owners generally is beyond all question; but the cost to the water authority of conferring that benefit is also very great—commonly (according to the proportion of the natural flow intended to be rendered uniform) 20 to 35 per cent. of the whole expenditure upon the reservoir works.

Yield of stream with reservoir.

Down to the middle of the 19th century, the proportioning of the size of a reservoir to its work was a very rough operation. There were few rainfall statistics, little was known of the total loss by evaporation, and still less of its distribution over the different periods of dry and wet weather. Certain general principles have since been laid down, and within the proper limits of their application have proved excellent guides. Generally it has been stated, with respect to any watershed area, that if from the average annual rainfall of the three driest consecutive years we deduct the corresponding evaporation and absorption by vegetation, the result will be the *available supply* or *flow* from that area. But this is evidently only the case when the reservoir impounding the water from such an area is of just sufficient capacity to equalize that flow without possible exhaustion in any one of the three summers. If the reservoir were larger it might equalize the flow of the four or more driest consecutive years, which would be somewhat greater than that of the three; if smaller, we might only be able to count upon the average of the flow of the two driest consecutive years, and there are many reservoirs which will not yield the average even of the single driest year. With further experience it has become obvious that very few reservoirs are capable of equalizing the full flow of the three consecutive driest years, and each engineer, in estimating the yield of such reservoirs, has deducted from the quantity ascertained on the assumption that they do so a certain quantity representing, according to his judgment, the overflow which in one or more of such years might occur. The actual size of the reservoir which would certainly yield the assumed supply throughout the driest periods has therefore been largely a matter of judgment. Empirical rules have grown up assigning to each district, according to its average rainfall, a particular number of days' supply, independently of any inflow, as the contents of the reservoir necessary to secure a given yield throughout the driest seasons. But any such generalizations are dangerous, and have frequently led to disappointment and sometimes to needless expenditure. The exercise of sound judgment in such matters will always be necessary, but it is nevertheless important to formulate so far as possible the conditions upon which that judgment should be based. It is necessary to know not only the mean flow of the stream, as represented by the rainfall less the evaporation, but also the distribution of that flow throughout the year.

The most trying distribution of which the author has had experience in the United Kingdom, or which he has been able to discover from a comparison of rainfalls upon nearly impermeable areas exceeding 1000 acres, is graphically represented in Fig. 3. In this the total depth of the diagram is marked 100 per cent., and represents the total flow of the year, while the months during which that flow occurs are measured horizontally. The thick irregular line shows the least favourable distribution, cumulatively recorded throughout the year, of the flow off the ground, resulting from the fluctuations of rainfall during a single year, while the straight line $a\,b$ represents uniformly distributed supply, also cumulatively recorded, of the same quantity of water over the same period. But, apart from the diurnal fluctuations which are equalized by local "service reservoirs," uniform distribution of supply throughout twelve months is rarely what we require; and to represent the demand in most towns correctly, we should increase the angle of this line during the summer and diminish it during the winter months, as indicated by the dotted lines $b\,b$. The most noticeable features of this particular diagram are as follows: Up to the end of 59 days (to the 28th February) the rate of flow is, with rare exceptions, greater than the mean flow for the year, but during the 184 days between this and the end of the 243rd day (31st August) the rate of flow is generally below the mean, while from that day to the end of the year it is again above the mean. Now in order that a reservoir may enable the varying flow, represented cumulatively by the irregular line, to be discharged in a continuous and uniform flow to satisfy a demand represented cumulatively by the straight line, its capacity must obviously be at least equal to the greatest deficiency $c\,d$ of the cumulative flow below the cumulative demand, plus the greatest excess $f\,e$ of the cumulative flow over the cumulative demand. The former is the later condition, and arises in this case on the 243rd day (31st August), when the total cumulative deficiency is graphically shown by the vertical distance $d\,g$ to the line $a'\,a'$ drawn parallel to $a\,a$, and touching the point e of maximum excess of cumulative flow. This height, shown by a thickened line, is equal, on the vertical scale, to the difference between 48 per cent. and 78 per cent., or 30 per cent. of the stream flow during the year. A reservoir so proportioned to the demand, with a small addition to avoid drawing off the bottom water, would probably be safe in Great Britain in any year, or, if it failed, that failure would be of very short duration, and would probably only occur once in 50 years.

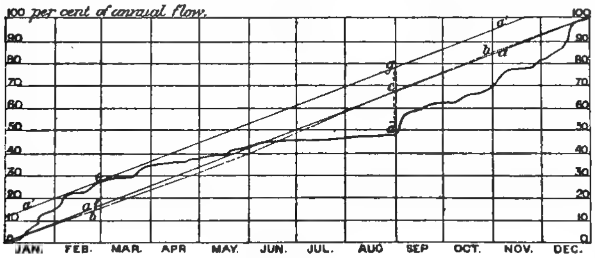

Fig. 3.

It may be at first sight objected that a case is assumed in which there is no overflow before the reservoir begins to fall, and therefore no such loss as generally occurs from that cause. This is true, but it is only so because we have made our reservoir large enough to contain all the water that falls before the 28th February in this particular year, and if more water had fallen before that date the rainfall for the year would have been increased, and the year would not have been the driest. Experience shows, in fact, that, for the assumed rainfall of the year, the distribution on the diagram is the least favourable likely to occur, and that if for the same average fall a different distribution occurs, that distribution will not try the reservoir more severely, unless the demand is differently distributed. The particular drought shown on the diagram is the result of an exceptionally early deficiency of rainfall. The reservoir begins to fall at the end of February, and continues to do so with few and short exceptions until the end of August, and it so happens that about the end of August the curved dotted line representing actual cumulative demand crosses the line of uniform demand, so that the excess of demand, represented by the slope from June to September, is balanced by the deficiency of demand, represented by the flatter slope in the first five months, except as regards the small quantity $b\,f$ near the end of February, which, not having been drawn off during January and February, must overflow before the end of February. When, however, the drought ends later, at the end of October, for example, the excess of the dotted line at that time is to be added to its deficiency at the end of February, or whenever the fall in the line of flow begins, and the capacity of the reservoir must be increased to this extent. When the maximum monthly demand does not exceed the average by more than 13 per cent., the excess from this cause at the end of the drought, added to the deficiency at the beginning of the drought, is about 3 per cent. of the flow during the year, and in the case of a one-year reservoir it therefore increases the necessary capacity from 30 to 33 per cent. of the flow. But in assuming this condition of demand, and increasing our reservoir to meet it, we assume also that some additional supply to that reservoir can be obtained from the previous year. The most trying assumption is that the rainfall of the previous year together with that of the driest year will be the rainfall of the two driest consecutive years. We have already seen that while the rainfall of the driest of 50 years is about 63 per cent. of the mean, that of the driest two consecutive years is about 72 per cent. of the mean. It follows, therefore, that the year immediately preceding the driest cannot have a rainfall less than about 81 per cent. of the mean. As the loss by evaporation is a deduction lying between a constant figure and a direct proportional to the rainfall, we should err on the safe side in assuming the flow to be increased proportionately to the rainfall, or by the difference between 63 and 81, equal to 18 per cent. of the mean of 50 years. This 18 per cent., if spread over the two years, is evidently much more than sufficient to meet the summer excess over the average demand up to the 15th October of the driest year; and an increase in the size of the reservoir sufficient to carry over, from the first to the second year, the small additional quantity of water represented by 3 per cent. of the yield of the driest year will therefore meet the irregular demand.

But in determining the capacity of reservoirs intended to yield a supply of water equal to the mean flow of two, three, or more years, the error, though on the safe side, caused by assuming the evaporation to be proportional to the rainfall, is too great to be neglected. The evaporation slightly increases as the rainfall increases, but at nothing like so high a rate. Having determined this evaporation for the second driest consecutive year and deducted it from the rainfall—which, as above stated, cannot be less than 81 per cent. of the mean—we may extend our cumulative diagram of flow into the reservoir, and of demand, from one to two years. In the same way we may group in a single diagram any number of consecutive driest years, and either ascertain the reservoir capacity necessary for a given uniform yield (represented cumulatively by a straight line corresponding with *a′ a′*, but drawn over all the years instead of one), or conversely, having set up a vertical at the most trying point (representing, in percentage of the total annual flow of the driest year, the capacity of reservoir which it may be convenient to provide), we may draw a straight line of uniform yield from the head of that vertical to the previous point of maximum excess of cumulative flow. That line, produced to the boundaries of the diagram, will give the total uniform supply which may be safely drawn from the reservoir within the given period, always provided that the higher end to the right does not rise above the thick irregular line of natural cumulative flow. It is to be observed that any irregularity in the rate of supply from the reservoir may occur between the critical periods of maximum excess of cumulative flow and maximum deficiency of cumulative flow (*e* and *g* respectively, in the one year diagram), which does not increase the total supply between those points, or cause the line of cumulative supply from the reservoir to cut the line of cumulative flow into it; and the correction for excess of demand during dry weather in the single year reservoir evidently requires no addition by reason of the increase in the number of years over which the reservoir equalizes the flow.

From a diagram, covering many years and constructed upon these principles, the general diagram (Fig. 4) has been produced. To illustrate its use, assume the case of a mean rainfall of 50 inches (figured in the right-hand column at the end of a curved line) and of 14 inches of evaporation and absorption by vegetation (marked upon that line). The ordinate, to any point upon this curved line, then represents the yield per day for each acre of drainage area, from a reservoir whose capacity is equal to the corresponding abscissa. Thus, if we require a yield of 1080 gallons per acre, we find the point on the curve, whose ordinate is 1080, on the scale to the left of the diagram; while on the scale at the foot we find that the corresponding abscissa is equal to 120,000 gallons. If, then, for example, the drainage area is 2000 acres, the required reservoir capacity will be 240,000,000 gallons (in addition to any allowance for bottom water, or excess of summer demand above the mean supply). The point which, in this case, we have selected on the curve, is intersected by the left-hand radial line, showing that the yield of the reservoir is exactly equal to the natural flow during the driest year; and therefore, as already stated, that the capacity of the reservoir is just 30 per cent. of that flow. Similarly, the yield from any given reservoir, or the capacity required for any yield, corresponding with any mean rainfall from 30 to 100 inches, and with the flow over any period, from the driest year to the six or more consecutive driest years, may be determined from the diagram.

It is instructive to note the ratio of increase of reservoir capacity and yield respectively for any given rainfall. Thus, assuming a mean rainfall of 60 inches during 50 years, subject to evaporation and absorption equal to 14 inches throughout the dry period under consideration, we find from the diagram the following quantities (in gallons per acre of drainage area) and corresponding ratios:—

Number of driest consecutive years the flow of which is equalized.	Net Capacity of Reservoir.			Yield of Reservoir.		
	Gallons per acre of drainage area.	In terms of 1 year Reservoir=100.	Increase per cent. on each step.	Gallons per day.	In terms of yield of driest year=100(=30 per cent. of natural flow).	Increase per cent. on each step.
1	166,000	100	0	1475	100	0
2	258,000	155·4	55·4	1815	123·1	23·1
3	329,000	198·2	27·5	1987	134·7	9·4
4	390,000	234·9	18·5	2103	142·6	5·9
5	441,000	265·7	13·1	2187	148·3	4·0
6	487,000	293·4	10·4	2255	152·9	3·1

It is thus manifest that so great is the increase required in the size of a reservoir in relation to its increased yield, that only in the most favourable places for reservoir construction, or under the most pressing need, can it be worth while to go beyond the capacity necessary to render uniform the flow of the two or three driest consecutive years.

It must be clearly understood that the diagram Fig. 4 does not relieve the reader from any exercise of judgment, except as regards the net capacity of reservoirs when the necessary data have been obtained. It is merely a geometrical determination of the conditions necessarily consequent upon a given mean rainfall over many years, upon evaporation and absorption in particular years (both of which he must determine for himself), and upon certain limiting variations of the rainfall, already stated to be the result of numerous records maintained in Great Britain for more than 50 years. It must also be remembered that the total capacity of a reservoir must be greater than its net available capacity, in order that in the driest seasons fish life may be maintained and no foul water drawn off.

Throughout Europe the annual variations of rainfall, in relation to the mean, follow nearly the same law as in Great Britain, but in some parts the distribution of rainfall in a single year is often more trying. The droughts are longer, and the rain, when it falls, especially along the Mediterranean coast, is often concentrated into shorter periods. Moreover, it often falls upon sun-heated rocks, thus increasing the evaporation for the time; but gaugings made in the northern Apennines indicate that this loss is more than compensated by the greater rapidity of the fall and of the consequent flow. In such regions, therefore, for reservoirs equalizing the flow of two or more years, the capacity necessary does not materially differ from that required in Great Britain. As the tropics are approached, even in mountain districts, the irregularities become greater, and occasionally the rainy season is entirely absent for a single year, though the mean rainfall is considerable.

Springs and Wells.—We have hitherto dealt only with the collection and storage of that portion of the rainfall which flows over the surface of nearly impermeable areas. Upon such areas the loss by percolation into the ground may be neglected, and the only loss to be considered is that of re-evaporation into the air and of absorption by vegetation. The crust of the earth varies from almost complete impermeability to almost complete permeability. Among the sedimentary rocks we have, for example, in the clay slates of the Silurian formations, and in parts of the Greensand and Chalk, the opposite extremes; while the igneous rocks are for the most part only permeable in virtue of the fissures they invariably contain. Wherever, below the surface, there are pores or fissures, water

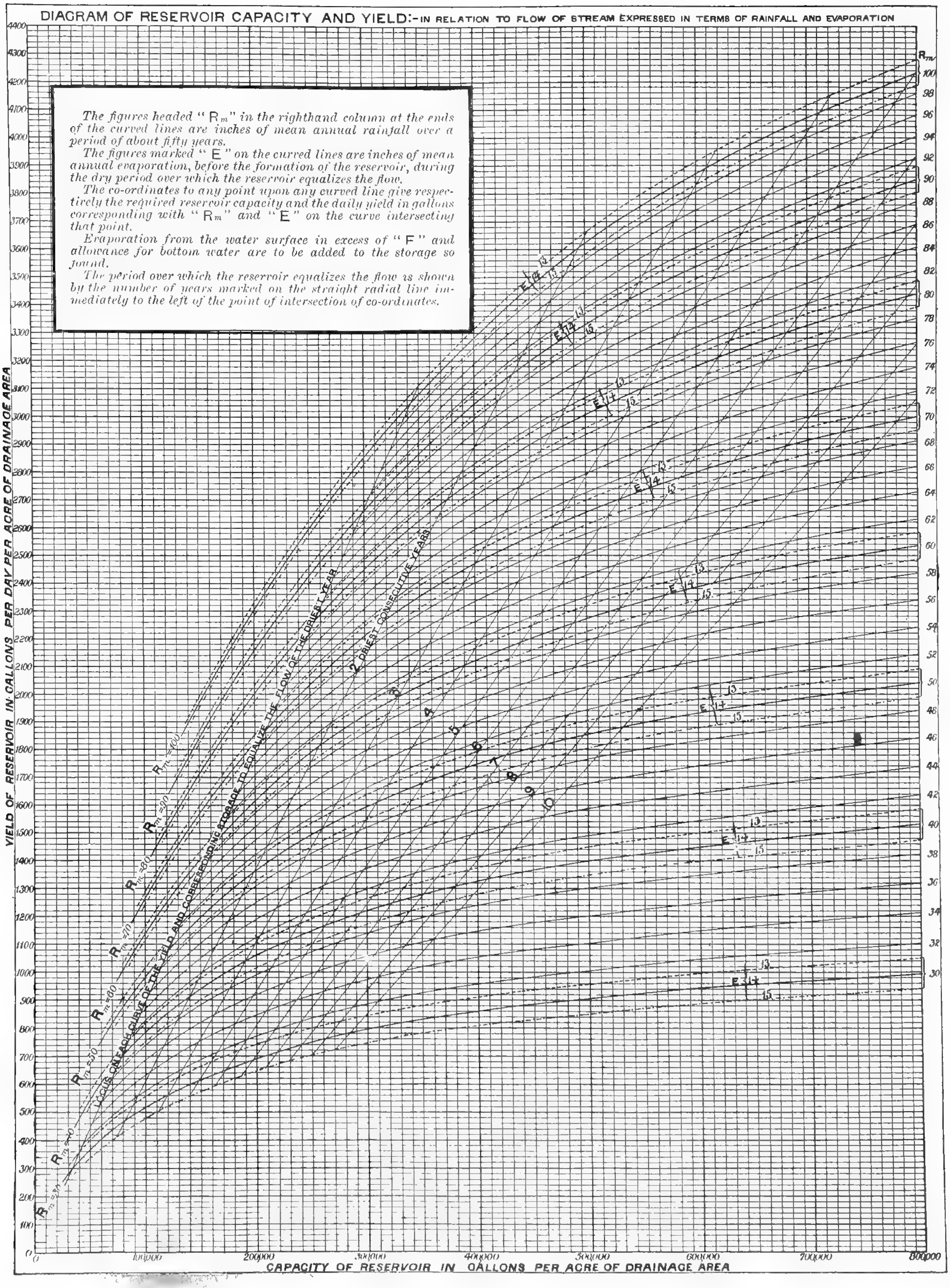

DIAGRAM OF RESERVOIR CAPACITY AND YIELD:-IN RELATION TO FLOW OF STREAM EXPRESSED IN TERMS OF RAINFALL AND EVAPORATION

The figures headed " R*m" in the righthand column at the ends of the curved lines are inches of mean annual rainfall over a period of about fifty years.*

The figures marked " E *" on the curved lines are inches of mean annual evaporation, before the formation of the reservoir, during the dry period over which the reservoir equalizes the flow.*

The co-ordinates to any point upon any curved line give respectively the required reservoir capacity and the daily yield in gallons corresponding with " R*m" and "* E *" on the curve intersecting that point.*

Evaporation from the water surface in excess of " F *" and allowance for bottom water are to be added to the storage so found.*

The period over which the reservoir equalizes the flow is shown by the number of years marked on the straight radial line immediately to the left of the point of intersection of co-ordinates.

Fig. 4.

Origin of springs.

derived from rainfall is (except in the rare cases of displacement by gas) found at heights determined by the resistance to its passage underground towards some neighbouring sea, lake, or water-course. The positions of the springs at which such water reaches the surface are determined by the superimposition of permeable upon less permeable strata, sometimes combined with a fault or a synclinal fold of the strata, forming the more permeable portion into an underground basin lying within comparatively impermeable boundaries. At the lower lip or at the most permeable part of such a basin the water collected from rainfall issues as a spring.

Perennial springs of large volume rarely occur in Great Britain at a sufficient height to afford supplies by gravitation, the best known being those from the Chalk discharged either below or near the sea-level; but from the Limestone of Italy and other parts of the world very considerable volumes issue far above the sea-level, and are thus available, without pumping, for the supply of distant towns. On a small scale, however, springs are fairly distributed over the United Kingdom, for there are no formations, except perhaps blown sand, which do not vary in their resistance to the percolation of water, and therefore tend to produce overflow above the valley levels. But even the rural populations have generally found springs not sufficiently constant for their use. The natural remedy has been to excavate to the underground basins, at levels below their natural outfalls, and thus to obtain access to stored water which after prolonged droughts might cease to overflow, or the overflow of which may be too distant. Hence throughout the world we find the shallow well still very common in villages and near isolated dwellings. The shallow well, however, rarely supplies enough water for more than a few houses, and the cost of pumping and distribution by pipes being generally prohibitive, the water has to be carried by hand. It follows that such wells are almost invariably found in immediate proximity to human habitations, with the natural consequence that the water is, as a rule, seriously polluted. Deep wells owe their comparative immunity from pollution to the circumstances that the larger quantity of water yielded renders it worth while to pump that water and convey it over greater distances, and that any impurities must pass through a great depth of filtering material and take a long time to reach the well. The principal water-bearing formations, utilized in Great Britain by means of deep wells, are the Chalk and the New Red Sandstone. The Upper and Middle Chalk are permeable almost through their mass. They hold water like a sponge, but part with it under pressure to fissures by which it is intersected, and, in the case of the Upper Chalk, to beds of flints. A well sunk in these formations without striking any fissure or water-bearing flint bed would receive water only at a very slow rate; but if, on the other hand, it struck one or more of the natural water-ways, the quantity of water capable of being drawn from it would be greatly increased. This increase is simply due to the much greater water-bearing area with which the well is thus put into communication. In practice it is usual to drive small tunnels, or "adits" as they are called, below the water-level, to intercept fissures and water-bearing beds, and thus still farther extend the collecting area.

Permeability of different strata.

It is a notable peculiarity of the Upper and Middle Chalk formations that below the present valleys the underground water passes more freely than elsewhere. This is explained by the fact that the Chalk fissures are almost invariably rounded and enlarged by the erosion of carbonic acid carried by the water passing through them. These fissures take the place of the streams in an impermeable area, and those beneath the valleys must obviously be called upon to discharge more water from the surface, and thus be brought in contact with more carbonic acid, than similar fissures elsewhere. Hence in the process of time they have become greatly enlarged, and the best position for a well in the Chalk is therefore generally that over which, if the strata were impermeable, the largest quantity of surface water would flow. The Lower Chalk formation is for the most part little permeable. It, however, contains many ruptures and dislocations, "smashes" as they are now commonly called, in the interstices of which large bodies of water, received from the Upper and Middle Chalk, may be naturally stored, or which may merely form large passages for the stores of water above them. A striking example is that known as Lydden Spout, under Abbot's Cliff, near Dover. The acid erosion of the chalk is shared by all the purer limestones, such as the Carboniferous or Mountain Limestone, but no similar benefit is felt. So greatly has this formation been distorted, that the valleys which traverse it are not the valleys which may be conceived to have originally supplied carbonic acid to its fissures, and all trace of the lines of underground erosion is generally lost.

Next in importance to the Chalk formations comes the Trias or New Red Sandstone, consisting in Great Britain of two main divisions, the Keuper at the top and the Bunter below, of which the greater part, with the exception of the Red Marls forming the upper part of the Keuper, is permeable. Some portions of the New Red Sandstone contain, when saturated, even more water than Chalk; but, as in the case of the Chalk, a well or borehole in the sandstone yields very little water unless it strikes a fissure; hence it is a common thing to form underground chambers or adits in search of additional fissures, and sometimes to sink many vertical boreholes with the same object in view.

There are other water-bearing formations, such as the Greensands, the permeability of which varies very greatly in different districts. Where it is considerable, the sand is generally in a loose condition, and the difficulty of sinking a deep well through it is thus greatly increased. Moreover, when such a well is successfully sunk, special precautions are required to prevent sand from being forced in as well as water. Perhaps the most important of these formations in Great Britain is that portion of the Lower Greensand, the outcrop of which, emerging along the south-eastern shore of the Wash, passes south-westwards. This formation, probably more or less permeable throughout, attains a thickness to the east of Bedford considerably exceeding 250 feet, and is to be utilized for the supply of Bedford and other large areas in the county.

Yield of wells.

In formations like loose Greensand, the cost of driving horizontal adits, which must necessarily in such cases be lined with brickwork or other materials, would be prohibitive, and the yield to the well is therefore confined to the quantity of water which can reach it without the aid of artificial passages, and which can be introduced into it free from sand. A well, surrounded by a porous mass of sand charged with water, receives its supply by percolation across whatever opening into the well may have been prepared for its passage and closed by strainers against the sand which seeks to follow it. A few feet from any such opening the hemispherical area, traversed by the water from all directions, may be many times greater than the area of the opening into the well; therefore it is only at, and close to, the opening that the frictional resistance of the sand to the flow of the water is at all important, and anything that reduces that resistance will proportionately increase the total yield. This end may be accomplished by injecting air or water through the opening into the sand, and alternately reversing the flow to allow the finer disturbed particles to pass with the water into the well. If such work is properly conducted, the whole of the sand surrounding each opening may be so far freed from the finer particles which it contains that the yield will be immensely increased. Where, however, rock of any kind is encountered, the yield of a well (under a given head of water) can only be increased by enlargement of the main well in depth or diameter, or by boreholes or adits. No rule as to the adoption of any one of these courses can be laid down, nor is it possible, without examination of each particular case, to decide whether it is better to attempt to increase the yield of the well or to construct an additional well some distance away. By lowering the head of water in a well the yield is always temporarily increased, but, unless the rate of flow towards the well is equal to the quantity drawn from it, the yield thus at first obtained cannot be permanent. Every well has its own particular level of water while steady pumping at a given rate is going on, and if that level is lowered by harder pumping, it may take months, or even years, for the water in the interstices of the rock to accommodate itself to the new conditions; but the permanent yield after such lowering will always be much less than might be supposed from the quantity pumped shortly after the change. We have hitherto supposed the pumps for drawing the water to have been placed in the well so as to be accessible without being lifted out. Pumps, however, may be (and have been) placed deep down in boreholes, by which means the head of pressure in the boreholes tending to hold the water back in the rock has been greatly reduced, and the supply has consequently been increased; but when the cost of maintenance is included, the increased supply from the adoption of this method rarely justifies expectations. When the water has been drawn down to the new level its passage through the Sandstone or Chalk in the neighbourhood of the borehole is further resisted, both by virtue of the smaller length of borehole below the water and of the greater quantity of water called upon to pass into that smaller length; and there are many instances in which repeated lowering and increased pumping, both from wells and boreholes, have had the result of reducing the water available, after a few years, nearly to the original quantity; in some cases it falls even lower than when pumped from a greater height. One other method—the use of the so-called "air-lift"—should be mentioned. This ingenious device, which has been employed for some years in America, has been adopted in a few places in Great Britain. The object attained by the air-lift is precisely the same as that attained by putting a pump some distance down a borehole; but instead of the head being reduced by means of the pump, it is reduced by mixing the water with air. A pipe is passed down the borehole to the desired depth, and connected with air-compressors at the surface. The compressors being set to work, the air is caused to issue from the lower end of the pipe and to mix in fine bubbles with the rising column of water, sometimes several hundred feet in height. The effect is that the weight of the column of water, or rather of water and air mixed, is reduced in proportion to the volume of air it contains. The method will therefore always increase the yield for the time, and it may do so permanently, though to a very much smaller extent than at first; but its economy must always be less than that of direct pumping.

Fresh water below sea-level.

Sedimentary rocks, formed below the sea or salt lagoons, must originally have contained salt water in their interstices. On the upheaval of such rocks above the sea-level, fresh water from rainfall began to flow over the surface, and, so far as the strata were permeable, to lie in their interstices upon the salt water. The weight of the original salt water above the sea-level, and of the fresh water so superimposed upon it, caused an outflow towards the sea. A hill, as it were, of fresh water rested in the interstices of the rock upon the salt water, and continuing to press downwards, forced out the salt water even below the level of the sea. There is, indeed, no physical reason why this process should not continue to any depth at which the rock is sufficiently porous to admit of the necessary percolation, and in such rocks fresh water has usually been found as far down as borings have yet penetrated. It would conceivably take but a small fraction of the period that has in most cases elapsed since such upheavals occurred for the whole of the salt water to be thus replaced by fresh water, and for the condition to be attained as regards saturation with fresh water, in which we now find the porous portions of the earth's crust wherever the rainfall exceeds the evaporation. There are cases, however, such as the valley of the Jordan, where the ground is actually below the sea-level, and where, as the total evaporation is equal to or exceeds the rainfall, the lakes also are below the sea-level. Thus, if there is any percolation between the Mediterranean and the Dead Sea, it must be towards the latter.

In considering the theory of well supplies it is important to bear these facts in mind. The crust of the earth, so far as it is permeable and above the sea-level, receives from rainfall its supply of fresh water. That supply, so far as it is not evaporated or absorbed by vegetation, passes away by the streams or rivers or sinks into the ground. If the strata were uniformly porous the water would lie in the rock at different depths below the surface (but always above the sea-level), according to the time of year and distribution of the rainfall. It would slowly, but constantly, percolate downwards and towards the sea, and would issue at or below the sea-level, rarely reaching the earth's surface earlier except in deep valleys. Precisely the same thing happens in the actual crust of the earth, except that, in the formations usually met with, the strata are so irregularly permeable that no such uniform percolation occurs, and most of the water, instead of oozing out below the sea-level, meets with obstructions which cause it to issue, sometimes below the sea-level and sometimes above it, in the form of springs. After prolonged and heavy rainfall the upper boundary of the subsoil water is in most strata practically coincident with the surface. After prolonged droughts it still retains more or less the same figure as the surface, but has sunk to lower depths.

Perhaps the only cases of nearly uniform percolation in nature are those which occur in some islands or peninsulas formed wholly of sea sand. Here water is held up in the sand above the sea-level by the more or less continuous supply from rainfall, and may be drawn off by wells or borings. But such formations are generally recent, and the rainfall has often not had time to displace the sea water much below the sea-level. On such an island, a mile and a quarter in diameter, in the centre of which a borehole had been put down, brackish water was reached at a depth of only 196 feet; this formed a saucer, as it were, floating upon the salt water, but ever descending towards a more cup-like form.

Although such uniformly permeable sand is rarely met with in great masses, it is useful to consider in greater detail so simple a case. Let Fig. 5 be the section of a circular island a mile and a quarter in diameter, of uniformly permeable sand. The surface of the ground is shown by a strong black line, the limit downwards of the permeable sand by the full line *f f*, the mean sea-level *a a* by a dotted line, and the natural mean level of saturation $b\,b$ above the sea-level by a curved dot and dash line. The water, contained in the interstices of the sand above the mean sea-level, would (except in so far as a film, coating the sand particles, is held up by capillary attraction) gradually sink to the sea-level if there were no rainfall. The resistance to its passage through the sand is, however, sufficiently great to prevent this from occurring while percolation from annual rainfall takes place. Hence, according to the age of the island or promontory, we have some such constantly deepening figure as $c\,c$, representing the bounding surface between fresh and salt water. A well is sunk in the middle of the island, and a certain quantity of water is drawn daily. For small supplies such a well may be perfectly successful; but however small the quantity drawn, it obviously has the effect of diminishing the supply of fresh water, which contributes to the maintenance of the level of saturation above the sea-level; and with further pumping the fresh water would be so far drawn upon that the mean level of saturation would sink, first to a figure such as that represented by the new level of saturation $d\,d$, and later to the figure represented by the lines $e\,e$, in which the level of saturation has everywhere been drawn below the mean sea-level. At this stage the converse process begins, and percolation inland from the sea occurs. The figure in this case of uniform percolation assumed by the water levels approaching a deep well is a surface of revolution, and however irregular the percolation and the consequent shape of the figure, it is commonly, but somewhat incorrectly, called the "cone of depression." It cannot have straight, or approximately straight, sides in any vertical plane, but in nature is an exceedingly irregular figure drawn about curves—not unlike those in Fig. 5. In this case, as in that of a level plane of uniformly porous sand, the vertical section of the figure has asymptotes to the vertical well and to the natural level of the subsoil water; and in the case of the sand island, upon horizontal impermeable strata, the vertical sections of the water surface are logarithmic curves. The illustration has been drawn from calculations which, on the hypothesis of uniform permeability, show that when the water is pumped down to the lower curve $e\,e$ the well yields four times as much water as it would from the upper curve $d\,d$, in both cases assuming steady pumping for an indefinite period.

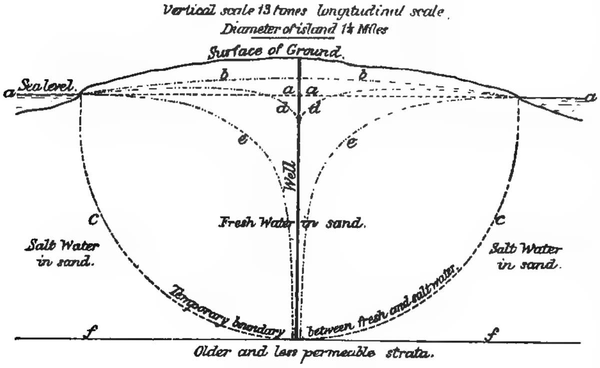
Vertical scale 13 times longitudinal scale.
Diameter of island 1¼ Miles
Surface of Ground.
Sea level.
a
a
b
b
a
a
d
d
e
e
Well
c
c
Fresh Water in sand.
Salt Water in sand.
Salt Water in sand.
Temporary boundary between fresh and salt water.
f
f
Older and less permeable strata.

Fig. 5.

The importance of this illustration is to be found elsewhere than in islands, or peninsulas, or in uniformly porous sand. Where the strata are not uniformly porous, they may resist the passage of water from the direction of the sea or they may assist it; and round the whole coast of England, in the Magnesian limestone to the north-east, in the Chalk and Greensand to the east and south, and in the New Red Sandstone to the west, the number of wells which have been abandoned as potable supplies, owing to the percolation of sea water, is very great. Perhaps the first important cases occurred in the earlier part of the 19th century on the Lancashire shore of the Mersey estuary, where, one after another, deep wells in the New Red Sandstone had to be abandoned for most purposes. On the opposite side, in the Cheshire peninsula, the total quantity of water drawn has been much less, but even here serious warnings have been received. In 1895 the single well then supplying Eastbourne was almost suddenly rendered unfit for use, and few years pass without some similar occurrence of a more or less serious kind. The remarkable suddenness with which such changes are brought about is not to be wondered at when the true cause is considered. The action of sandstone in filtering salt waters was investigated in 1878 by Mr Isaac Roberts, F.R.S., who showed that when salt water was allowed to percolate blocks of sandstone, the effluent was at first nearly fresh, the salt being filtered out and crystallized for the most part near the surface of ingress to the sandstone. As the process continued the salt-saturated layer, incapable of further effective filtration, grew in thickness downwards, until in the process of time it filled the whole mass of sandstone. But before this was accomplished the filtration of the effluent became defective and brackish water was received, which rapidly increased nearly to the saltness of the inflow. Into such blocks, charged with salt crystals and thoroughly dried, fresh water was then passed, and precisely the converse process took place. A thickness of only 12 inches of Bunter sandstone proved at first to be capable of removing more than 80 per cent. of the chlorides from sea water; but, after the slow passage of only 0·6 gallon through one cubic foot of stone, the proportion removed fell to 8·51 per cent. The general lesson to be learned from these facts is, that if the purity of the water of wells not far removed from the sea is to be maintained, that water must not be pumped down much below the sea-level. In short, the quantity of water drawn must in no case be allowed to exceed the quantity capable of being supplied through permeable areas by rain falling upon the surface of the land. If it exceeds that quantity, the stock of water held in the interstices of the rock, and capable of flowing towards the well, must disappear; and the deficit between the supply and demand can only be made up by water filtering from the sea and reaching the well at first quite free from salt, but sooner or later in a condition unfit for use.

II. DAMS.

Earthen dams.

Any well-made earthen embankment of moderate height, and of such thickness and construction as to ensure freedom from excessive percolation at any point, will in the course of time become almost impermeable to surface water standing against it; and when permeable rocks are covered with many feet of soil, the leakage through such soil from standing water newly placed above it generally diminishes rapidly, and in process of time often ceases entirely. Even the beds of sluggish rivers carrying fine detritus over porous strata generally become so impermeable that excavations made in their neighbourhood, though freely collecting the subsoil water, receive no river water whatever. Thus natural or artificial surfaces which are completely permeable to rainfall may become almost impermeable when protected by surface water from drought and frost, and from earth-worms, vegetation, and artificial disturbance. But in order that this may be so, the initial resistance to percolation of water at every part of the soil or embankment must be such that the motion of the water shall be insufficient to disturb the water-borne mineral and organic particles lodged on the surface or in the interstices of the soil. If, therefore, a reservoir so formed survives the first few years without serious leakage, it is not likely, in the absence of artificial disturbance, to succumb owing to leakage at a later period. Hence, as the survival of the fittest, there are many artificial waters with low dams consisting exclusively of earth—and sometimes very sandy earth—satisfactorily performing their functions with no visible leakage. But if, as in the case of a reservoir for water supply, large portions of the bottom are liable to be uncovered and exposed to hot sunshine, it is never advisable to depend upon this action where the materials of the bottom are naturally permeable.

Construction.

According to the commoner method of construction in Great Britain, wherever an area intended to be converted into a reservoir is not everywhere bounded by sufficiently impermeable rising ground, a trench is cut along the portion not so bounded, and carried down to rock or such other formation as, in the engineer's opinion, forms a sufficiently impermeable sheet beneath the whole surface to be covered with water. Into this trench so-called "puddled clay," that is, clay rendered plastic by kneading with water, is filled and thoroughly worked with special tools, and trodden in layers. In this manner an underground compartment is formed, the bottom of which is natural, and the sides partly natural and partly artificial, both offering high resistance to the passage of water. Above ground the same puddle walls or cores are carried up to the required level, and are supported as they rise by embankments of earth on either side.

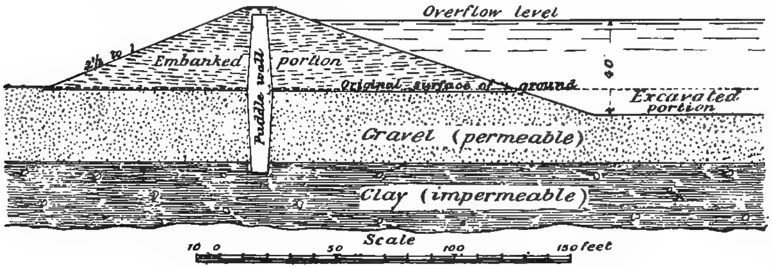

Fig. 6.—Section of Typical Low Earth Embankment in Flat Plain.

Fig. 6 is a typical section of a low dam of this class, impounding water upon gravel overlying impermeable clay. In such a structure the whole attention as regards water-tightness should be concentrated upon the puddle wall or core. When, as may happen in dry seasons, the puddle wall remains long above the water level, it parts with moisture and contracts. It is essential that this contraction shall not proceed to such an extent as may possibly produce cracking. Drying is retarded, and the contraction due to a given degree of drying is greatly reduced by the presence of sand and small stones among the clay. Nearly all clays, notably those from the Glacial deposits, naturally contain sand and stones, 40 to 50 per cent. by weight of which is not too much if uniformly distributed. But in the lower parts of the trench, where the clay can never become dry, plasticity and ductility are, for reasons to be explained below, the first consideration, and there the proportion of grit should be lower. The embankments are merely to support the puddle and to keep it moist above the ground level when the reservoir is low. They may be quite permeable, but to prevent undue settlement and distortion they must, like the puddle, be well consolidated. In order to prevent a tendency to slip, due to sudden and partial changes of saturation, and still more to prevent the accumulation of pressure beneath the outer embankment from escapes of water through or below the puddle, that embankment should always be permeable, except near the puddle, and well drained at the base. The less permeable materials should be confined to the inner parts of the inner embankment, where, when the water level falls, they may remain moist without becoming liable to slip. The inner slope should be protected from the action of waves by so-called "hand-pitching," consisting of roughly-squared stonework, bedded upon a layer of broken stone to prevent local disturbance of the embankment by action of the water between the joints of the larger stones. The largest and deepest reservoirs formed by means of dams of this class are to be found in mountain valleys, where it often happens that only a single straight dam crossing the valley is required; but an exception has been made in connexion with the London water-supply. The Staines reservoirs, designed by Messrs Hunter and Middleton for the storage of Thames water—mainly to avoid depletion of the river by pumping for the supply of London in summer weather—are constructed upon a nearly level plane of gravel overlying the impermeable London Clay formation, and are therefore of the class shown in Fig. 6. The puddle trenches pass down to the clay, and, with the puddle walls and embankments, entirely surround each reservoir. This exception is a notable one, for although the depth of water is only 40 feet, the water area already authorized is nearly 400 acres, while the capacity of the reservoirs will exceed three thousand million gallons.

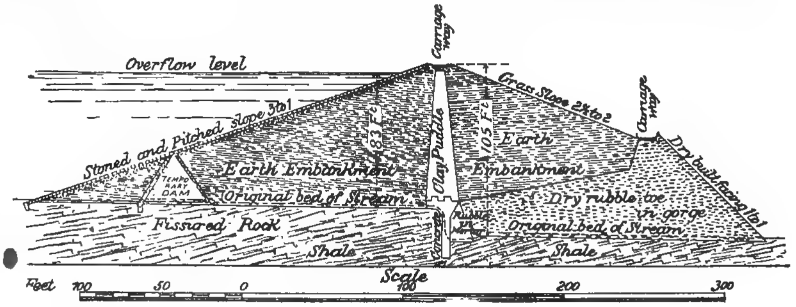

Fig. 7.—Earth Embankment, with stone toe and concrete trench.

In mountain valleys, rock or shale, commonly the most impermeable materials met with in such positions, are sometimes not reached till great depths are attained. There are several cases in Great Britain in which it has been necessary to go down about 200 feet below the water level of the intended reservoir. The highest dams of this class impound water to a level of about 110 feet above the bottom of the valley. Such great works have generally been well constructed, and there are many which after fifty years of use are perfectly sound and water-tight, and afford no evidence of deterioration. On the other hand, the partial or total failure of smaller dams of this description to retain the reservoir water has been much more common in the past than is generally supposed. Throughout Great Britain there are still many reservoirs, with earthen dams, which cannot safely be filled; and others which, after remaining for years in this condition, have been repaired. From such cases and their successful repair valuable experience of the causes of failure may be derived.

Erosion by leakage.

Most of these causes are perfectly well understood by experienced engineers, but instances of malconstruction of recent date are still met with. A few such cases will now be mentioned. The base of a puddle trench is often found to have been placed upon rock, perfectly sound in itself, but having joints which are not impermeable. The loss of water by leakage through such joints or fissures below the puddle wall may or may not be a serious matter in itself; but if at any point there is sufficient movement of water across the base to produce the slightest erosion of the clay above it, that movement almost invariably increases. In this manner the finer particles of clay in a line crossing its base are washed away, while the sandy particles remain behind and form a constantly deepening porous bar of sand crossing the base of the puddle. Percolation through this sand is thus added to the original leakage. Sometimes, but not always, when the barrier of clay is passed, the water rises to the surface of the ground, producing a visibly turbid spring. Directly such a leakage begins to carry away particles of clay a space, formerly occupied by mixed clay and sand, becomes contracted to the volume of the sand alone. As erosion continues, the contraction continues, chiefly by the falling in of the clay roof above the sand. Thus, the permeable bar grows vertically rather than horizontally, and ultimately assumes the form of a thin vertical sheet traversing the puddle wall, often diagonally in plan, and having a thickness which has varied in different cases from a few inches to a couple of feet or more, of almost clean sand rising to an observed height of 30 or 40 feet, and only arrested there by the necessary lowering of the reservoir to avoid serious danger. The settlement of the plastic clay above the eroded portion soon produces a surface depression over or nearly over the leakage, and thus sometimes gives the first warning of impending danger. It is not always possible to prevent any leakage whatever through the strata below the bottom or beyond the ends of the trench, but it is always possible to render such leakage entirely harmless to the work above it, and to carry the water by relief-pipes to visible points at the lower toe of the dam. Wherever the base of a puddle wall cannot be worked into a continuous bed of clay or shale, or tied into a groove cut in sound rock free from water-bearing fissures, the safest course is to base it on an artificial material at once impermeable and incapable of erosion, interposed between the rock and the puddled clay. Water-tight concrete is a suitable material for the purpose; it need not be made so thick as the puddle core, and is therefore sometimes used with considerable advantage in lieu of the puddle for the whole depth below ground. In Fig. 7 a case is shown to be so treated. Obviously, the junction between the puddle and the concrete might have been made at any lower level.

Unequal settlement.

However well the work may be done, the lower part of a mass of puddled clay invariably settles into a denser mass when weighted with the clay above. If, therefore, one part is held up, while an adjoining part has no support but the clay beneath it, a fracture—not unlike a geological fault—must result. Fig. 8 is a part longitudinal section through the puddle wall of an earthen embankment. The puddle wall is crossed by a pedestal of concrete carrying the brick discharge culvert. The puddle at *a* was originally held up by the flat head of this pedestal; not so the puddle at *b*, which under the superincumbent weight settled down and produced the fault *bc*, accompanied with a shearing or tangential strain or, less probably, with actual fracture in the direction *bd*. Serious leakage at once began at *b*, and washed out the clay particle by particle, but did not wash out the sand, which remained behind in the crevice. The clay roof constantly falling in caused the leakage to work up along the plane *bd* of tangential strain. The overflow level of the water, originally at *ef*, was lowered for safety to *gh*; and for many years the reservoir was worked with its general level much below *gh*. The sand-filled vein, several inches in width, was found, on taking out the puddle, to have terminated near the highest level to which the water was allowed to rise, but not to have worked downwards.

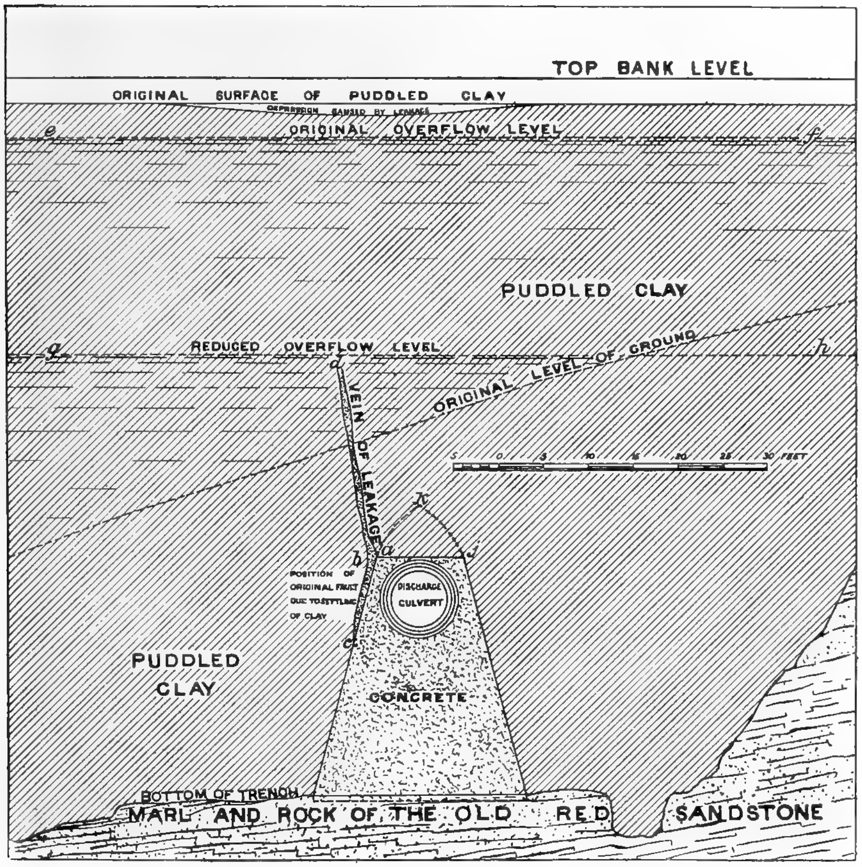
TOP BANK LEVEL
ORIGINAL SURFACE OF PUDDLED CLAY
DEPRESSION CAUSED BY LEAKAGE
ORIGINAL OVERFLOW LEVEL
e
f
PUDDLED CLAY
g
REDUCED OVERFLOW LEVEL
h
ORIGINAL LEVEL OF GROUND
d
VEIN OF LEAKAGE
5 0 5 10 15 20 25 30 FEET
k
a
j
b
POSITION OF ORIGINAL FRUST DUE TO SETTLING OF CLAY
DISCHARGE CULVERT
c
PUDDLED CLAY
CONCRETE
BOTTOM OF TRENCH
MARL AND ROCK OF THE OLD RED SANDSTONE

FIG. 8.—Lower Neuadd Culvert Leakage.

There can be little doubt that the puddle at the right-hand angle *j* was also strained, but not to rupture, as owing to the rise of the bottom there was comparatively little room for settlement on that side. In repairing this work the perfectly safe form shown by the dotted lines *ka*, *kj* was substituted for the flat surface *aj*, and this alone would have prevented dangerous shearing strains. As an additional precaution, however, deep tongues of concrete, like those in Fig. 7, were built in the rock throughout the length of the trench, and carried up the sides and over the top of the pedestal. The puddle was then replaced, and remains perfectly water-tight. The lesson taught by Fig. 8 applies also to the end of puddle walls where they abut against steep faces of rock. Unless such faces are so far below the surface of the puddle, and so related to the lower parts of the trench that no tension, and consequent tendency to separation of the puddle from the rock, can possibly take place, leakage with disastrous results may occur.

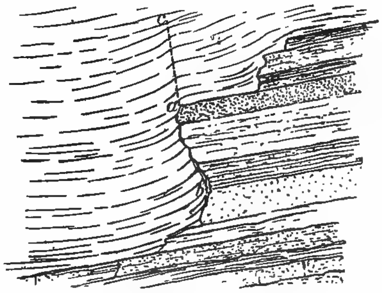

FIG. 9.—Overhanging Rock Leakage.

In other cases leakage and failure have arisen from allowing a part of the rock bottom of a puddle trench to overhang, as in Fig. 9. Here the straining of the original horizontal puddle in settling down is indicated in a purposely exaggerated way by the curved lines. There is considerable distortion of the clay, resulting from combined shearing and tensile stress, above each of the steps of rock, and reaching its maximum at and above the highest step *ab*, where it has proved sufficient to produce a dangerous line of weakness *ac*, the tension at *a* either causing actual rupture, or such increased porosity as to permit of percolation capable of keeping open the wound. In such cases as are shown in Figs. 8 and 9 the growth of the sand vein is not vertical, but inclined towards the plane of greatest distortion. In Fig. 9 a further cause of occasional failure, referred to above as sometimes due to allowing the ends of puddle walls to abut against steep faces of rock, is shown at *b*, where the clay has actually drawn away from the rock. When it is considered that a parting, sufficient to allow the thinnest film of water to pass, may start the formation of a vein of porous sand in the manner above explained, it will be readily seen how great must be the attention to details, in unpleasant places below ground, and below the water level of the surrounding area, if safety is to be secured. In cases like Fig. 9 the rock should always be cut away to a slope, such as that shown in Fig. 10.

If no difference of water-pressure had been allowed between the two sides of the puddle trench in Figs. 8 or 9 until the clay had ceased to settle down, it is probable that the interstices, at first formed between the puddle and the concrete or rock, would have been sufficiently filled to prevent injurious percolation at any future time. Hence it is always a safe precaution to afford plenty of time for such settlement before a reservoir is charged with water. But to all such precautions should be added the use of concrete or brick-work tongues running longitudinally at the bottom of the trench, such as those shown at a higher level in Fig. 7.

Defects in puddle wall.

In addition to defects arising out of the condition or figure of the rock or of artificial work, upon which the puddle clay rests, the puddle wall itself is often defective. The original material may have been perfectly satisfactory, but if, for example, in the progress of the work a stream of water is allowed to flow across it, fine clay is sometimes washed away, and gravel or sand left to a sufficient extent to permit of future percolation. Unless such places are carefully dug out or repuddled before the work of filling is resumed, the percolation may increase along the vertical plane where it is greatest, by the erosion and falling in of the clay roof, as in the other cases cited. Two instances probably originating in some such cause are shown in Fig. 11 in the relative positions in which they were carefully measured when found, as the puddle was removed from a crippled reservoir dam. They are vertical planes stretching entirely across the puddle trench, and reaching in one case, *aa*, nearly to the highest level at which the reservoir had been worked for seventeen years after the leakage had been discovered. The larger and older of these veins was $44\frac{1}{2}$ feet high, of which 14 feet was above the ground; and it is interesting to note that this portion, owing probably to the smaller resistance to leakage, was much wider than below. The little vein to the left marked *bb*, about $3\frac{1}{2}$ feet deep, is curious. It looks like the beginning of success of an effort made by a slight percolation during the whole life of the reservoir to increase itself materially by erosion. There is no reason to believe that the cause of such a leakage could be developed except during construction, and it is certain that once begun it would increase. Only a knowledge of the great loss of capital that has resulted from abortive reservoir construction justifies this notice of defects which can always be avoided, and are too often the direct result, not of design, but

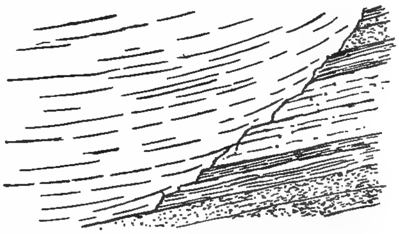

FIG. 10.—Proper Figure for Rock Slope.

of parsimony in providing a sufficiency of intelligent, experienced, and conscientious supervision, especially below ground, in the execution of such works.

In some cases, as, for example, when a high earthen embankment crosses a gorge, and there is plenty of stone to be had, it is desirable to place the outer toe of the earthen bank upon a toe or platform of rubble stonework, as in Fig. 7, by which means the height of the earthen portion may be reduced and complete drainage secured. But here again great care must be exercised in the packing and consolidation of the stones, which will otherwise crack and settle.

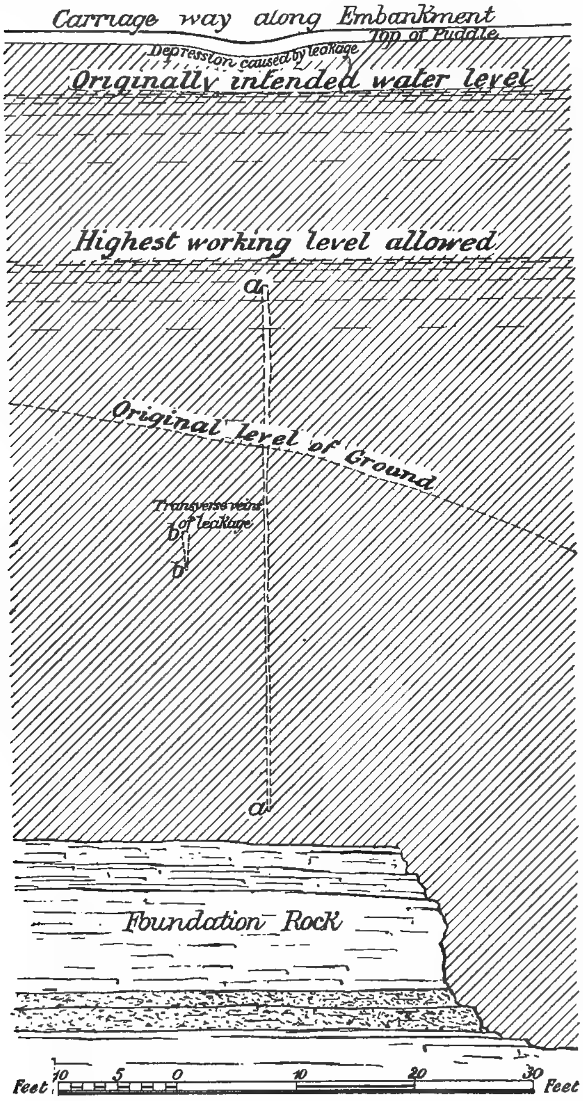
Carriage way along Embankment
Top of Puddle
Depression caused by leakage
Originally intended water level
Highest working level allowed
a
Original level of Ground
Transverse veins of leakage
b
b
a
Foundation Rock
Feet
10
5
0
10
20
30
Feet

Fig. 11.—Vertical Veins Leakage.

As with many other engineering works, the tendency to slipping either of the sides of the valley or of the reservoir embankment itself has often given trouble, and has sometimes led to serious disaster. This, however, is a kind of failure not always attributable to want of proper inspection, but rather to improper choice of the site, or treatment of the case, by those primarily responsible.

Dams with diaphragms of wood, steel, concrete, &c.

In countries where good clay or retentive earth cannot be obtained, numerous alternative expedients have been adopted with more or less success. In the mining districts of America, for example, where timber is cheap, rough stone embankments have been lined on the water face with timber to form the water-tight septum. In such a position, even if the timber can be made sufficiently water-tight to begin with, the alternate immersion and exposure to air and sunshine promotes expansion and contraction, and induces rapid disintegration, leakage, and decay. Such an expedient may be justified by the doubtful future of mining centres, but would be out of the question for permanent water-supply. Riveted sheets of steel have been occasionally used, and, where bedded in a sufficient thickness of concrete, with success. At the East Cañon Creek dam, Utah, the height of which is about 61 feet above the stream, the trench below ground was filled with concrete much in the usual way, while above ground the water-tight diaphragm consists of a riveted steel plate varying in thickness from $\frac{5}{16}$ inch to $\frac{3}{16}$ inch. This steel septum was protected on either side by a thin wall of asphaltic concrete supported by rubble stone embankments, and owing to irregular settling of the embankments became greatly distorted, apparently, however, without causing leakage. Asphalt, whether a natural product or artificially obtained, as, for example, in some chemical manufactures, is a most useful material if properly used in connexion with reservoir dams. Under sudden impact it is brittle, and has a conchoidal fracture like glass; but under continued pressure it has the properties of a viscous fluid. The rate of flow is largely dependent upon the proportion of bitumen it contains, and is of course retarded by mixing it with sand and stone to form what is commonly called asphalt concrete. But given time, all such compounds, if they contain enough bitumen to render them water-tight, appear to settle down even at ordinary temperatures as heavy viscous fluids, retaining their fluidity permanently if not exposed to the air. Thus they not only penetrate all cavities in an exceedingly intrusive manner, but exert pressures in all directions, these, owing to the density of the asphalt, being more than 50 per cent. greater than would be produced by a corresponding depth of water. From the neglect of these considerations numerous failures have occurred.

In one instance in the writer's experience the retaining wall of a service reservoir, abutting upon a street footway in the higher part of a great town, had been built of ashlar of exceptional thickness, divided longitudinally by a thin vertical diaphragm of bituminous composition. In the process of time this asphalt very slowly settled down, till, eighteen years after the reservoir was constructed, the diaphragm had considerably increased in thickness, and the outside batter of the wall had been correspondingly reduced. Slow and insidious though the action was, its effect in pressing the wall over was at last noticed from the thoroughfare, though there was no leakage, and by timely warning a terrible disaster was averted. This retaining wall, considered as a monolith, had abundant strength to resist any possible water-pressure from the reservoir; but its half-thickness was quite incapable of withstanding the lateral pressure due to an apparent solid, but a virtual fluid, one-and-a-half times the density of water, acting under a head somewhat greater than the head of water in the reservoir.

Elsewhere, a simple concrete or masonry wall or core has been used above as well as below ground, being carried up between embankments either of earth or rubble stone. This construction has received its highest development in America. At the south end of the new masonry dam now being built across the Croton river for the supply of New York, the section of the main dam changes to a masonry core wall carried into the hill and supported above ground by earthen embankments. At its junction with the main dam this core wall when finished will be 175 feet high. Its base is there 18 feet thick, reduced 10 feet higher up to about 14 feet, and at the top to about 6 feet. The precaution is taken to slope the sides of the trench for a depth of about 20 feet, and then to carry it down vertically, about twice as wide as the average thickness of the wall, the space so left being refilled with earth. By this expedient the strains to which the wall would be subject if the lower part were fixed, and the upper part only sustained by artificial embankments liable to irregular saturation and settlement, will be greatly reduced.[1] On the Titicus, a tributary of the Croton river, an earthen dam was completed in 1895, with a core wall 100 feet high—almost wholly above the original ground level—which is said to be impermeable; but other dams of the same system, with core walls of less than 100 feet in height, are apparently in their present condition not impermeable. Reservoir No. 4 of the Boston waterworks, completed in 1885, has a concrete core wall of this description. The embankment is 1800 feet long and 60 feet high. The core wall is about 8 feet thick at the bottom and 4 feet thick at the top, and in the middle of the valley nearly 100 feet in height. At irregular intervals of 150 feet or more buttresses 3 feet wide and 1 foot thick break the continuity on the water side. That this work has been regarded as successful is shown by the fact that Reservoir No. 6 of the same waterworks was subsequently constructed and completed in 1894 with a similar core wall. The embankments supporting the last named appear to have been constructed with great care, and with walls of such proportions it is obvious that extreme care is necessary to avoid sufficient irregular settlement of the earthwork to produce undue strains in the diaphragm. There is no serious difficulty in so constructing walls of this kind as to be practically water-tight while they remain unbroken; but they are undoubtedly subject to irregular stresses which cannot be calculated, and under which, speaking generally, plastic materials are much safer. In Great Britain masonry or concrete core walls have been generally confined to positions below ground, in which case it is better to construct them against the solid earth or rock. Thus placed, no serious strains are caused either by undue changes of temperature or by movements of the lateral supports, and with proper ingredients and care a very thin wall may be made perfectly water-tight, and in some English practice has proved satisfactory.

Masonry dams.

The next class of dam to be considered is that in which the structure as a whole is so bound together that, with certain reservations, it may be considered as a monolith subject chiefly to the overturning tendency of water-pressure resisted by the weight of the structure itself and the supporting pressure of the foundation. Masonry dams are merely retaining walls of exceptional size, in which the overturning pressure is water. If such a dam is sufficiently strong, and is built upon sound and moderately rough rock, it will always be incapable of sliding. Assuming also that it is incapable of crushing under its own weight and the pressure of the water, it must, in order to fail entirely, turn over on its outer toe, or upon the outer face at some higher level. It may do this in virtue of horizontal water-pressure alone, or of such pressure combined with upward pressure from intrusive water at its base or in any higher horizontal plane. Assume first, however, that there is no uplift from intrusive water. This case, neglecting as it does the limited resistance to crushing, is entirely hypothetical, but is useful to fix the ideas. As the pressure of water is *nil* at the surface and increases in direct proportion to the depth, the overturning moment is as the cube of the depth; and the only figure which has a moment of resistance due to gravity, varying also as the cube of its depth, is a triangle. The form of stability having the least sectional area is therefore a triangle. It is obvious that the angles at the base of such a hypothetical dam must depend upon the relation between its density and that of the water. It can be shown, for example, that for masonry having a density of 3, water being 1, the figure of minimum section is a right-angled triangle, with the water against its vertical face; while for a greater density the water face must lean towards the water, and for a less density away from the water, so that the water may lie upon it. For the sections of masonry dams actually used in practice, if designed on the condition that the centre of all vertical pressures shall be, as hereafter provided, at two-thirds the width of the base from the inner toe, the least sectional area for a density of 2 also has a vertical water face. As the density of the heaviest rocks is only 3, that of a masonry dam must be below 3, and in practice such works if well constructed vary from 2·2 to 2·6. For these densities, the deviation of the water face from the vertical in the figure of least sectional area is, however, so trifling that, so far as this consideration is concerned, it may be neglected.

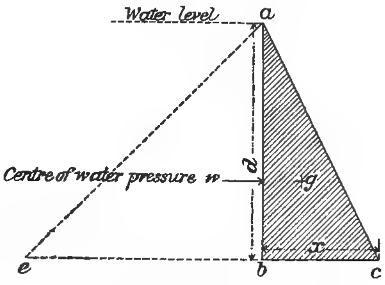

Fig. 12.—Diagram of Right-Angled Triangle Dam.

If the right-angled triangle *abc*, Fig. 12, be a profile 1 foot thick of a monolithic dam, subject to the pressure of water against its vertical side to the full depth $ab=d$ in feet, the horizontal pressure of water against that section of the dam, increasing uniformly with the depth, is properly represented by the equilateral right-angled triangle *abe*, in which *be* is the maximum water-pressure due to the full depth d, while the area $abe=d^2/2$ is the total horizontal pressure against the dam, in cubic feet of water, acting at one-third its depth above the base. Then $w=d^2/2$ is the resultant horizontal pressure with an overturning moment of

$$\frac{d^2}{2}\cdot\frac{d}{3}=\frac{d^3}{6}. \qquad (1)$$

If x be the width of the base, and ρ the density of the masonry, the weight of the masonry in terms of a cubic foot of water will be $\rho\frac{dx}{2}$, acting at its centre of gravity g, situated at $\frac{2x}{3}$ from the outer toe, and the moment of resistance to overturning on the outer toe,

$$\rho\frac{dx}{2}\cdot\frac{2x}{3}=\rho\frac{dx^2}{3}. \qquad (2)$$

Equating the moment of resistance (2) to the overturning moment (1), we have

$$\rho\frac{dx^2}{3}=\frac{d^3}{6}$$

and

$$x=\frac{d}{\sqrt{2\rho}}.$$

That is to say, for such a monolith to be on the point of overturning under the horizontal pressure due to the full depth of water, its base must be equal to that depth divided by the square root of twice the density of the monolith. For a density of 2·5 the base would therefore be 44·7 per cent. of the height.

Factors of safety.

We have now to consider what are the necessary factors of safety, and the modes of their application. In the first place, it is out of the question to allow the water to rise to the vertex *a* of such a masonry triangle. A minimum thickness must be adopted to give substance to the upper part; and where the dam is not used as a weir it must necessarily rise several feet above the water, and may in either event have to carry a roadway. Moreover, considerable mass is required to reduce the internal strains caused by changes of temperature. In the next place, it is necessary to confine the pressure, at every point of the masonry, to an intensity which will give a sufficient factor of safety against crushing. The upper part of the dam having been designed in the light of these conditions, the whole process of completing the design is simple enough when certain hypotheses have been adopted, though somewhat laborious in its more obvious form. It is clear that the greatest crushing pressure must occur, either with the reservoir empty at the lower part of the water face *ab*, or with the reservoir full at the lower part of the outer face *ac*. If the dam is well built the intensity of vertical pressure will (neglecting local irregularities) vary nearly uniformly from face to face along any horizontal plane. Thus, to take the simplest case, if *abce* (Fig. 13) represents a rectangular mass already designed for the superstructure, and *g* its centre of gravity, the centre of pressure upon the base will be vertically under *g*, that is, at the centre of the base, and the load will be properly represented by the rectangle *bfgc*, of which the area is equal to the total load and the uniform depth to its uniform intensity. At this high part of the structure the intensity of pressure will of course be much less than its permissible intensity. If now we assume the water to have a depth *d* above the base, the total water pressure represented by the triangle *kbh* will have its centre at *d*/3 from the base, and by the parallelogram of forces assuming the density of the masonry to be 2·5, we find that the centre of pressure upon the base *bc* is shifted from the centre of the base to a point *i* nearer to the outer toe *c*, and the rectangular diagram of pressures will thus be distorted from the figure *bfgc* to the equal figure *bjlc*, having its centre *o*, vertically under the point at which the resultant of all the forces cuts the base *bc*. For any lower level the same treatment may, step by step, be adopted, until the maximum intensity of pressure *cl* exceeds the assumed permissible maximum, or the centre of pressure approaches within an assigned distance from the outer toe *c*, when the base must be widened until the maximum intensity of pressure or the centre of pressure, as the case may be, is brought within the prescribed limit. The resultant profile is of the kind shown in Fig. 14.

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[1] It appears that this remarkable core wall, a great part of which has been constructed, is not destined to be completed. A commission appointed to consider the question having examined the condition, as regards saturation, of the outer earthen embankments of other dams with high core walls on the Croton river or its tributaries, has submitted an adverse report, and it is understood that the masonry dam will be carried across the whole width of the valley.

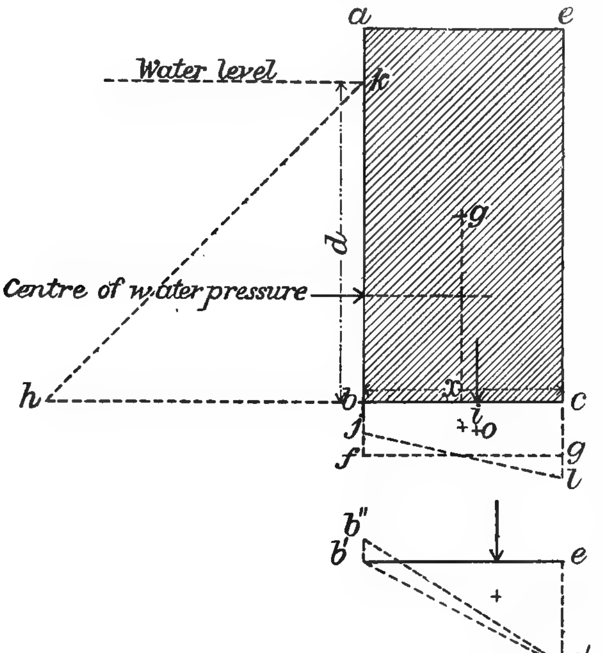


FIG. 13.—Factor of Safety Diagram.

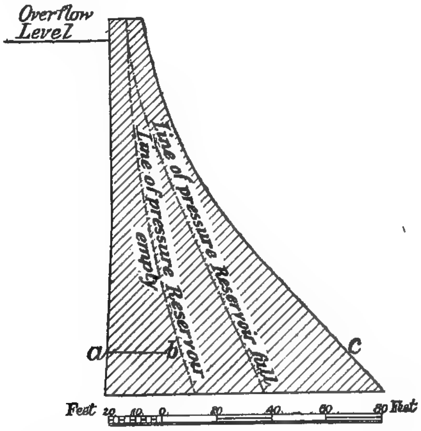
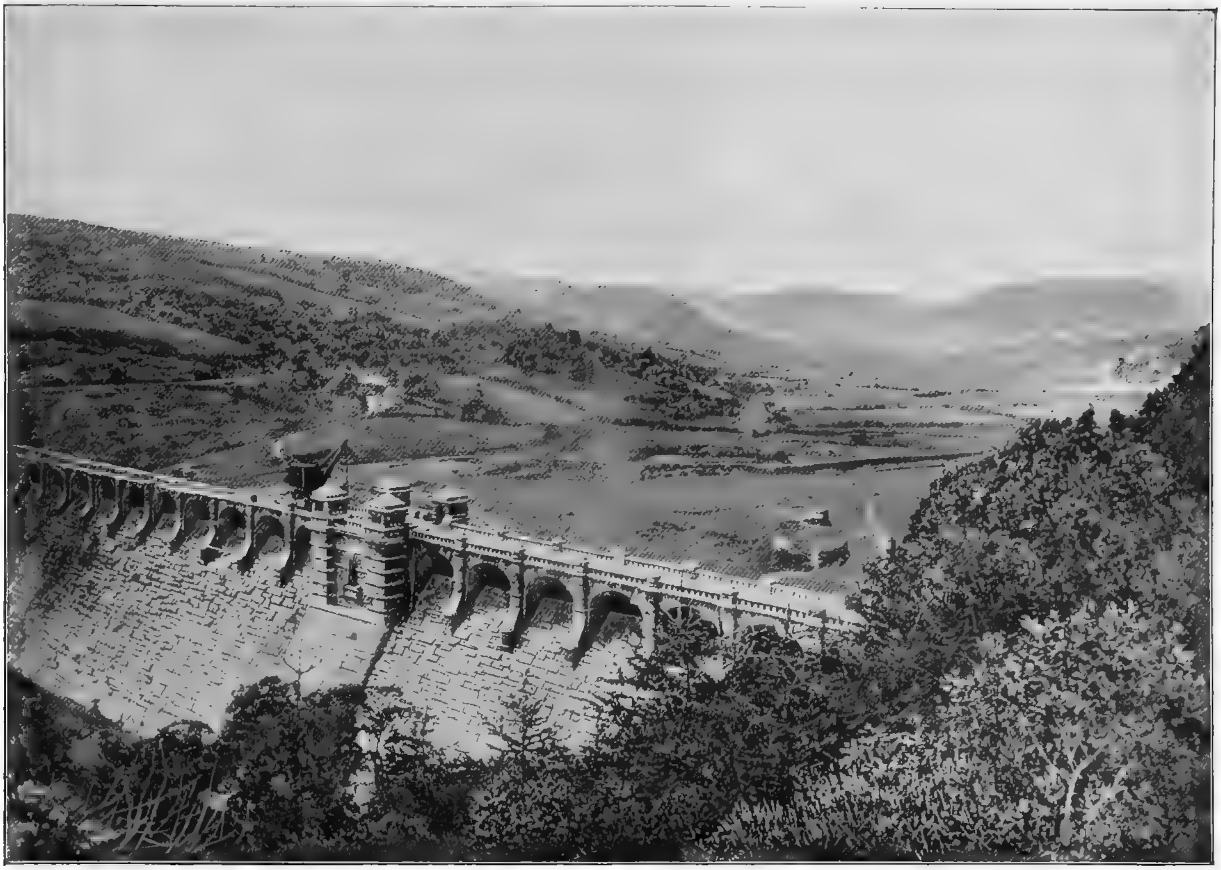

Overflow Level
Line of pressure Reservoir full
Line of pressure Reservoir empty
a
b
c
Feet 20 40 0 20 40 60 80 Feet

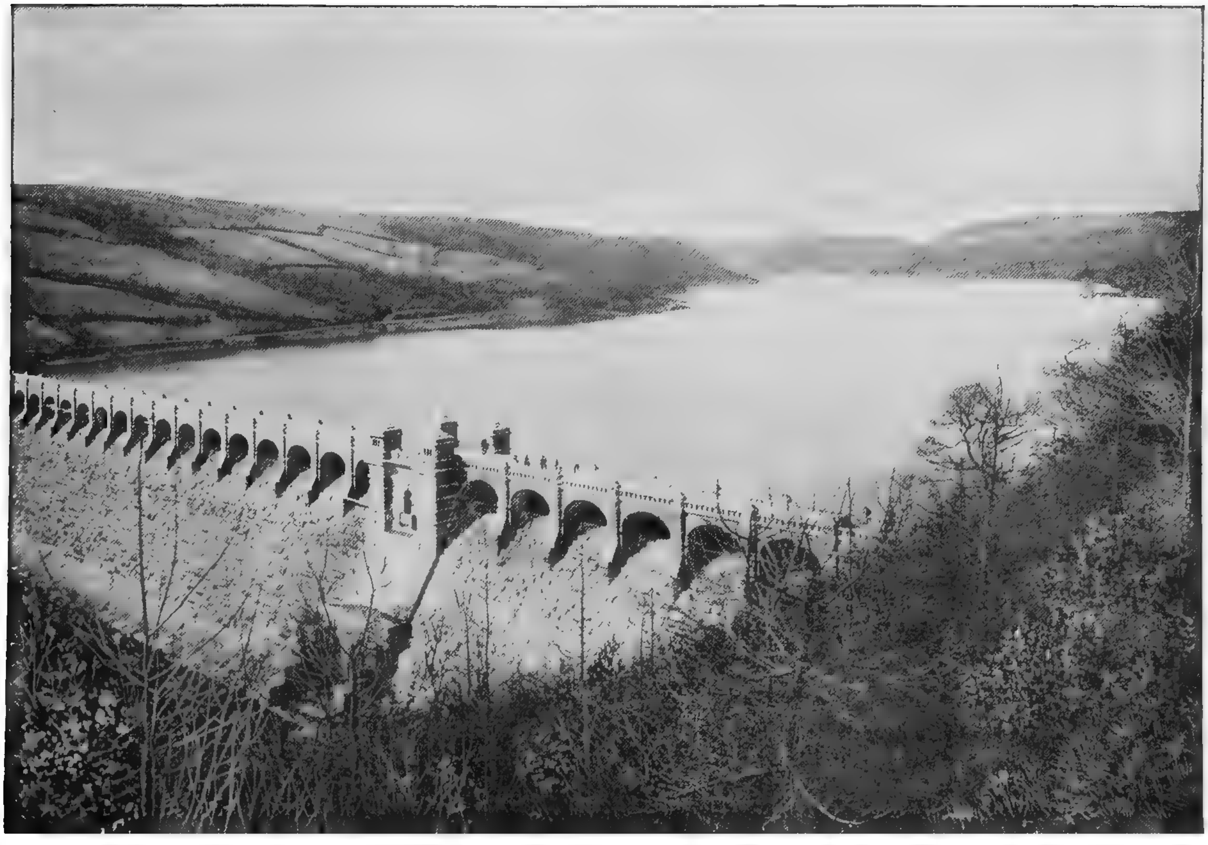
FIG. 14.—Diagram showing Lines of Pressure in Masonry Dam.

Having thus determined the outer profile under the conditions hitherto assumed, it must be similarly ascertained that the water face is everywhere capable of resisting the vertical pressure, and the base of each compartment must be widened if necessary in that direction also. Hence in dams above 100 feet in height, further adjustment of the outer profile may be required by reason of the deviation of the inner profile from the vertical. The effect of this process is to give a series of points in the horizontal planes at which the resultants of all forces above those planes respectively cut the planes. Curved lines, as dotted in Fig. 14, drawn through these points give the centre of pressure, for the reservoir full and empty respectively, at any other horizontal plane. For the sake of simplicity only gravity and horizontal water pressure have hitherto been referred to; but wind pressure should not be neglected, and where the water face is curved in vertical section the weight of the water lying vertically above such face is to be added to the vertical pressures. The effect of waves is only pertinent to the upper portion of the dam, but the pressure of ice may in some cases affect the design to a somewhat greater depth. These general principles had been recognized before 1870 by Messrs Graeff and Delocre of the Ponts et Chaussées, and had been put into practice in the Furens dam near St Etienne. When the late Professor Rankine, F.R.S., whose remarkable perception of the practical fitness or unfitness of purely theoretical deductions gives his writings exceptional value, received from Major Tulloch, R.E., on behalf of the municipality of Bombay, a request to consider the subject generally, and with special reference to very high dams, such as have since been constructed in India, Rankine pointed out that before the vertical pressure approached the maximum pressure permissible, the pressure tangential to the slope might reach it. Thus conditions of stress are conceivable in which the maximum would be tangential to the slope, and would therefore increase the vertical stress in proportion to the cosecant of the slope. It is very doubtful whether this pressure is ever reached, but such a limit rather than that of the vertical stress must be considered when the height of a dam demands it. Next, Rankine pointed out that, in a structure exposed to the overturning action of forces which fluctuate in amount and direction, there should be no appreciable tension at any point of the masonry. But there is a still more important reason why this condition should be strictly adhered to as regards the inner face. We have hitherto considered only the *horizontal* overturning pressure of the water; but if from originally defective construction, or from the absence of vertical pressure towards the water edge of any horizontal joint, as at *ab* in Fig. 14, water intrudes beneath that part of the masonry more readily than it can obtain egress along *bc*, or in any other direction towards the outer face, we shall have the uplifting and overturning pressure due to the full depth of water in the reservoir over the width *ab* added to the horizontal pressure, in which case all our previous calculations would be futile. The condition, therefore, that there shall be no tension is important; but when we come to construction, we must see also that no part of the wall shall be less permeable than the water face. In Fig. 13 we have seen that the varying depth of the area *bjlc* approximately represents the varying distribution of the vertical stress. If, therefore, the centre of the figure became so far removed to the right as to make *j* coincident with *b*, the diagram of stresses would become the triangle *b'el'*, and the vertical pressure at the inner face would be *nil*. This will evidently happen when the centre of pressure is two-thirds from the inner toe and one-third from the outer toe; and if we displace the centre of pressure still farther, the condition that the centre of figure of the diagram shall be vertically under that centre of pressure can only be fulfilled by allowing the line *b'l'* to cross the base as at *b''l'*, thus giving a negative pressure or tension at the inner toe. Hence it follows that the line of pressures, when the reservoir is full, should not at any horizontal plane fall outside the middle third of the width of that plane.

Rankine in his report adopted the prudent course of taking as the safe limits certain pressures to which, at that time, such structures were known to be subject. Thus for the inner face he took, as the limiting vertical pressure, 320 feet of water, or nearly 9 tons per square foot, and for the outer face 250 feet of water, or about 7 tons per square foot. For simplicity of calculation Rankine chose logarithmic curves for both the inner and outer faces, and they fit very well with the conditions. Since his time an immense amount of mathematical energy has been devoted to the problem, but nothing better has been evolved, and results have in some cases been brought out which physical considerations would have shown the authors to be quite inapplicable in practice.

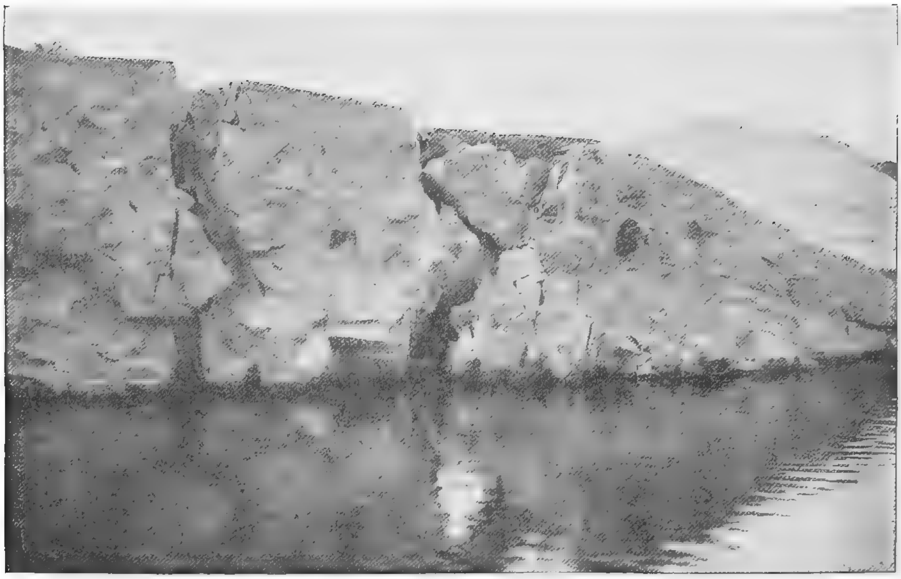


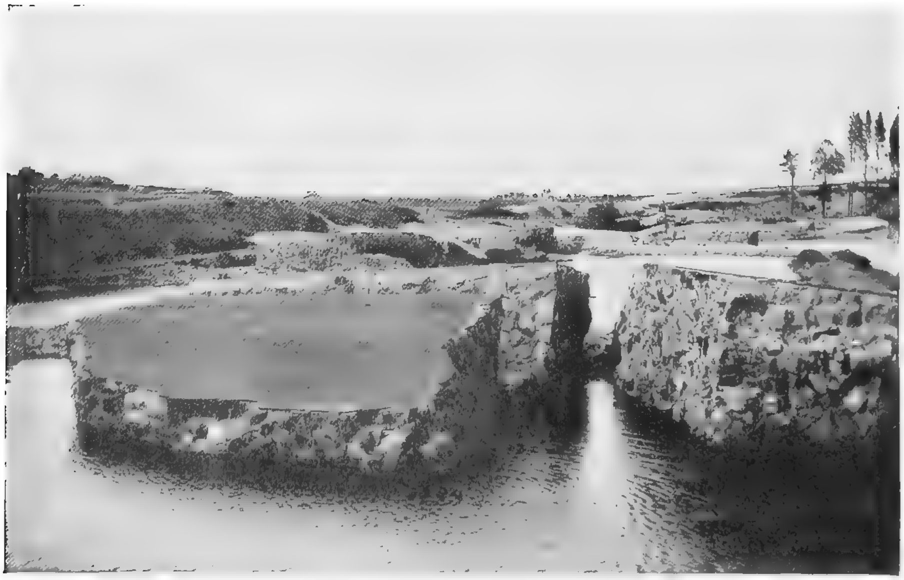
THE VYRNWY VALLEY, MONTGOMERYSHIRE, June 1888.



LAKE VYRNWY, December 1889.

(From Photographs by J. Maclardy.)





BOUZEY MASONRY DAM.

Masses of masonry from the ruptured dam, weighing about 1000 tons each, lying in the positions below the reservoir to which they had been carried by the flood consequent upon the failure of the dam in April 1895.

So far we have only considered water-pressure against the reservoir side of the dam; but it sometimes happens that the water-pressure against the outer face is considerable enough to modify the lower part of the section. In dams of moderate height above ground and considerable depth below ground there is, moreover, no reason why advantage should not be taken of the earth resistance due either to the downstream face of the trench against which the foundations are built, or to the materials excavated and properly embanked against that face above the ground level, or to both. We do not always know the least resistance which it is safe to give to a retaining wall subject to the pressure of earth, or, conversely, the maximum resistance to side-thrust which natural or embanked earth will afford, because we wisely neglect the important but very variable element of adhesion between the particles. It is notorious among engineers that retaining walls designed in accordance with the well-known theory of conjugate pressures in earth are unnecessarily strong, and this arises mainly from the assumption that the earth is merely a loose granular mass without any such adhesion. As a result of this theory, in the case of a retaining wall supporting a vertical face of earth beneath an extended horizontal plane level with the top of the wall, we get

$$P=\frac{wx^2}{2}\cdot\frac{1-\sin\phi}{1+\sin\phi},$$

where P is the horizontal pressure of the earth against the wall exerted at one-third its height, w the weight of unit volume of the material, x the height of the wall, and ϕ the angle of repose of the material. That the pressure so given exceeds the maximum possible pressure we do not doubt; and, conversely, if we put

$$P'=\frac{wx^2}{2}\cdot\frac{1+\sin\phi}{1-\sin\phi},$$

we may have equal confidence that P' will be less than the maximum pressure which, if exerted by the wall against the earth, will be borne without disturbance. The theory of conjugate pressures in earth, applied with due consideration for the angle of repose and the variations introduced by earth embankments of limited width, is perfectly safe for use in determining the resistance of earth to the overturning of masonry dams. The greater portion of the length both of the Neuadd and the Fisher Tarn dams was designed on these principles with much economy and with perfectly satisfactory results.

In the construction of the Vyrnwy masonry dam Portland cement, mortar, and concrete were used in the joints. Even when less than a year old, 9-inch cubes of this material never cracked under compression below 100 tons per square foot; and the mean resistance to cracking of all the blocks tested between two and three years after moulding exceeded 215 tons per square foot, while blocks cut from the concrete of the dam gave from 184 to 329 tons per square foot. It has been shown that the best hydraulic lime, or volcanic puzzuolana and lime, if properly ground while slaking, and otherwise treated in the best-known manner, as well as some of the so-called natural (calcareous) cements, will yield results certainly not inferior to those obtained from Portland cement. The only objection that can in any case be urged against the natural products is that a longer time is required for induration; but in the case of masonry dams sufficient time necessarily passes before any load, beyond that of the very gradually increasing masonry, is brought upon the structure. The result of using properly treated natural limes is not to be judged from the careless manner in which such limes have often been used in the past. Any stone of which it is desirable to build a masonry dam must possess an average strength at least as great as the above figures for concrete and mortar; the clay slate of the Lower Silurian formation, used in the case of the Vyrnwy dam, had an ultimate crushing strength of from 700 to 1000 tons per square foot. If, therefore, with such materials the work is well done, and is not subsequently liable to be wasted or disintegrated by expansion or contraction or other actions which in the process of time affect all exposed surfaces, it is clear that 15 to 20 tons per square foot must be a perfectly safe load. There are many structures at present in existence bearing considerably greater loads than this, and the masonry of at least one, the Bear Valley dam in California, is subject to compressive stresses, reaching, when the reservoir is full, at least 40 to 50 tons per square foot, while certain brickwork linings in mining shafts are subject to very high circumferential stresses, due to known water-pressures. In one case which has been investigated this circumferential pressure exceeds 26 tons per square foot, and the brickwork, which is 18 inches thick and 20 feet internal diameter, is perfectly sound and water-tight. In portions of the structure liable to important changes of pressure from the rise and fall of the water and subject to the additional loads which expansion and contraction by changes of temperature induce, and in view of the great difficulty of securing that the average modulus of elasticity in all parts of the structure shall be approximately the same, it is probably desirable to limit the calculated load upon any external work, even of the best kind, to 15 tons per square foot. It is clear that the material upon which any high masonry dam is founded must have a large factor of safety against crushing under the greatest load that the dam can impose upon it, and this consideration unfits any site for the construction of a masonry dam where sound rock, or at least a material equal in strength to the strongest shale, cannot be had; even in the case of such a material as shale the foundation must be well below the ground.

Materials.

The actual construction of successful masonry dams has varied from the roughest rubble masonry to ashlar work. It is probable, however, that, all things considered, random rubble in which the flattest side of each block of stone is dressed to a fairly uniform surface, so that it may be bedded as it were in a tray of mortar, secures the nearest approach to uniform elasticity. Such stones may be of any size (in the Vyrnwy dam they reached 8 or 10 tons each), and the spaces between them, where large enough, must be similarly built in with smaller, but always the largest possible, stones; spaces too small for this treatment must be filled and rammed with concrete. All stones must be beaten down into their beds until the mortar squeezes up into the joints around them. The faces of the work may be of squared masonry, thoroughly tied into the hearting; but, in view of the expansion and contraction mentioned below, it is better that the face masonry should not be coursed. Generally speaking, in the excavations for the foundations springs are met with; these may be only sufficient to indicate a continuous dampness at certain beds or joints, but all such places should be connected by relief drains carried to visible points at the back of the dam. It should be impossible, in short, for any part of the rock beneath the dam to become charged with water under pressure, either directly from the water in the reservoir or from higher places in the mountain sides, as may conceivably happen when a large area of rock at the base of a dam is sealed down. For similar reasons care must be taken to ensure that the structure of the water face of the dam shall be the least permeable of any part. In the Vyrnwy, Neuadd, and Fisher Tarn dams this was secured by bedding the stones near to the water face in somewhat finer mortar than the rest, and in the first case by placing pads to fill the joints for several inches from the water face, so that the mortar was kept away from the face and was well held up to its work. On the removal of the pads, or the cutting out of the face of the mortar where pads were not used, the vacant joint was gradually filled with almost dry mortar, a hammer and caulking tool being used to consolidate it. By these means practical impermeability was obtained. If the pores of the water face are thus rendered extremely fine, the surface water, carrying more or less fine detritus and organic matter, will soon close them entirely and assist in making it the least permeable portion of the structure.

But no care in construction can prevent the compression of the mass as the superincumbent weight comes upon it. Any given yard of height measured during construction, or at any time after construction, will be less than a yard when additional weight has been placed upon it; hence the ends of such dams placed against rock surfaces must move with respect to those surfaces when the superincumbent load comes upon them. This action is obviously much reduced where the rock sides of the valley rise slowly; but in cases where the rock is very steep, the safest course is to face the facts, and not attempt to cement the masonry to the rock, but rather to provide a vertical key, or dowel joint, of some material like asphalt, which will always remain watertight. Such a joint, moreover, will yield without damage to the stresses caused by expansion and contraction to which the dam must necessarily be subject. So far as the writer has been able to observe or ascertain, there are only two or three masonry dams in Europe or America which have not been cracked transversely in their higher parts. They generally leak a little near the junction with the rock, and at some other joints in intermediate positions. In the case of the Neuadd dam this difficulty was met by deliberately omitting the mortar in transverse joints at regular intervals near the top of the dam, except just at their faces, where it of course cracks harmlessly, and by filling the rest with asphalt. Serious movement from expansion and contraction does not usually extend to levels which are kept moderately damp, or to the greater mass of the dam, many feet below high-water level, and it is much more satisfactory to distribute the total movement over numerous transverse planes than to risk the travelling of cracks, due to more concentrated movement, from the vertical into more or less horizontal directions, and thus render the upward pressure of intrusive water possible.

The Furens dam, already referred to as the earliest type of a scientifically designed structure of the kind, is subject to a pressure of about 166 feet of water: the valley it crosses is only about 300 feet wide at the water level, and the dam is curved in plan to a radius of 828 feet. Much discussion has taken place as to the utility of such curvature. A simple calculation will show that, except in very narrow valleys with steep sides, a masonry dam, assumed to depend for its stability upon resistance tangential to the curvature, as in a horizontal arch, becomes of much larger sectional area than a corresponding gravity dam, and therefore that it is generally not worth while to attempt the reduction of those stresses which are produced purely by water-pressure against the masonry, by giving a curvature to the dam. This consideration becomes the more pertinent, by reason of the necessarily smaller resistance to compression in a horizontal than in a vertical direction. But in narrow rock gorges extremely interesting problems relating to the combined action of horizontal and vertical stresses arise, and in some such cases it is evident that much may be done by means of horizontal curvature to reduce the quantity of masonry without reduction of strength. The Bear Valley dam, California, is the most daring example in existence of the employment of the arch principle. Its height from the rock bed is 64 feet, and it is subject during floods to a head of water not much less. The length of the chord of the arc across the valley is about 250 feet and the radius 335 feet. The dam was begun in 1883, with a base 20 feet thick, narrowing to 13 feet at a height of 16 feet. The cost of this thickness being regarded as too great, it was abruptly reduced to 8 feet 6 inches, and for the remaining 48 feet it was tapered up to a final width of about 3 feet. The masonry is described by Mr Schuyler as "a rough uncut granite ashlar, with a hearting of rough rubble all laid in cement mortar and gravel." This dam has been in satisfactory use since 1885, and the slight filtration through the masonry which occurred at first is said to have almost entirely ceased. It is not improbable that the immunity from cracks in this case is actually due to the thinness of the structure, and this leads to the consideration of the utility of the curved form in wider valleys merely for the purpose of diminishing the strains which arise from expansion and contraction. In all dams, especially when the outer face is towards the sun, expansion of that face during the day and contraction during the night takes place in any free direction. If we curve the dam upstream the exposed face will be comparatively free to expand and contract horizontally; while the water face, possibly maintained at a nearly uniform temperature, can only do so by straining. Between summer and winter there is the same tendency to maintain the outer face in a variable condition of horizontal tension; and clearly, the thicker the dam and the smaller the radius, the greater must be that tension. It appears, therefore, that the comparative freedom to expand and contract given to a long dam by curving it may permit of strains which are less manageable than those in a straight dam. In any event, precautions of the same kind to avoid harmful cracking are desirable.

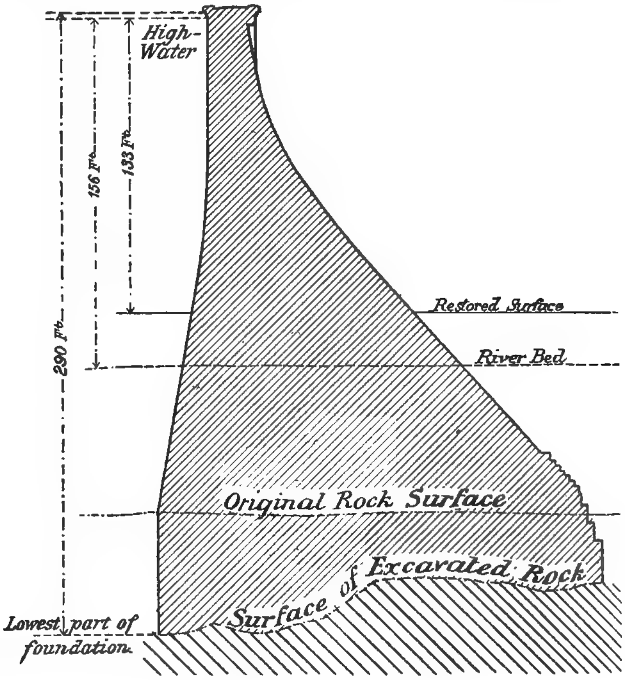


Fig. 15.—Section of Croton Dam.

The first masonry dam of importance constructed in Great Britain was that upon the river Vyrnwy, a tributary of the Severn, in connexion with the Liverpool water-supply (Plate I.). Its height, subject to water-pressure, is about 134 feet, and a carriage-way is carried on arches at an elevation of about 18 feet higher. As this dam is about 1180 feet in length from rock to rock, it receives practically no support from the sides of the valley. Its construction drew much attention to the subject of masonry dams in England, where the earthwork dam, with a wall of puddled clay, had hitherto been almost universal, and after it five more masonry dams of smaller size were completed, while in connexion with the Elan and Claerwen works, in Mid-Wales, for the supply of Birmingham, six masonry dams were projected, some of which are nearing completion, including the Caban Goch dam, 590 feet long at the water level, and subject to a water-pressure of 152 feet above the rock foundations and of 122 feet above the river bed, and the Craig-yr-allt Goch dam, subject to a head of 133 feet. The latter dam is curved in plan, the radius being 740 feet and the chord of the arc 515 feet. In the Derwent Valley scheme, in connexion with the water supplies of Derby, Leicester, Nottingham, and Sheffield, six more are projected. Of these the highest is the Hagglee, on the Ashop, a tributary of the Derwent, which will impound water to about 136 feet above the river bed, the length from rock to rock being 980 feet. Two of these dams are now in course of construction, one of which, the Howden, will be 1080 feet in length and will impound water to a depth of 114 feet above the river bed. In 1892 the excavation was begun for the foundations of a masonry dam across the Croton river, in connexion with the supply of New York, which eclipses every other project of the kind. The length of the new Croton dam from rock to rock at the overflow level is about 1500 feet. The water face, over the maximum depth at which that face cuts the rock foundations, is subject to a water-pressure of about 260 feet, while the height of the dam above the river bed is 163 feet. The section shown in Fig. 15 has been well considered. The hearting is of rubble masonry, and the faces are coursed ashlar. So-called "natural cement" has been used, except during frosty weather, when Portland cement was substituted on account of its more rapid setting. An important feature in connexion with this dam is the nature of the foundation upon which it stands. Part of the rock is schist, but the greater portion limestone, similar in physical qualities to the Carboniferous limestone of Great Britain. The lowest part of this rock was reached after excavating through alluvial deposits to a depth of about 70 feet, but owing to its fissured and cavernous nature it became necessary to excavate to much greater depths, reaching in places more than 120 feet below the original bottom of the valley. Great pains appear to have been taken to ascertain that the cavernous portions of the rock had been cut out before the building was begun.

Failures.

Something has been said of the failures of earthen dams. Many masonry dams have also failed, but, speaking generally, we know less of the causes which have led to such failures. The examination of one case, however, namely, the bursting in 1895 of the Bouzey dam, near Épinal, in France, by which many lives were lost, has brought out several points of great interest. It is probably the only instance in which a masonry dam has slipped upon its foundations, and also the only case in which a masonry dam has actually overturned, while curiously enough there is every probability that the two circumstances had no connexion with each other. The work was examined by Professor Unwin[1] and the writer shortly after the catastrophe, and the condition in which the ruined portion was then seen is shown in Plate II. Some of the blocks of rubble masonry carried down the stream weighed several hundred tons. The original section of the dam is shown by the continuous thick line in Fig. 16, from which it appears that the work was subject to a pressure of only about 65 feet of water. In the year 1884 a length of 450 feet of the dam, out of a total length of 1706 feet, slipped upon its foundation of soft sandstone, and became slightly curved in plan as shown at *a*, *b*, Fig. 17, the maximum movement from the original straight line being about a foot. The accident was repaired by the construction of the cross-lined portions in the section (Fig. 16). These precautions were perfectly effective in securing the safety of the dam up to the height to which the counterfort was carried. As a consequence of this horizontal bending of the dam vertical cracks appeared and were repaired. Eleven years after this, and about fifteen years after the dam was first brought into use, it overturned on its outer edge, at about the level indicated by the dotted line just above the counterfort; and there is no good reason to attribute to the movement of 1884 or, to the vertical cracks it caused, any influence in the overturning of 1895. Some of the worst cracks were, indeed, entirely beyond the portion overturned, which consisted of the mass 570 feet long by 37 feet in depth, and weighing about 20,000 tons, shown in elevation in Fig. 17. The line of pressures as generally given for this dam with the reservoir full, on the hypothesis that the density of the masonry was a little over 2, is shown by long and short dots in Fig. 16. Materials actually collected from the dam indicate that the mean density did not exceed 1·85 when dry and 2·07 when saturated, which would bring the line of pressures even closer to the outer face at the top of the counterfort. In any event it must have approached well within 3½ feet of the outer face, and was more nearly five-sixths than two-thirds of the width of the dam distant from the water face; there must, therefore, have been considerable vertical tension at the water face, variously computed according to the density assumed at from 1¼ to 1¾ ton per square foot. This, if the dam had been thoroughly well constructed, either with hydraulic lime or Portland cement mortar, would have been easily borne. The materials, however, were poor, and it is probable that rupture by tension in a roughly horizontal plane took place. Directly this occurred, the front part of the wall was subject to an additional overturning pressure of about 35 feet of water acting upwards, equivalent to about a ton per square foot, which would certainly, if it occurred throughout any considerable length of the dam, have immediately overturned it. But, as a matter of fact, the dam actually stood for about fifteen years. Of this circumstance there are two possible explanations. It is known that more or less leakage took place through the dam, and to moderate this the water face was from time to time coated and repaired with cement. Any cracks were thus, no doubt, temporarily closed; and as the structure of the rest of the dam was porous, no opportunity was given for the percolating water to accumulate in the horizontal fissures to anything like the head in the reservoir. But in reservoir work such coatings are not to be trusted, and a single horizontal crack might admit sufficient water to cause an uplift. Then, again, it must be remembered that although the full consequences of the facts described might arise in a section of the dam 1 foot thick (if that section were entirely isolated), they could not arise throughout the length unless the adjoining sections were subject to like conditions. Any horizontal fissure in a weak place would, in the nature of things, strike somewhere a stronger place, and the final failure would be deferred. Time would then become an element. By reason of the constantly changing temperatures and the frequent filling and emptying of the reservoir, expansion and contraction, which are always at work tending to produce relative movements wherever one portion of a structure is weaker than another, must have assisted the water-pressure in the extension of the horizontal cracks, which, growing slowly during the fifteen years, provided at last the area required to enable the intrusive water to overbalance the little remaining stability of the dam.

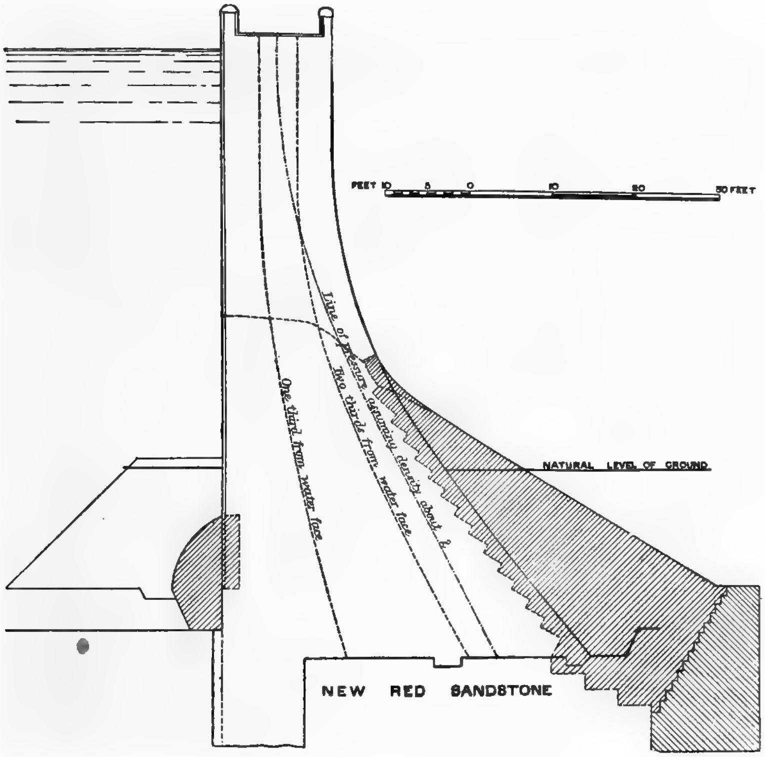

FEET 10 5 0 10 20 30 FEET
Line of pressure, assuming density about 2
Two thirds from water face
One third from water face
NATURAL LEVEL OF GROUND
NEW RED SANDSTONE

FIG. 16.—Section of Bouzey Dam.

It is obvious that the water of a reservoir must never be allowed to rise above a certain prescribed height at which the works will be perfectly safe. In all reservoirs impounding the natural flow of a stream, this involves the use of an overflow.

Overflow.

Where the dam is of masonry it may be used as a weir; but where earthwork is employed, the overflow, commonly known in such a case as the "bye-wash," should be an entirely independent work, consisting of a low weir of sufficient length to prevent an unsafe rise of the water level, and of a narrow channel capable of easily carrying away any water that passes over the weir. The absence of one or both of these conditions has led to the failure of many dams.

Reservoirs unsafe from this cause still exist in the United Kingdom. Where the contributory drainage area exceeds 5000 acres, the discharge, even allowing for so-called "cloud-bursts," rarely or never exceeds the rate of about 300 cubic feet per second per 1000 acres, or 1500 times the minimum dry weather flow, taken as one-fifth of a cubic foot; and if we provide against such an occasional discharge, with a possible maximum of 400 cubic feet at much more distant intervals, a proper factor of safety will be allowed. But when a reservoir is placed upon a smaller area the conditions are materially changed. The rainfall which produces, as the average of all the tributaries in the larger area, 300 cubic feet per second per 1000 acres, is made up of groups of rainfall of very varying intensity, falling upon different portions of that area, so that upon any section of it the intensity of discharge may be much greater.

The height to which the water is permitted to rise above the sill of the overflow depends upon the height of the embankment above that level (in the United Kingdom commonly 6 or 7 feet), and this again should be governed by the height of possible waves. In open places that height is seldom more than about one and a half times the square root of the "fetch," or greatest distance in nautical miles from which the wave has travelled to the point in question; but in narrow reaches or lakes it is relatively higher. In lengths not exceeding about 2 miles, twice this height may be reached, giving for a 2-mile "fetch" about 3½ feet, or 1¾ foot above the mean level. Above this again, the height of the wave should be allowed for "wash," making the embankment in such a case not less than 5¼ feet above the highest water level. If, then, we determine that the depth of overflow shall not exceed 1½ foot, we arrive at 6¾ feet as sufficient for the height of the embankment above the sill of the overflow. Obviously we may shorten the sill at the cost of extra height of embankment, but it is rarely wise to do so.

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[1] See *Proc. Inst. C. E.*, vol. cxxvi. pp. 91–95.

The overflow sill or weir should be a masonry structure of rounded vertical section raised a foot or more above the waste-water course, in which case for a depth of 1½ foot it will discharge, over every foot of length, about 6 cubic feet per second. Thus, if the drainage area exceeds 5000 acres, and we provide for the passage of 300 cubic feet per second per 1000 acres, such a weir will be 50 feet long for every 1000 acres. But, as smaller areas are approached, the excessive local rainfalls of short duration must be provided for, and beyond these there are extraordinarily heavy discharges generally over and gone before any exact records can be made; hence we know very little of them beyond the bare fact that from 1000 acres the discharge may rise to two or three times 300 cubic feet per second per 1000 acres. In the writer's experience at least one case has occurred where, from a mountain area of 1300 acres, the rate per 1000 was for a short time certainly not less than 1000 cubic feet per second. Nothing but long observation and experience can help the hydraulic engineer to judge of the configuration of the ground favourable to such phenomena. It is only necessary, however, to provide for these exceptional discharges during very short periods, so that the rise in the water level of the reservoir may be taken into consideration; but subject to this, provision must be made at the bye-wash for preventing such a flood, however rare, from filling the reservoir to a dangerous height.

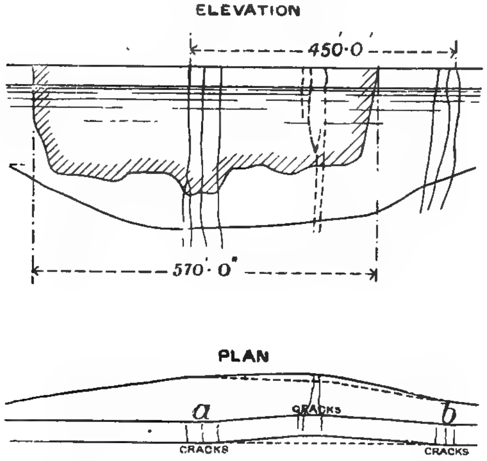


Fig. 17.—Elevation and Plan of Bouzey Dam.

From the overflow sill the bye-wash channel may be gradually narrowed as the crest of the embankment is passed, the water being prevented from attaining undue velocity by steps of heavy masonry, or, where the gradient is not very steep, by irregularly set masonry.

Reservoirs.

From very ancient times in India, Ceylon, and elsewhere, reservoirs of great area, but generally of small depth, have been built and used for the purposes of irrigation; and in modern times, especially in India and America, comparatively shallow reservoirs have been constructed of much greater area, and in some cases of greater capacity, than any in the United Kingdom. Yet the hilly parts of the last-named country are rich in magnificent sites at sufficient altitudes for the supply of any parts by gravitation, and capable, if properly laid out, of affording a volume of water, throughout the driest seasons, far in excess of the probable demand for a long future. Many of the great towns had already secured such sites within moderate distances, and had constructed reservoirs of considerable size, when, in 1879 and 1880 respectively, Manchester and Liverpool obtained statutory powers to draw water from relatively great distances, viz., from Thirlmere in Cumberland, in the case of Manchester, and from the river Vyrnwy, in the case of Liverpool. The latter work, completed in 1892, includes a reservoir which is still by far the largest in Europe.

Lake Vyrnwy.

This reservoir is situated in a true Glacial lake-basin, and having therefore all the appearance of a natural lake, is commonly known as Lake Vyrnwy. It is 825 feet above the sea, has an area of 1121 acres, an available capacity exceeding 12,000 million gallons, and a length of nearly 5 miles. Its position in North Wales is shown in black in Fig. 18, and the two views on Plate I. show respectively the portion of the valley visible from the dam before impounding began, and the same portion as a lake on the completion of the work. Before the valves in the dam were closed, the village of Llanwddyn, the parish church, and many farmsteads, were demolished. The church was rebuilt outside the watershed, and the remains from the old churchyard were removed to a new cemetery adjoining it. The fact that this valley is a post-Glacial lake-basin was attested by the borings and excavations made for the foundations of the dam. The trench in which the masonry was founded covered an area 120 feet wide at the bottom, and extending for 1172 feet across the valley. Its site had been determined by about 190 borings, probings, and shafts, which, following upon the indications afforded by the rocks above ground, proved that the rock bed crossing the valley was higher at this point than elsewhere. Here then, buried in alluvium at a depth of 50 to 60 feet from the surface, was found the rock bar of the post-Glacial lake; at higher points in the valley, borings nearly a hundred feet deep had failed to reach the rock. The Glacial striæ, and the dislocated rocks—moved a few inches or feet from their places, and others, at greater distances, turned over, and beginning to assume the sub-angular form of Glacial boulders—were found precisely as the glacier, receding from the bar, and giving place to the ancient lake, had left them, covered and preserved by sand and gravel washed from the terminal morain. Later came the alluvial silting-up. Slowly, but surely, the deltas of the tributary streams advanced into the lake, floods deposited their burdens of detritus in the deeper places, the lake shallowed and shrank and in its turn yielded to the winding river of an alluvial strath, covered with peat, reeds, and alders, and still liable to floods. It is interesting to record that during the construction of the works the implements of Neolithic man were found, near the margin of the modern lake, below the peat, and above the alluvial clay on which it rested. Most of the large reservoir sites in Wales, shown by shaded lines in Fig. 18, are in all probability similar post-Glacial lake-basins, and in the course of time may become the sites of still greater reservoirs. They are provided with well-proportioned watersheds and rainfall, and being nearly all more than 500 feet above the sea, may be made available for the supply of pure water by gravitation to any part of England. In 1892 the Corporation of Birmingham obtained powers for the construction of six reservoirs on the rivers Elan and Claerwen, also shown in Fig. 18. The sites of these reservoirs are long narrow valleys, not lake basins, and their aggregate capacity will be about 18,000 million gallons.

Of natural lakes in Great Britain raised above their ordinary levels that the upper portions may be utilized as reservoirs, Loch Katrine supplying Glasgow is well known. Whitehaven is similarly supplied from Ennerdale, and in the year 1894 Thirlmere in Cumberland was brought into use, as already mentioned, for the supply of Manchester. The corporation have statutory power to raise the lake 50 feet, at which level it will have an available capacity of about 8000 million gallons; to secure this a masonry dam has been constructed, though the lake is at present worked at a lower level.

Purification.

When surface waters began to be used for potable purposes, some mode of arresting suspended matter, whether living or dead, became necessary. In many cases gauze strainers were at first employed, and, as an improvement upon or addition to these, the water was caused to pass through a bed of gravel or sand, which, like the gauze, was regarded merely as a strainer. As such strainers were further improved, by sorting the sand and gravel, and using the fine sand only at the surface, better clarification of the water was obtained; but chemical analysis indicated, or was at the time thought to indicate, that that improvement was practically confined to clarification,

Sand filtration.

as the dissolved impurities in the water were certainly very little changed. Hence such filter beds, as they were even then called, were regarded as a luxury rather than as a necessity, and it was never suspected that, notwithstanding the absence of chemical improvement in the water, changes did take place of a most important kind. Following upon Dr Koch's discovery of a method of isolating bacteria, and of making approximate determinations of their number in any volume of water, a most remarkable diminution in the number of microbes contained in sand-filtered water was observed; and it is now well known that when a properly constructed sand-filter bed is in its best condition, and is worked in the best-known manner, nearly the whole of the microbes existing in the crude water will be arrested. The sand which is nominally the filter has interstices about thirty times as wide as the largest dimensions of the larger microbes; and the reason why these, and, still more, why organisms which were individually invisible under any magnifying power, and could only be detected as colonies, were arrested, was not understood. In process of time it became clear, however, that the worse the condition of a filter bed, in the then general acceptation of the term, the better it was as a microbe filter; that is to say, it was not until a fine film of mud and microbes had formed upon the surface of the sand that the best results were obtained.

Even yet medical science has not determined the effect upon the human system of water highly charged with bacteria which are not known to be individually pathogenic. In the case of the bacilli of typhoid and cholera, we know the direct effect; but apart altogether from the presence of such specific poisons, polluted water is undoubtedly injurious. Where, therefore, there is animal pollution of any kind, more especially where there is human pollution, generally indicated by the presence of *bacillus coli communis*, purification is of supreme importance, and no process has yet been devised which, except at extravagant cost, supersedes for public supplies that of properly-conducted sand filtration. Yet it cannot be too constantly urged that such filtration depends for its comparative perfection upon the surface film, that this surface film is not present when the filter is new, or when its materials have been recently washed, that it may be, and very often is, punctured by the actual working of the filters, or for the purpose of increasing their discharge, and that at the best it must be regarded as an exceedingly thin line of defence, not to be depended upon as a safeguard against highly polluted waters, if a purer source of supply can possibly be found. Such filters are not, and in the nature of things cannot be, worked with the precision and continuity of a laboratory experiment.

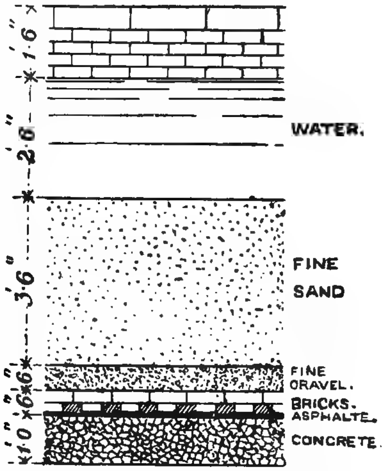
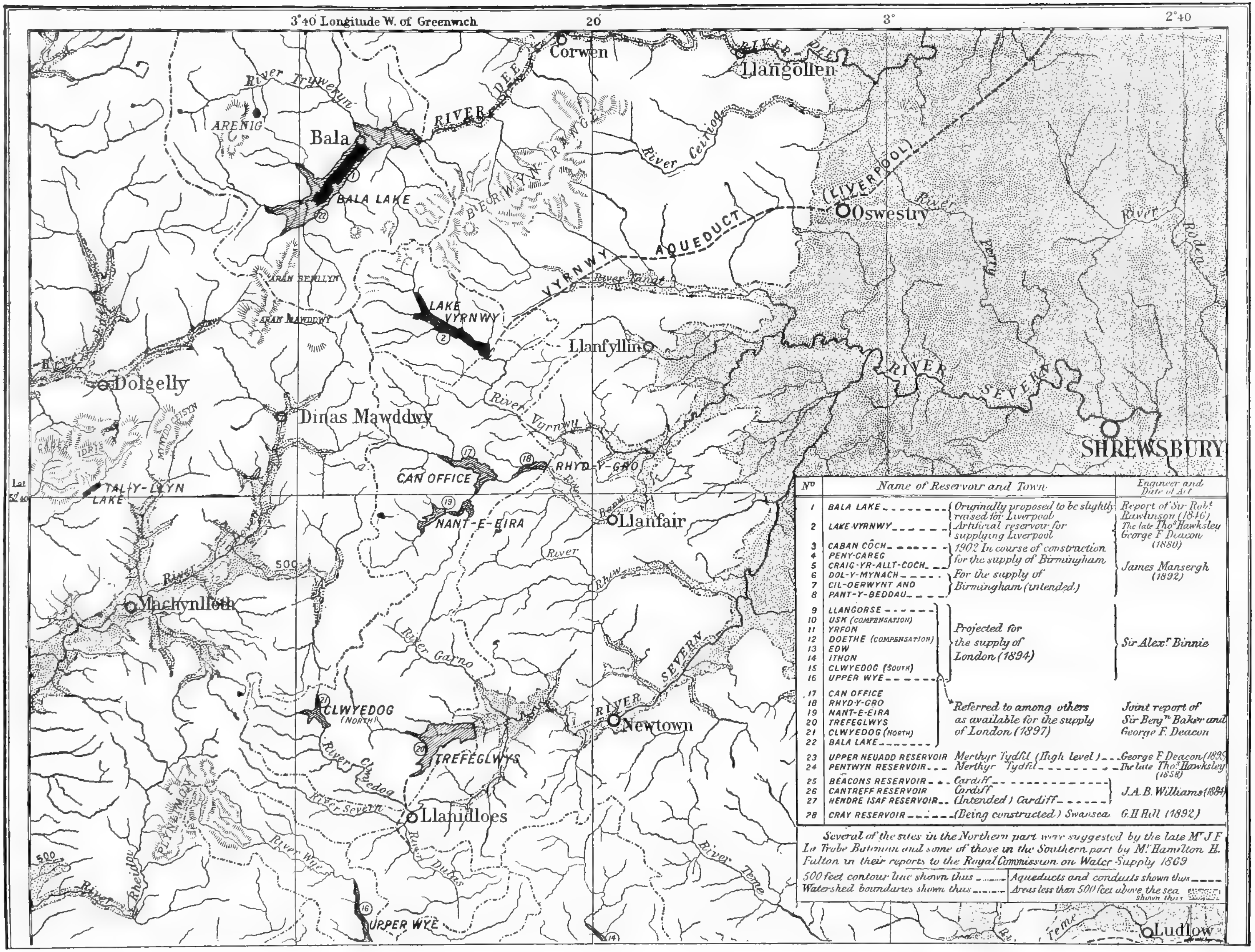


Fig. 19.—Section of Sand Filter Bed.

In Fig. 19 a section is shown of an efficient sand-filter bed. The thickness of sand is 3 feet. In the older filters it was usual to support this sand upon small gravel resting upon larger gravel, and so on until the material was sufficiently open to pass the water laterally to under-drains. But a much shallower and certainly not less efficient filter can be constructed by making the under-drains cover the whole bottom. In Fig. 19 the sand rests on small gravel of such degree of coarseness that the whole of the grains would be retained on a sieve of ⅛-inch mesh and rejected by a sieve of ½-inch mesh in the clear, supported upon a 3-inch thickness of bricks laid close together, and constituting the roof of the under-drains, which are formed by other bricks laid on thin asphalt, upon a concrete floor. In this arrangement the whole of the materials may be readily removed for cleansing. In the best filters an automatic arrangement for the measurement of the supply to each separate filter, and for the regulation of the quantity within certain limits, is adopted, and the resistance at outflow is so arranged that not more than a certain head of pressure, about 2½ feet, can under any circumstances come upon the surface film, while a depth of several feet of water is maintained over the sand. It is essential that during the working of the filter the water should be so supplied that it will not disturb the surface of the sand. When a filter has been emptied, and is being re-charged, the water should be introduced from a neighbouring filter, and should pass upwards in the filter to be charged, until the surface of the sand has been covered. The unfiltered water may then be allowed to flow quietly and to fill the space above the sand to a depth of 2 or 3 feet. It would appear to be impossible with any water that requires filtration to secure that the first filtrate shall be satisfactory if filtration begins immediately after a filter is charged; and if the highest results are to be obtained, either the unfiltered water must be permitted to pass extremely slowly over the surface of the sand without passing through it, or to stand upon the sand until the surface film has formed. With waters giving little or no sediment, which are often the most dangerous, some change, as by the first method, is necessary. It has been proposed, on the other hand, to allow the filter to act slowly until the surface film is formed, and to discard the first effluent. This course can scarcely fail to introduce into the sand many bacteria, which may be washed through when the full working of the filters is begun; and it should not, therefore, be adopted when the source of the supply is known to be subject to human pollution. The time for the formation of an efficient surface varies, according to the quality of the raw water, from a few hours to a few days. Judging from the best observations that have been made on a large scale, the highest rate of efficient filtration when the surface film is in good condition is about 4 inches downwards per hour of the water contained above the sand, equivalent to about 50 gallons per day from each square foot of sand. When the surface film has once been formed, and the filter has begun its work, it should continue without interruption until the resistance of that film becomes too great to permit of the necessary quantity of water being passed. That period will vary, according to the condition of the water, from eight or ten days to four weeks. The surface film, together with half an inch to an inch of sand, is then carefully scraped off and stored for subsequent washing and use. This process may be repeated many times until the thickness of the fine sand is reduced to about 18 inches, when the filter bed should be restored to its full thickness.

A lately discovered effect of sand filtration is of great importance in connexion with the subject Aqueduct, treated in vol. xxv. A brown slimy sediment, having the appearance of coffee grounds when placed in clear water, has been long observed in pipes conveying surface waters from mountain moorlands. The deposit grows on the sides of the pipes and accumulates at the bottom, and causes most serious obstruction to the flow of water. The chemists and bacteriologists do not appear to have finally determined the true nature and origin of this growth, but it is found in the impounded waters, and passes into the pipes, where it rapidly increases. It is checked even by fine copper wire gauze strainers, and where the water passes through sand-filter beds in the course of an aqueduct, the growth, though very great between the reservoir and the filter beds, is almost absent between the filter beds and the town. Even the growth of the well-known nodular incrustations in iron pipes is much reduced by sand filtration. From these facts it is clear that, other things being the same, the best position for the strainers and filter beds is as close as possible to the reservoir.

Some surface waters dissolve lead when bright, but cease to do so when the lead becomes tarnished. More rarely the action is continuous, and the water after being passed through lead cisterns and pipes produces lead poisoning—so called "plumbism." The liability to this appears to be entirely removed by efficient sand filtration.



Nº	Name of Reservoir and Town		Engineer and Date of Act
1	BALA LAKE	Originally proposed to be slightly raised for Liverpool	Report of Sir Robt. Rawlinson (1846)
2	LAKE VYRNWY	Artificial reservoir for supplying Liverpool	The late Thos. Hawksley George F. Deacon (1880)
3	CABAN CÔCH	1902 In course of construction for the supply of Birmingham	James Mansergh (1892)
4	PENY-CAREG		
5	CRAIG-YR-ALLT-COCH		
6	DOL-Y-MYNACH	For the supply of Birmingham (intended.)	
7	CIL-OERWYNT AND		
8	PANT-Y-BEDDAU		
9	LLANGORSE	Projected for the supply of London (1894)	Sir Alexr. Binnie
10	USK (COMPENSATION)		
11	YRFON		
12	DOETHE (COMPENSATION)		
13	EDW		
14	ITHON		
15	CLWYEDOG (SOUTH)		
16	UPPER WYE		
17	CAN OFFICE	Referred to among others as available for the supply of London (1897)	Joint report of Sir Benjn. Baker and George F. Deacon
18	RHYD-Y-GRO		
19	NANT-E-EIRA		
20	TREFEGLWYS		
21	CLWYEDOG (NORTH)		
22	BALA LAKE		
23	UPPER NEUADD RESERVOIR	Merthyr Tydfil (High level)	George F. Deacon (1895)
24	PENTWYN RESERVOIR	Merthyr Tydfil	The late Thos. Hawksley (1858)
25	BEACONS RESERVOIR	Cardiff	J. A. B. Williams (1884)
26	CANTREFF RESERVOIR	Cardiff	
27	HENDRE ISAF RESERVOIR	(Intended) Cardiff	
28	CRAY RESERVOIR	(Being constructed) Swansea	G. H. Hill (1892)

Several of the sites in the Northern part were suggested by the late Mr. J. F. La Trobe Bateman and some of those in the Southern part by Mr. Hamilton H. Fulton in their reports to the Royal Commission on Water Supply 1869

500 feet contour line shown thus -.-.-.-
Watershed boundaries shown thus -.-.-.-
Aqueducts and conduits shown thus ----
Areas less than 500 feet above the sea shown thus ░

Joins cut line below.

Joins cut line above.

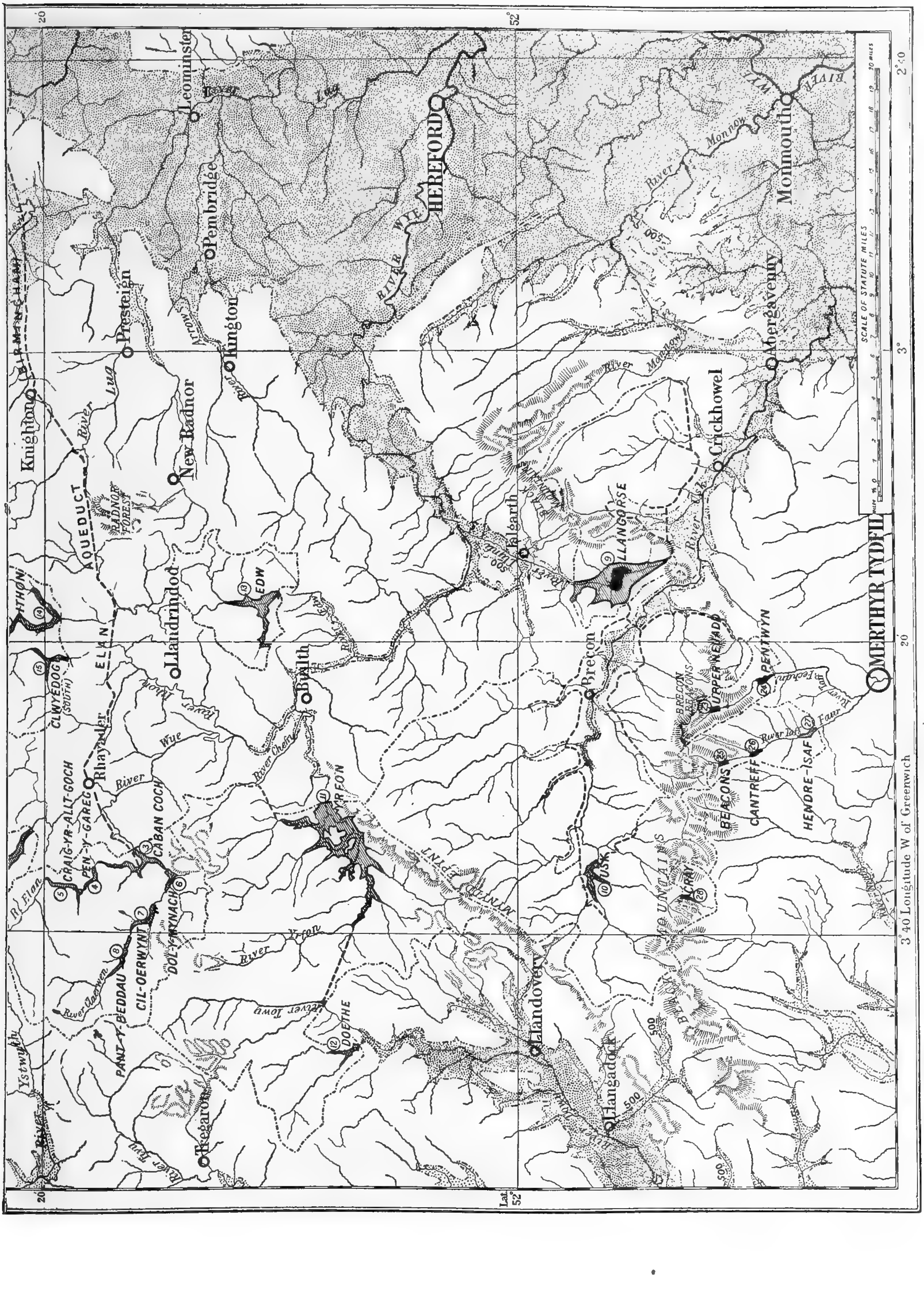


Fig. 18.—Welsh Reservoir Sites.

Sand filtration, even when working in the best possible manner, falls short of the perfection necessary to prevent the passage of bacteria which may multiply after the filter is passed. Small, however, as the micro-organisms are, they are larger than the capillary passages in some materials through which water under pressure may be caused to percolate. It is therefore natural that attempts should have been made to construct filters which, while permitting the slow percolation of water, should preclude the passage of bacteria or their spores. In the laboratory of Pasteur probably the first filter which successfully accomplished this object was produced. In this apparatus, known as the Pasteur-Chamberland filter, the filtering medium is biscuit porcelain. It was followed by the Berkefield filter, constructed of baked infusorial earth. Both these filters arrest the organisms by purely mechanical action, and if the joints are water-tight and they receive proper attention and frequent sterilization, they both give satisfactory results on a small scale for domestic purposes. The cost, however—to say nothing of the uncertainty—where large volumes of water are concerned, much exceeds the cost of obtaining initially safe water. Moreover, if a natural water is so liable to pathogenic pollution as to demand filtration of this kind, it ought at once to be discarded for an initially pure supply; not necessarily pure in an apparent or even in a chemical sense, for water may be visibly coloured, or may contain considerable proportions both of organic and inorganic impurity, and yet be tasteless and free from pathogenic pollution.

There are several materials now in use possessing remarkable power to decolourize, clarify, chemically purify, and oxidize water; but they are too costly for use in connexion with public water supplies unless a rate of filtration is adopted quite inconsistent with the formation of a surface film capable of arresting micro-organisms. This fact does not render them less useful when applied to the arts in which they are successfully employed.

Attempts have been made, by adding certain coagulents to the water to be filtered, to increase the power of sand and other granular materials to arrest bacteria when passing through them at much higher velocities than are possible for successful filtration by means of the surface film upon sand. The effect is to produce between the sand or other grains a glutinous substance which does the work performed by the mud and microbes upon the surface of the sand filter. Elsewhere centrifugal force, acting somewhat after its manner in the cream separator, has been called in aid.

Sedimentation tanks.

The sedimentation tank forms a very important help to filtration. In the case of river waters liable to turbidity the water should always be passed through such tanks before being placed in the filters. They form, moreover, additional safeguards against organic impurity. Sedimentation tanks on a sufficient scale may effect the purification of the water to almost any desired extent. This is shown to be the case by the purity of some lake waters; but the first cost of the works and the subsequent removal of the sediment are in some cases a serious matter, and any approach to the comparatively perfect action of lakes is out of the question. By the use of such tanks, however, when the condition of the water demands it, and by passing the effluent water through sand filters when in good condition, the number of microbes is found to be reduced by as much as 97 or even 99 per cent. This, when attained, is undoubtedly a most important reduction in the chance of pathogenic bacteria passing into the filtered water; but much more must be done than has hitherto in most places been done to ensure the constancy of such a condition before it can be assumed to represent the degree of safety attained. No public supply should be open to any such doubt as ought to, or may, deter people from drinking the water without previous domestic filtration or boiling.

Distribution.

Intermittent supply.

The earliest water supplies in Great Britain were generally distributed at low pressure by wooden pipes or stone or brick conduits. For special purposes the Romans introduced cast-lead pipes, but they were regarded as luxuries, not as necessaries, and gave way to cheaper conduits made, as pump barrels had long been made, by boring out tree trunks, which are occasionally dug up in a good state of preservation. This use of tree-trunks as pipes is still common in the wooded mountain districts of Europe. Within the 19th century, however, cast iron became general in the case of large towns; but following the precedent inseparable from the use of weaker conduits, the water was still delivered under very low pressure, rarely more than sufficient to supply taps or tanks near the level of the ground, and generally for only a short period out of each twenty-four hours. On the introduction of the Waterworks Clauses Act, 1847, an impetus was given to high-pressure supplies, and the same systems of distributing mains were frequently employed for the purpose; but with few exceptions the water continued to be supplied intermittently, and cisterns or tanks were necessary to store it for use during the periods of intermission. Thus it happened that pipes and joints intended for a low-pressure supply were subjected, not only to high pressure, but to the trying ordeal of suddenly varying pressures. As a rule such pipes were not renewed: the leakage was enormous, and the difficulty was met by the very inefficient method of reducing the period of supply still farther. But even in entirely new distributing systems the network is so extensive, and the number of joints so great, that the aggregate leakage is always considerable; the greatest loss being at the so-called "ferrules" connecting the mains with the house "communication" or "service" pipes, in the lead pipes, and in the household fittings. But a far greater evil than mere loss of water and inconvenience soon proved to be inseparable from intermittent supply. Imagine a hilly town with a high-pressure water supply, the water issuing at numerous points, sometimes only in exceedingly small veins, from the pipes into the sub-soil. In the ordinary course of intermittent supply or for the purpose of repairs, the water is cut off at some point in the main above the leakages; but this does not prevent the continuance of the discharge in the lower part of the town. In the upper part there is consequently a tendency to the formation of a vacuum, and some of the impure sub-soil water near the higher leakages is sucked into the mains, to be mixed with the supply when next turned on. We are indebted to the Local Government Board for having traced to such causes certain epidemics of typhoid, and there can be no manner of doubt that the evil has been very general. It is therefore of supreme importance that the pressure should be constantly maintained, and to that end, in the best-managed waterworks, the supply is not now cut off even for the purpose of connecting house-service pipes, an apparatus being employed by which this is done under pressure. Constant pressure being granted, constant leakage is inevitable, and being constant it is not surprising that its total amount often exceeds the aggregate of the much greater, but shorter, draughts of water taken for various household purposes. There is therefore, even in the best cases, a wide field for the conservation and utilization of water hitherto entirely wasted.

Constant supply.

Following upon the passing of the Waterworks Clauses Act, 1847, a constant supply was attempted in many towns, with the result in some cases that, owing to the enormous loss arising from the prolongation of the period of leakage from a fraction of an hour to twenty-four hours, it was impossible to maintain the supply. Accordingly, in some places large sections of the mains and service pipes were entirely renewed, and the water consumers were put to great expense in changing their fittings to new and no doubt better types, though the old fittings were only in a fraction of the cases actually causing leakage. But whether or not such stringent methods were adopted, it was found necessary

Detection of waste.

to organize a system of house-to-house visitation and constantly recurring inspection. In Manchester this was combined with a most careful examination, at a depôt of the Corporation, of all fittings intended to be used. Searching tests were applied to these fittings, and only those which complied in every respect with the prescribed regulations were stamped and permitted to be fixed within the limits of the water supply. But this did not obviate the necessity for house-to-house inspection, and although the number of different points at which leakage occurred was still great, it was always small in relation to the number of houses which were necessarily entered by the inspector; moreover, when the best had been done that possibly could be done to suppress leakage due to domestic fittings, the leakage below ground in the mains, ferrules, and service pipes still remained, and was often very great. It was clear, therefore, that in its very nature, house-to-house visitation was both wasteful and insufficient, and it remained for Liverpool to correct the difficulty by the application, in 1873, of the "Differentiating waste water meter," which has since been extensively used for the same purpose in various countries. One such instrument was placed below the roadway upon each main supplying a population of generally between 1000 and 2000 persons.

Its action is based upon the following considerations: When water is passing through a main and supplying nothing but leakage the flow of that water is necessarily uniform, and any instrument which graphically represents that flow as a horizontal line conveys to the mind a full conception of the nature of the flow, and if by the position of that line between the bottom and the top of a diagram the quantity of water (in gallons per hour, for example) is recorded, we have a full statement, not only of the rate of flow, but of its nature. We know, in short, that the water is not being usefully employed. In the actual instrument, the paper diagram is mounted upon a drum caused by clockwork to revolve uniformly, and is ruled with vertical hour lines, and horizontal quantity lines representing gallons per hour. Thus, while nothing but leakage occurs the uniform horizontal line is continued. If now a tap is opened in any house connected with the main, the change of flow in the main will be represented by a vertical change of position of the horizontal line, and when the tap is turned off the pencil will resume its original vertical position, but the paper will have moved like the hands of a clock over the interval during which the tap was left open. If, on the other hand, water is suddenly drawn off from a cistern supplied through a ball-cock, the flow through the ball-cock will be recorded, and will be represented by a sudden rise to a maximum, followed by a gradual decrease as the ball rises and the cistern fills; the result being a curve having its asymptote in the original horizontal line. Now, all the uses of water, of whatever kind they may be, produce some such irregular diagrams as these, which can never be confused with the uniform horizontal line of leakage, but are always superimposed upon it. It is this leakage line that the waterworks engineer uses to ascertain the truth as to the leakage and to assist him in its suppression. In well-equipped waterworks each house service pipe is controlled by a stop-cock accessible from the footpath to the officials of the water authority, and the process of waste detection by this method depends upon the manipulation of such stop-cocks in conjunction with the differentiating meter. As an example of one mode of applying the system, suppose that a night inspector begins work at 11.30 P.M. in a certain district of 2000 persons, the meter of which records at the time a uniform flow of 2000 gallons an hour, showing the not uncommon rate of leakage of 24 gallons per head per day. The inspector proceeds along the footpath from house to house, and outside each house he closes the stop-cock, recording opposite the number of each house the exact time of each such operation. Having arrived at the end of the district he retraces his steps, re-opens the whole of the stop-cocks, removes the meter diagram, takes it to the night complaint office, and enters in the "night inspection book" the records he has made. The next morning the diagram and the "night inspection book" are in the hands of the day inspector, who compares them. He finds, for example, from the diagram that the initial leakage of 2000 gallons an hour has in the course of a 4½ hours' night inspection fallen to 400 gallons an hour, and that the 1600 gallons an hour is accounted for by fifteen distinct drops of different amounts and at different times. Each of these drops is located by the time and place records in the book and the time records on the diagram as belonging to a particular service pipe; so that out of possibly 300 premises the bulk of the leakage has been localized in or just outside fifteen. To each of these premises he goes with the knowledge that a portion of the total leakage of 2000 gallons an hour is almost certainly there, and that it must be found, which is a very different thing from visiting three or four hundred houses, in not one of which he has any particular reason to expect to find leakage. Even when he enters a house with previous knowledge that there is leakage, its discovery may be difficult. It is often hidden, sometimes underground, and may only be brought to light by excavation. In these cases, without some such system of localization, the leakage might go on for years or for ever. There are many and obvious variations of the system. That described requires a diagram revolving once in a few hours, otherwise the time scale will be too close; but the ordinary diagram revolving once in 24 hours is often used quite effectively in night inspections by only closing those stop-cocks which are actually passing water. This method was also first introduced in Liverpool. The night inspector carries with him a stethoscope, often consisting merely of his steel turning-rod, with which he sounds the whole of the outside stop-cocks, but only closes those through which the sound of water is heard. An experienced man, or even a boy, if selected as possessing the necessary faculty (which is sometimes very strongly marked), can detect the smallest dribble when the stop-cock is so far closed as to restrict the orifice. Similar examinations by means of the stop-valves on the mains are also made, and it often happens that the residual leakage (400 gallons an hour in the last case) recorded on the diagram, but not shut off by the house stop-cocks, is mentioned by the inspector as an "outside waste," and localized as having been heard at a stop-cock and traced by sounding the pavement to a particular position under a particular street. All leakages found on private property are duly notified to the water tenant in the usual way, and subsequent examinations are made to ascertain if such notices have been attended to. If this work is properly organized, nearly the whole of the leakage so detected is suppressed within a month. A record of the constantly fluctuating so-called "night readings" in a large town is most interesting and instructive. If, for example, in the case of a hundred such districts we watch the result of leaving them alone, a gradual growth of leakage common to most of the districts, but not to all, is observed, while here and there a sudden increase occurs, often doubling or trebling the total supply to the district. Upon the original installation of the system in any town, the rate of leakage and consequent total supply to the different districts is found to vary greatly, and in some districts it is usually many times as great per head as in others. An obvious and fruitful extension of the method is to employ the inspectors only in those districts which, for the time being, promise the most useful results.

Supply by meter.

In many European cities the supply of water, even for domestic purposes, is given through ordinary water meters, and paid for, according to the meter record, much in the same manner as a supply of gas or electricity. By the adoption of this method great reductions in the quantity of water used and wasted are in some cases effected, and the water tenant pays for the leakage or waste he permits to take place, as well as for the water he uses. The system, however, does not assist in the detection of the leakage which inevitably occurs between the reservoir and the consumer's meter; thus the whole of the mains, joints, and ferrules connecting the service pipes with the mains, and the greater parts of the service pipes, are still exposed to leakage, without any compensating return to the water authority. But the worst evil of the system, and one which must always prevent its introduction into the United Kingdom, is the circumstance that it treats water as an article of commerce, to be paid for according to the quantity taken. In the organization of the best municipal water undertakings in the United Kingdom the free use of water is encouraged, and it is only the leakage or occasional improper employment of the water that the water authority seeks, and that successfully, to suppress. The objection to the insanitary effect of the meter-payment system has, in some places, been sought to be removed by providing a fixed quantity of water, assumed to be sufficient, as the supply for a fixed minimum payment, and by using the meter records simply for the purpose of determining what additional payment, if any, becomes due from the water tenant. Clearly, if the excesses are frequent, the limit must be too low; if infrequent, all the physical and administrative complication involved in the system is employed to very little purpose.

The question of the distribution of water, rightly considered, resolves itself into a question of delivering water to the water tenant, without leakage on the way, and of securing that the fittings employed by the water tenant shall be such as to afford an ample and ready supply at all times of the day and night without leakage and without any unnecessary facilities for waste. If these conditions are complied with, it is probable that the total rate of supply will not exceed, even if it reaches, the rate necessary in any system, not being an oppressive and insanitary system, by which the water is paid for according to the quantity used. (G. F. D.)

Waters, Territorial.—"Territorial waters" are the belt of sea adjacent to their shores which states respect as being under their immediate territorial jurisdiction, subject only to a right of "inoffensive" passage through them by vessels of all nations. As to the breadth of the belt and the exact nature of this inoffensive right of passage, however, there is still much controversy. The 3 miles' limit recognized and practised by Great Britain, France, and the United States of America seems to have been derived from the cannon range of the period, when it was adopted as between Great Britain and the United States, *i.e.*, towards the close of the 18th century. Bynkershoek, a famous Dutch jurist, whose authority at one time was as great in England as in his own country, in a dissertation on the Dominion of the Sea (1702), had devised a plausible juridical theory to support a homogeneous jurisdiction over environing waters in the place of the quite arbitrary claims made at that time to any distance seawards from whole seas to range of vision. Starting from the fact that fortresses can give effective protection within range of their cannon, and that in practice this effective protection was respected, he argued that the respect was not due to the reality of the presence of cannon, but to the fact that the state was in a position to enforce respect. This it could do from any point along its shore. Hence his well-known doctrine: *terrae dominium finitur, ubi finitur armorum vis.* The doctrine satisfied a requirement of the age and became a maxim of international law throughout northern Europe, both for the protection of shore fisheries and for the assertion of the immunity of adjacent waters of neutral states from acts of war between belligerent states. Germany still holds in principle to this varying limit of cannon range. Norway has never agreed to the 3 mile, maintaining that the special configuration of her coast necessitates the exercise of jurisdiction over a belt of 4 miles. Spain lays claim to jurisdiction over 6 miles from her shores. The writers and specialists on the subject are quite as much divided. A British Fishery Commission in 1893 reported that "the present territorial limit of 3 miles is insufficient, and that, for fishery purposes alone, this limit should be extended, provided such extension can be effected upon an international basis and with due regard to the rights and interests of all nations." The committee recommended that "a proposition on these lines should be submitted to an international conference of the Powers who border on the North Sea." There is already an international convention, dated 6th May 1882, between Great Britain, France, Belgium, Holland, Germany, and Denmark, relating to the regulation of the fisheries in the North Sea, which has fixed the limit of territorial waters as between the contracting parties at 3 miles measured from low-water mark and from a straight line drawn from headland to headland at the point where they are 10 miles across. In the British Act of 29th June 1893, giving effect to a subsequent convention (16th November 1887) between the same parties for the regulation of the liquor traffic in the North Sea, "territorial waters" are declared to be as defined in the Territorial Waters Jurisdiction Act, 1878. In this Act the definition is as follows:—

> The territorial waters of Her Majesty's dominions in reference to the sea means such part of the sea adjacent to the coast of the United Kingdom, or the coast of some other part of Her Majesty's dominions, as is deemed by international law to be within the territorial sovereignty of Her Majesty; and for the purpose of any offence declared by this Act to be within the jurisdiction of the admiral, any part of the open sea within one marine league of the coast measured from low-water mark shall be deemed to be open sea within the territorial waters of Her Majesty's dominions.

This definition only restricts the operation of the 3 miles limit to offences dealt with in the Act, and does not deal with bays. The Act of 1893 declares that the articles of the convention "shall be of the same force as if they were enacted in the body of the Act," but this convention gives no definition of territorial waters.

The jurisdiction exercised in British territorial waters under the Territorial Waters Jurisdiction Act of 1878[1] is asserted without distinction between them and inland waters. "All offences" committed by any person, whether a British subject or not, and whether or not committed "on board or by means of a foreign ship," "within the territorial waters of Her Majesty's dominions," are made punishable under it. No exception is made for offences committed on merely passing foreign vessels, except that there is this attenuation in their case, that no prosecution can take place without a special authorization given by certain high officers of state.[2] It is doubtful whether any Continental state would recognize so complete a jurisdiction. The subject has been exhaustively dealt with by both the Institute of International Law and the International Law Association, the following considerations and rules being suggested:—

> Whereas there is no reason to confound in a single zone the distance necessary for the exercise of sovereignty and protection of coast fisheries and the distance necessary to guarantee the neutrality of non-belligerents in time of war; And whereas the distance most commonly adopted of 3 miles from low-water mark has been recognized as insufficient for the protection of coast fisheries; And whereas, moreover, this distance does not correspond to the real range of cannon placed on the coast; The following dispositions are adopted:—
>
> Art. I. The state has the right of sovereignty over a belt of sea along its coast subject to the right of inoffensive passage reserved in article 5. This belt is called territorial waters (*mer territoriale*).
>
> Art. II. Territorial waters extend for 6 sea miles (60 to 1 degree of latitude) from low-water mark along the whole extent of its coasts.
>
> Art. III. For bays, territorial waters follow the trend of the coast except that it is measured from a straight line drawn across the bay from the two points nearest the sea where the opening of the bay is of 12 marine miles in width, unless a greater width shall have become recognized by an immemorial usage.
>
> Art. IV. In case of war the adjacent neutral state shall have the right to extend by its declaration of neutrality or by special notification its neutral zone from 6 miles to cannon range from the coast.
>
> Art. V. All ships, without distinction, have the right of inoffensive passage through territorial waters, subject to the belligerent right to regulate, and for purposes of defence to bar, the passage through the said waters for every ship, and subject to the right of neutrals to regulate the passage through the said waters for ships of war of all nationalities.
>
> Art. VI. Crimes and offences committed on board foreign ships passing through territorial waters by persons on board such ships, upon persons or things on board the same ships, are, as such, beyond the jurisdiction of the adjacent state, unless they involve a violation of the rights or interests of the adjacent state, or of its subjects or citizens not forming part of its crew or its passengers.

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[1] This Act was passed to meet what was thought to be a defect in British law, the decision in the well-known *Franconia* case having been that territorial waters were "out of the realm," and that criminal jurisdiction within them over a foreign ship could be exercised only in virtue of an Act of Parliament.

[2] Proceedings, says sec. 3 of the Act, for the trial and punishment of a person who is not a British subject, and who is charged with any offence as is declared by this Act to be within the jurisdiction of the admiral, shall not be instituted in any Court of the United Kingdom, except with the consent of one of the principal Secretaries of State, and on his certificate that the institution of such proceedings is in his opinion expedient, and shall not be instituted in any British dominions outside of the United Kingdom except with the leave of the governor of the part of the dominions in which such proceedings are proposed to be instituted, and on his certificate that it is expedient that such proceedings should be instituted.

Art. VII. Ships passing through territorial waters must conform to the special rules laid down by the adjacent state, in the interest and for the security of navigation and for the police of the sea.

Art. VIII. Ships of all nationalities, by the simple fact of being in territorial waters, unless merely passing through them, are subject to the jurisdiction of the adjacent state.

The adjacent state has the right to continue upon the high seas the pursuit of a ship commenced within territorial waters, and to arrest and try it for an offence committed within the limits of its waters. In case of capture on the high seas the fact shall, however, be notified without delay to the state to which the ship belongs. The pursuit is interrupted from the moment the ship enters the territorial waters of its own state or of a third Power. The right of pursuit ceases from the moment the ship enters a port either of its own country or of a third Power.

Art. IX. The special position of ships of war and of ships assimilated to them is reserved.

Art. X. The provisions of the preceding articles are applicable to straits not exceeding 12 miles in width, with the following modifications and exceptions :—

(1) Straits, the coast of which belong to different Powers, form part of the territorial waters of the adjacent states, their jurisdiction respectively extending to the middle line of the straits ;

(2) Straits whose coasts belong to the same state, and which are indispensable for maritime communication between two or more states other than the state in question, form part of the territorial waters of the said state whatever the proximity of the two coasts may be ;

(3) Straits serving as a passage between one open sea and another can never be closed.

Art. XI. The position of straits already regulated by conventions or special usage is reserved.

The Dutch Government in 1896 brought these rules to the notice of the leading European Governments, and suggested the desirability of concluding an international convention on the subject. The only Government which was unfavourable to the proposal was that of Great Britain.

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Watertown, a town of Middlesex county, Massachusetts, U.S.A., on the north bank of the Charles river, adjoining Cambridge, and on the Fitchburg (Boston and Maine) Railroad. It contains a United States arsenal, the beautiful Mount Auburn cemetery, and extensive and varied manufactures. It is one of the oldest towns of the state, having been incorporated in 1630. Population, (1890), 7073 ; (1900), 9706.

Watertown, a city of New York, U.S.A., capital of Jefferson county. It is situated in 43° 58′ N. and 75° 54′ W., on Black river, 7 miles from its mouth in Lake Ontario, and on a line of the New York Central and Hudson River Railroad, in the northern part of the state, at an altitude of 418 feet. Black river furnishes excellent water-power, which is extensively used in manufactures, particularly in carriage and waggon works, paper, planing, and flour mills, foundries and machine-shops, and furniture factories. Population (1890), 14,725 ; (1900), 21,696.

Watertown, a city of Dodge and Jefferson counties, Wisconsin, U.S.A., situated in 43° 12′ N. and 88° 48′ W., on the river Rock, and on lines of the Chicago and North-Western and the Chicago, Milwaukee, and St Paul railways, in the south-eastern part of the state, at an altitude of 824 feet. The river furnishes valuable water-power, which has been put to use in varied manufactures. Watertown contains North-western University, a Lutheran institution, opened in 1865. Population (1890), 8755 ; (1900), 8437.

Waterville, a city of Kennebec county, Maine, U.S.A., on the river Kennebec, 18 miles above Augusta, and on a line of the Maine Central Railroad, in the southern part of the state, at an altitude of 112 feet. It has excellent water-power, and has cotton factories, foundries, railway repair works, and other industries. It is the seat of Colby University, a Baptist institution, opened in 1818. Waterville was settled about 1650, was set off and incorporated as a town in 1802, and received a city charter in 1888. Population (1890), 7107 ; (1900), 9477.

Watervliet, a city of Albany county, New York, U.S.A., formerly the village of West Troy, in the low ground on the west bank of the river Hudson, opposite Troy, in the eastern part of the state. The United States Government arsenal contains large works for the construction of field, coast defence, and siege ordnance, and for the manufacture of shot and shell, gun-carriages, &c. Population (1890), 12,967 ; (1900), 14,321.

Watford, an ancient market town and parish, in the Watford, or Western, parliamentary division of Hertfordshire, England, 8 miles south-west of St Albans by rail, on the river Colne. Bushey, on the opposite side of the Colne, is connected with the town by a bridge of five arches. A chapel of ease, St John's, was built in 1893, and a Roman Catholic church in 1895. Population (1891), 17,063 ; (1901), 29,023.

Watkin, Sir Edward William, 1st BART. (1819–1901), English railway manager, was born in Manchester on 26th September 1819. In 1845 he became secretary of the Trent Valley line, which was soon afterwards absorbed by the London and North-Western Company. He next joined the Manchester and Sheffield Company, of which he became general manager and then chairman, subsequently combining with the duties thus entailed the chairmanship of the South-Eastern (1867) and of the Metropolitan (1872). His connexion with these three railways was maintained to within a short time of his death, and they formed the material of one of his most ambitious schemes—the establishment of a through route under one management from Dover to Manchester and the north. This was the end he had in view in his successful fight for the extension of the Manchester, Sheffield, and Lincolnshire Railway (now the Great Central) to London ; and his persistent advocacy of the Channel tunnel (*q.v.*) between Dover and Calais was really a further development of the same idea, for its construction would have enabled through trains to be run from Paris to Lancashire and Scotland, *viâ* the East London (of which also he was for a time chairman) and the Metropolitan. The latter scheme, however, failed to obtain the necessary public and political support. Other projects had even less success. His plans for a tunnel between Scotland and Ireland under the North Channel, and for a ship canal across Ireland from Galway to Dublin, did not come to anything ; while the great tower at Wembley Park (near Harrow), intended to surpass the Eiffel Tower at Paris, stopped at an early stage. It was in the realms of railway politics that Watkin showed to best advantage ; for the routine work of administration pure and simple he had no aptitude. He entered Parliament as a Liberal, and after representing Stockport from 1864 to 1868, sat as member for Hythe for twenty-one years from 1874, becoming a Liberal-Unionist at the time of the Home Rule split, and subsequently acting as a "free lance." In 1868 he received a knighthood, and in 1880 he was created a baronet. His death occurred at Northenden, Cheshire, on 13th April 1901. (H. M. R.)

Watson, Thomas (1557 (?)–1592), an English lyrical poet, whose position as a pioneer of the Elizabethans has of late years been considerably emphasized, was born in London, probably in 1557. He proceeded to Oxford, and, while quite a young man, enjoyed a certain reputation, even abroad, as a Latin poet. His *De Remedio Amoris*, which was perhaps his earliest important composition, is lost, and so is his "piece of work written in the commendation of women-kind," which was also in Latin verse. He came back to London and became a law-student. The earliest publication of Watson's, which has survived, is a Latin version of the *Antigone* of Sophocles, issued in 1581. It is dedicated to Philip Howard, Earl of Arundel, who was perhaps the patron of the poet, who seems to have spent some part of this year in Paris. Next year Watson appears for the first time as an English poet in some verses prefixed to Whetstone's *Heptameron*, and also in a far more important guise, as the author of the Ἑκατομπαθία or *Passionate Century of Love*. This is a collection or cycle of 100 pieces, in the manner of Petrarch, celebrating the sufferings of a lover and his long farewell to love. The technical peculiarity of these interesting poems is that, although they appear and profess to be sonnets, they are really written in triple sets of common six-line stanza, and therefore have eighteen lines each. It seems likely that Watson, who courted comparison with Petrarch, seriously desired to recommend this form to future sonneteers; but in this he had no imitators. Among those who were at this time the friends of Watson we note Matthew Royden and George Peele. In 1585 he published a Latin translation of Tasso's pastoral play of *Aminta*, and his version was afterwards translated into English by Abraham Fraunce (1587). Watson was now, as the testimony of Nash and others prove, regarded as the best Latin poet of England. In 1590 he published, in English and Latin verse, his *Melibœus*, an elegy on the death of Sir Francis Walsingham, and a collection of *Italian Madrigals*, put into English by Watson and set to music by Byrd. Of the remainder of Watson's career nothing is known, save that on the 26th of September 1592 he was buried in the church of St Bartholomew the Less, and that in the following year his latest and best book, *The Tears of Fancy*, was posthumously published. This is a collection of sixty sonnets, regular in form, so far at least as to have fourteen lines each. Spenser is supposed to have alluded to the untimely death of Watson in *Colin Clout's Come Home Again*, when he says:—

> "Amyntas quite is gone and lies full low,
> Having his Amaryllis left to moan,"

which perhaps points to Watson's having left a widow. It is certain that this poet enjoyed a great reputation in his lifetime, and that he was not without a direct influence upon the youth of Shakespeare. He was the first, after the original experiment made by Wyat and Surrey, to introduce the pure imitation of Petrarch into English poetry. He was well read in Italian, French, and Greek literature. Watson died young, and he had not escaped from a certain languor and insipidity which prevent his graceful verses from producing their full effect. This demerit is less obvious in his later than in his earlier pieces, and with the development of the age, Watson, whose contemporaries regarded him as a poet of true excellence, would probably have gained power and music. As it is, he has the honour of being one of the direct forerunners of Shakespeare (in *Venus and Adonis* and in the *Sonnets*), and of being the leader in the long procession of Elizabethan sonnet-cycle writers. The English works of Watson were first collected by Professor Edward Arber.

(E. G.)

Watts, George Frederick (1817– ——), English painter and sculptor, was born in London on 23rd February 1817. While hardly more than a boy he was permitted to enter the schools of the Royal Academy; but his attendance was short-lived, and his further art-education was confined to personal experiment and endeavour, guided and corrected by a constant appeal to the standard of ancient Greek sculpture. There are portraits of himself, painted in 1834; of Mr James Weale, about 1835; of his father, "Little Miss Hopkins," and Mr Richard Jarvis, painted in 1836; and in 1837 he was already far enough advanced to be an exhibitor at the Academy with a picture of "The Wounded Heron" and two portraits. His first exhibited figure-subject, "Cavaliers," appeared on the Academy walls in 1839, and was followed in 1840 by "Isabella e Lorenzo," in 1841 by "How should I your true love know," and in 1842 by a scene from *Cymbeline* and a portrait of Mrs Ionides. The Royal Commission appointed for the decoration of the new Houses of Parliament, offered prizes in 1842 to those artists whose cartoons for frescoes should be adjudged best adapted to its object, and at the exhibition in Westminster Hall next year Watts secured a prize of £300 for a design of "Caractacus led in triumph through the streets of Rome." This enabled him to visit Italy in 1844, and he remained there during the greater portion of the three following years, for the most part in Florence, where he enjoyed the patronage and personal friendship of Lord Holland, the British ambassador. For him he painted a portrait of Lady Holland, exhibited in 1848, and in his Villa Careggi, near the city, a fresco, after making some experimental studies in that medium, fragments of which are now in the Victoria and Albert Museum. To Lord Holland's encouragement, also, it was chiefly due that in 1846 the artist took part in another competition, the third organized by the Royal Commissioners, who on this occasion announced a further list of prizes for works in oil. Watts sent in a cartoon depicting "Alfred inciting his subjects to prevent the landing of the Danes, or the first naval victory of the English," which after obtaining a first-class prize of £500 at the exhibition in Westminster Hall, was purchased by the Government, and hangs in one of the committee rooms of the House of Commons. It led, moreover, to a commission for the fresco of "St George overcomes the Dragon," which, begun in 1848 and finished in 1853, forms part of the decorations of the Hall of the Poets in the Houses of Parliament. He next proposed to adorn gratuitously the interior of the Great Hall of Euston railway station with a series of frescoes illustrating "The Progress of the Cosmos," but the offer was refused. A similar proposition made shortly afterwards to the Benchers of Lincoln's Inn was received in a less commercial spirit, and was followed by the execution of the fresco, "Justice: a Hemicycle of Lawgivers" on the north side of their Hall.

While this large undertaking was still in progress Mr Watts was working steadily at pictures and portraits. In 1849 the first two of the great allegorical compositions which form the most characteristic of the artist's productions were exhibited—"Life's Illusions," an elaborate presentment of the vanity of human desires, and "The people that sat in darkness," turning eagerly towards the growing dawn. In 1850 he first gave public expression to his intense longing to improve the condition of humanity in the picture of "The Good Samaritan" bending over the wounded traveller; this, as recorded in the catalogue of the Royal Academy, was "painted as an expression of the artist's admiration and respect for the noble philanthropy of Thomas Wright, of Manchester," and to that city he presented the work. In 1856 Mr Watts paid a visit to Lord Holland at Paris, where he was then ambassador, and through him made the acquaintance and painted the portraits of Thiers, Prince Jerome Bonaparte, and other famous Frenchmen; while other celebrities who sat to him during these years were Guizot (1848), Colonel Rawlinson, C.B., Sir Henry Taylor, and Thomas Wright (1851), Lord John Russell (1852), Tennyson (1856, and again in 1859), John Lothrop Motley the historian (1859), the Duke of Argyll (1860), Lord Lawrence and Lord Lyndhurst (1862), Lord Wensleydale (1864), Mr Gladstone (1858 and 1865), Sir William Bowman and Swinburne (1865), Panizzi (1866), and Dean Stanley and Dr Joachim in 1867. Notable pictures of the same period are "Sir Galahad" (1862), "Ariadne in Naxos" (1863), "Time and Oblivion" (1864), originally designed for sculpture to be carried out "in divers materials after the manner of Pheidias," and "Thetis" (1866).

In spite of these and many other evidences of his importance, it was not until 1867 that Mr Watts was elected an Associate of the Royal Academy, but the council then conferred upon him the rare distinction of promoting him, in the course of the same year, to full Academicianship. Thenceforward he continued to exhibit each year, with a few exceptions, at the Academy, even after his retirement in 1896, and he was also a frequent contributor to the Grosvenor Gallery, and subsequently to the New Gallery, at which last a special exhibition of his works was held in the winter of 1896–97. Though he travelled abroad to some extent, going to Asia Minor in 1857 with the expedition sent to investigate the ruins of Halicarnassus, and visiting in later years Italy, Greece, and Egypt, the greater part of his life was passed in the laborious seclusion of his studio either at Little Holland House, Melbury Road, Kensington, where he settled in 1859, or in the country at Limnerslease, Compton, Surrey, and was, apart from his art, happily uneventful, the sole facts necessary to record being his marriage in 1886 with Miss Mary Fraser-Tytler, an early union with Miss Ellen Terry having been dissolved many years before; his twice receiving (1885 and 1894), but respectfully declining, the offer of a baronetcy, and his inclusion in June 1902 in the newly founded Order of Merit.

George Frederick Watts, R.A.
(From a photograph by Elliott and Fry, London.)

The world is exceptionally well provided with opportunities of judging of the qualities of Mr Watts's art, for with a noble generosity he presented to his country a representative selection of the best work of his long life. A prominent element in it, and one which must prove of the greatest value to posterity, is the inestimable series of portraits of his distinguished contemporaries, a series no less remarkable for its artistic than for its historical interest. A glance through the list of his subjects shows the breadth of his sympathies and his superiority to creed or party. Among politicians are the Duke of Devonshire (1883), Lords Salisbury (1884), Sherbrooke (1882), Campbell (1882), Cowper (1877), Ripon (1896), Dufferin (1897), and Shaftesbury (1882), Mr Gerald Balfour (1899), and Mr John Burns (1897); poets, Tennyson, Swinburne (1884), Browning (1875), Matthew Arnold (1881), Rossetti (1865, and subsequent replica), and William Morris (1870); artists, himself (1864, 1880, and eleven others), Lord Leighton (1871 and 1881), Calderon (1872), Prinsep (1872), Burne-Jones (1870), Millais (1871), Walter Crane (1891), and Alfred Gilbert (1896); literature is represented by John Stuart Mill (exhibited 1874), Carlyle (1869), George Meredith (1893), Max Müller (1895), and Mr Lecky (1878); music, by Sir Charles Hallé; while among others who have won fame in diverse paths are Lords Napier (1886) and Roberts (1899), General Baden-Powell (1902), Garibaldi, Sir Richard Burton (1882), Cardinal Manning (1882), Dr Martineau (1874), Sir Andrew Clark (1894), George Peabody, Mr Passmore Edwards, Claude Montefiori (1894). Even more significant from an artistic point of view is the great collection of symbolical pictures in the Tate Gallery which forms the artist's message to mankind. Believing devoutly in the high mission of didactic art, he strove ever to carry out his part of it faithfully. To quote his own words: "My intention has not been so much to paint pictures that charm the eye, as to suggest great thoughts that will appeal to the imagination and the heart, and kindle all that is best and noblest in humanity"; and his tenet is that the main object of the painter should be "demanding noble aspirations, condemning in the most trenchant manner prevalent vices, and warning in deep tones against lapses from morals and duties."

There are not wanting critics who radically dissent from this view of the proper functions of art. It must be admitted that there is force in their objection when the inner meaning of a picture is found to be exceedingly obscure, if not incomprehensible, without a verbal explanation. In the female figure, for instance, bending blindfolded on the globe suspended in space and sounding the sole remaining string upon her lyre, while a single star shines in the blue heavens, it is not obvious to everyone that the idea of "Hope" (1885) is suggested. There can be few, nevertheless, who will maintain that his aim is not a lofty one; and the strongest evidence of the artist's greatness, to those who accept his doctrine, is the fact that he has not only striven untiringly for his own ideals, but has very often gloriously attained them. Moreover, in so doing he has not failed on occasion to impart to his work much of that very charm which is to him a secondary consideration, or to exhibit an assured and accomplished mastery of the technical achievement which is to some the primary object and essential triumph of painting. It was, in short, the rare combination of supreme handicraft with a great imaginative intellect which secured to Mr Watts his undisputed place in the public estimation of his day. The grandeur and dignity of his style, the ease and purposefulness of his brushwork, the richness and harmoniousness of his colouring—qualities partly his own, partly derived from his study of Italian masters at an early and impressionable age—are acknowledged even by those to whom his elevated educational intentions are a matter of indifference, if not of absolute disapprobation; while many, to whom his exceptional artistic attainment is a sealed book, have gathered courage or consolation from the grave moral purpose and deep human sympathy of his teaching. He expresses his ideas for the most part in terms of beauty, an idealized, classical beauty of form, a glowing, Venetian beauty of colour, though his conviction of the deadly danger of heaped-up riches, which he vindicated in his life as well as in his work, has, in such cases as "The Minotaur" (exhibited in 1896), "Mammon" (1885), and "Jonah" (1895), where the unveiled vileness of Cruelty and Greed is fearlessly depicted, driven him to the presentment of sheer ugliness or brutality. Far oftener a vast, all-embracing tenderness inspires his work; it is the sorrow, not the sin, that stirs him. When he would rebuke the thoughtless inhumanity which sacrifices its annual hecatombs of innocent birds to fashionable vanity and grasping commerce, it is not upon the blood and cruelty that he dwells, but the pity of it that he typifies in "Dedication" or "The Shuddering Angel" (1892) weeping over the altar spread with Woman's spoils.

Yet it is as a teacher that the artist is seen at his highest: he would sooner point out the true way to those who seek it than admonish those who have wandered. He never wearies of emphasizing the reality of the power of Love, the fallacy underlying the fear of Death. To the early masters Death was a bare and ghastly skeleton, above all things to be shunned; to Watts it is a grand, impressive figure, awful indeed but not horrible, irresistible but not ruthless, a bringer of rest and peace, not to be rashly sought but to be welcomed when the inevitable hour shall strike. "Sic transit" (1892) conveys most completely, perhaps, Mr Watts's lesson on the theme of death. Stretched on a bier and reverently sheeted lies a corpse; strewn neglected on the ground lie the ermine robe of worldly rank, the weapons of the warrior, the lute of the musician, the book of human learning, the palmer's robe of late repentance, and the roses of fleeting pleasures; the laurel crown remains as the one thing worth the winning, and the inscription, "What I spent I had; what I saved I lost; what I gave I have," points the moral. Such is the significance of the still more masterly "Court of Death" (finally completed 1902 and now in the Tate Gallery). To the same early masters Love was usually a mere distributor of sensual pleasures, a tricksy spirit instinct with malice and bringing more harm than happiness to humanity, though neither was of much moment. Watts has not altogether ignored this view, and in "Mischief" (1878) has portrayed Man, love-led, entangled among the thorns of the world, but, in the main, Love to him is the chief guide and helper of mankind along the barren, rock-strewn path of life, through whom alone he can attain the higher levels, and who triumphs in the end over Death itself. To these views on the all-importance of love a trilogy of pictures in the Tate Gallery gives full expression. In the first, "Love and Life," exhibited in 1885 (see Plate), a replica of an earlier picture in the Metropolitan Museum, New York, and of another version presented by him to the Luxemburg, Paris, Love, a figure in the prime of manhood, leads and supports the slender, clinging girl who symbolizes Life up to the craggy mountain-top, while he partly shields her from the blast under a broad wing. Of this he himself said, "Probably 'Love and Life' best portrays my message to the age. Life, represented by the female figure, never could have reached such heights unless protected and guided by Love,"[1] and in the prefatory note to the exhibition of his works in 1896 he wrote, "The slight female figure is an emblem of the fragile quality in humanity, at once its weakness and its strength; *sensibility*, aided by Love, sympathy, tenderness, self-sacrifice, and all that the range of the term implies, humanity ascends the rugged path from brutality to spirituality." The limitations of earthly love are shown in the second "Love and Death," one version of which was exhibited in 1877 and others in 1896, &c. In this, Love, a beautiful boy, striving vainly to bar the door to the mighty figure of Death, is thrust back with crushed wings powerless to stay the advance; but that the defeat is merely apparent and temporary is suggested rather than asserted by the third "Love Triumphant" (1898), where Time, with broken scythe, and Death lie prostrate, while the same youth, with widespread wings and face and arms upraised to heaven, stands between them on tiptoe as if preparing to soar aloft. Though the purely symbolical is the most distinctive side of Mr Watts's art, it is by no means the only one. He has drawn inspiration largely from both the Old and New Testaments, more rarely from the poets and classical myths; still more rarely he has treated subjects of modern life, though even in these he has not abandoned his moral purpose, but has sought out such incidents, whether fictitious or historical, as will serve him in conveying some lesson or monition. The three pictures of the story of Eve in the Tate Gallery, "She shall be called woman" (1892), "Eve Tempted" and "Eve Repentant" (both exhibited in 1896), and "The Curse of Cain" (1872) in the Diploma Gallery, may be cited as examples of the first; "For he had great possessions" (1894) of the second; "Sir Galahad (1862), "Orpheus and Eurydice" (see Plate) and "Psyche" (1880), of the third; and "The Irish Famine" (about 1847), and "A patient life of unrewarded toil" (1890), of the last of these. Never has he treated religion from a sectarian point of view.

Mr Watts is before all things a painter with a grave and earnest purpose, painting because that form of expression was easier to him than writing, though he has published some few articles and pamphlets, chiefly on art matters; but he too has his lighter side, and has daintily treated the humorously fanciful in "Good luck to your fishing" (1889); "The habit does not make the monk" (1889), in which Cupid, half-hidden under the frock, taps maliciously at a closed door; and "Trifles light as air" (exhibited 1901), a swarm of little amorini drifting in the summer air like a cloud of gnats; while in "Experientia docet B.C." (1890), a primeval woman watching with admiration, not unmixed with anxiety, the man who has first swallowed an oyster, he condescends, not very successfully, to the frankly comic. These must be regarded, however, as merely the relaxations of the serious mind that has left its impress even on the relatively few, but very admirable, landscapes he produced, in which, as for instance "The Carrara Mountains from Pisa" (1881), a sober dignity of treatment is conspicuous.

Watts's technique is as individual as his point of view. It is chiefly remarkable for its straightforwardness and simplicity, and its lack of any straining after purely technical effects. The idea to be expressed is of far higher importance to him than the manner of expressing it. The statement of it should be a matter of good, sound workmanship, not of artistic agility or manual dexterity. To say what he has to say as clearly and briefly as may be is his aim, and when he has achieved the effect he desires, the method of his doing so is of no further moment. In the use of paint as paint, in the intrinsic beauties of surface and handling, he would seem in his later years to take no delight. Thus in parts of the picture the rough coarse canvas he prefers may be so thinly covered that every fibre of the material can be seen, while in others a richly modelled impasto loads the surface. He employs, as far as possible, pure colours laid on in direct juxtaposition or broken into and across each other, not blended and commingled on the palette. He eschews all elaboration of detail and, except in portraiture, works rarely from the living model, neglecting minor delicacies of form or passages of local colour, conventionalizing to a standard of his own rather than idealizing—a process not always unproductive of faults of drawing and proportion, as in the figure of "Faith" (1896), or of singularities of tint, as in the curious leaden face and prismatic background in "The dweller in the innermost" (1886). He avoids, as a rule, the use of definite outline, leaving the limits of his forms to melt imperceptibly into the background; nor does texture interest him greatly, and a uniform fresco-like surface is apt to represent flesh and foliage, distance and foreground alike. He intends deliberately that the things he depicts, be they what they may, shall be symbols, useful for their meaning alone, and he makes no attempt at conferring on them an accurate actuality, which might distract the attention from the paramount idea. That this reticence is intentional may be learned from an examination of his earliest works, in which the accessories are rendered with a precise, if sometimes a dry, truthfulness of observation; that it is not due to carelessness or indifference is shown by the inexhaustible patience with which each picture has been executed. His earlier pictures are unsurpassed in the art of England for fine technical qualities of colour and delicacy of handling. Though working unceasingly, Watts never hurried the completion of any canvas. Of two slightly differing versions of "Fata Morgana," both begun in 1847, the first was not finished before 1870, the second not until ten years later. Even after finishing a picture sufficiently for exhibition, he often subsequently worked further upon it. The portrait of Lord Leighton, exhibited in 1881, was repainted in 1888; the version of "Love and Death," exhibited in 1877, in 1883, and all the pictures presented to the Tate Gallery in 1897, were more or less retouched when hung there. Furthermore, he painted more than one version of several of his favourite subjects, a circumstance which, combined with the fact that he rarely added the year to his signature and kept no record of his annual production, makes the task of precisely dating his pictures for the most part impossible, while it renders any attempt to dispose his works in periods untrustworthy and artificial, since even the growth and inevitable decay of artistic power are to a considerable extent obscured.

Founded admittedly on the Grecian monuments, there is a sculpturesque rather than pictorial quality in most of his compositions, a regulated disposition which, though imparting often a certain air of unreality and detachment, inspires them nevertheless with that noble impressiveness which forms their most conspicuous characteristic. It is natural, therefore, that in sculpture itself he should also take a high place. A taste for this he acquired as a boy; he was a constant visitor to the studio of Behnes, where he not infrequently made drawings from the casts, though he was never in any sense his pupil. Among his works in this branch of art are a bust of "Clytie" (1868), monuments to the Marquis of Lothian, Bishop Lonsdale, and Lord Tennyson, a large bronze equestrian statue of "Hugo Lupus" at Eaton Hall (1884), and a colossal one of a man on horseback, emblematical of "Physical Energy," originally intended for a place on the Embankment, but now destined to stand among the Matoppo Hills as an enduring evidence of the artist's admiration for Cecil Rhodes. It was the practical idealism of Rhodes that appealed to him, and in this quality Watts himself was by no means lacking. Much of his time and attention were given to the promotion of the Home Arts and Industries Association; he assisted Mrs Watts with both money and advice in the founding of an art pottery at Compton, and in the building at the same place of a highly decorated mortuary chapel, carried out almost entirely by local labour; and it was entirely due to his initiative that the erection in Postmen's Park, Aldersgate Street,

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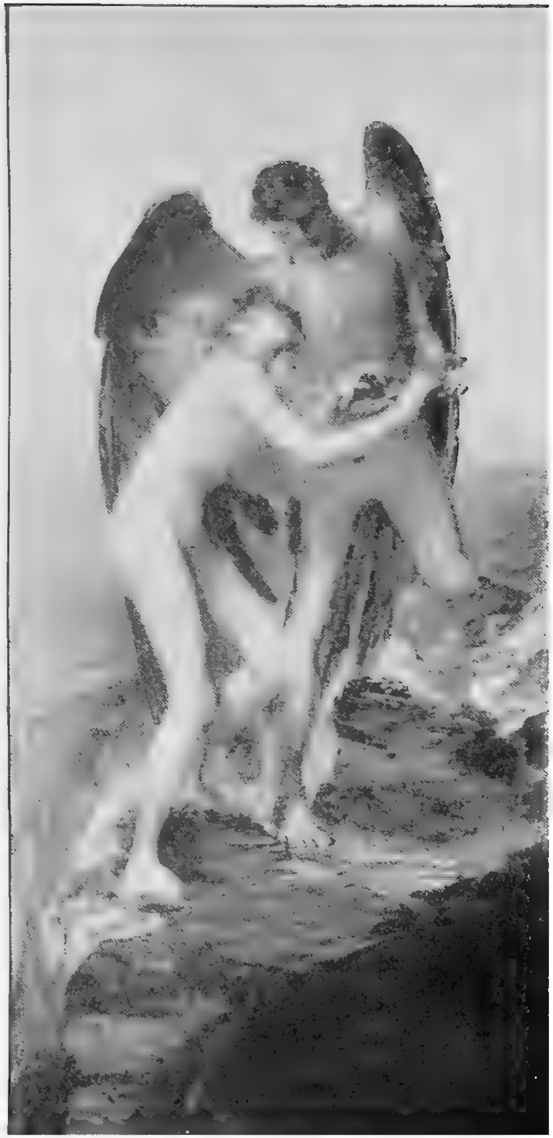
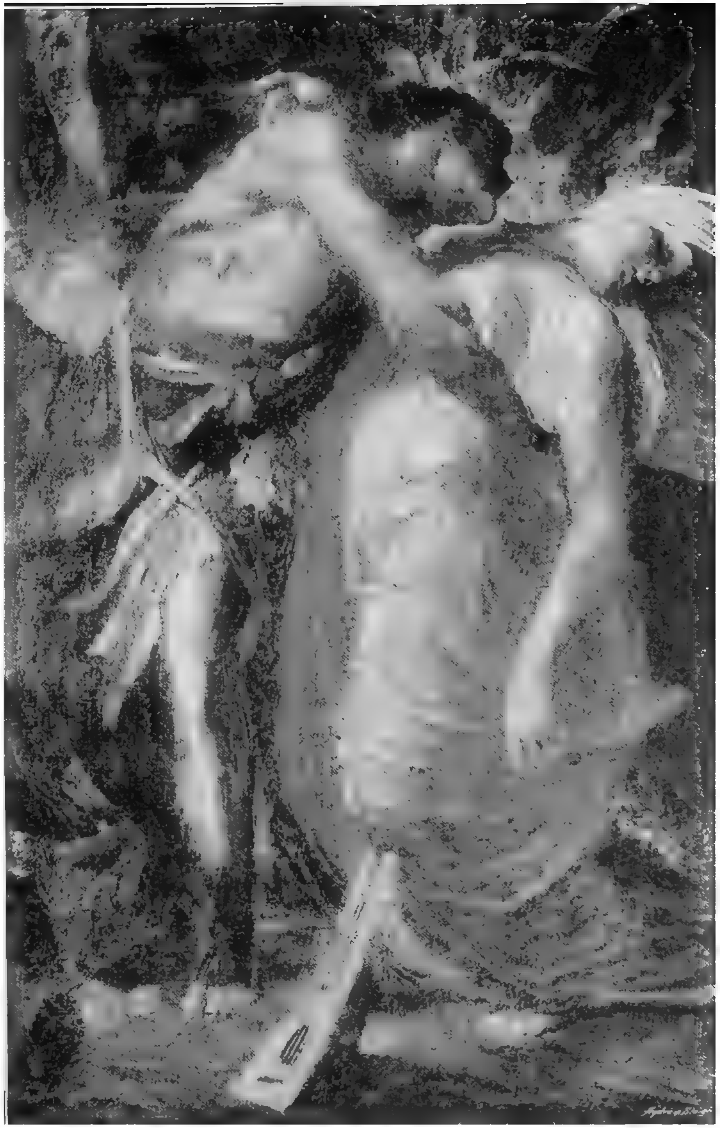
[1] *G. F. Watts, R.A.*, by Charles T. Bateman.



"LOVE AND LIFE." By G. F. WATTS, R.A.

(From a Photograph by W. A. Mansell and Co.)



"ORPHEUS AND EURYDICE." By G. F. WATTS, R.A.

(By permission of Mr. William Connal, Jun.)

London, of memorial tablets to the unsung heroes of everyday life was begun.

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Watts - Dunton, Walter Theodore (1836- ——), English man of letters, was born at St Ives, Huntingdon, in 1836, his family surname being Watts, to which he added in 1896 his mother's name of Dunton. He was originally educated as a naturalist, and moved much among the East Anglian gypsies, of whose superstitions and folk-lore he made careful study. Abandoning natural history for the law, he qualified as a solicitor and practised for many years in St Ives, giving his spare time to his chosen pursuit of literature. In 1872 he came up to London and contributed regularly to the *Examiner* from 1874 and to the *Athenæum* from 1875, being for more than twenty years the principal critic of poetry in the latter journal. Mr Watts-Dunton has been the friend of many of the leading men of letters of his time; he enjoyed the confidence of Tennyson, was interested in the Pre-Raphaelite movement, and has for many years shared the same home with Mr Swinburne. The obituary notices and appreciations of the poets of the time, which he has contributed to the *Athenæum* and other periodicals, have borne testimony to his sympathy, insight, and critical acumen. It was not, however, until he had passed his sixtieth year that he published any volume under his own name, his collection of poems called *The Coming of Love*, portions of which he had printed in newspapers from time to time, appearing as a complete book in 1897. In the following year his romance *Aylwin* attained immediate success, and ran through many editions in the course of a few months. Both *The Coming of Love* and *Aylwin* set forth, the one in poetry, the other in prose, the romantic and passionate associations of Romany life, and maintain the traditions of Borrow under somewhat novel aspects. Imaginative glamour and mysticism are their prominent characteristics, and the novel in particular has had its share in restoring the charms of pure romance to the favour of the general public.

Waukegan, a city of Illinois, U.S.A., capital of Lake county, on a cliff on the shore of Lake Michigan, 36 miles north of Chicago, and on the Chicago and North-Western and the Elgin, Joliet, and Eastern railways. It has a regular plan, well paved streets, and a water-supply. It has a good harbour and much lake traffic. Population (1880), 4012; (1890), 4915; (1900), 9426, of whom 2506 were foreign-born.

Waukesha, a village of Wisconsin, U.S.A., capital of Waukesha county. It is situated in 43° 01′ N. and 88° 12′ W., on the river Fox and the Chicago and North-Western, the Chicago, Milwaukee and St Paul, and the Wisconsin Central railways, in the south-eastern part of the state, at an altitude of 808 feet. It is irregularly laid out, and has water-works and a sewerage system. It is one of the leading health resorts of the state, containing magnesian springs, whose waters are reputed to cure liver and kidney troubles. The waters are bottled and sold in vast quantities throughout the country, and enjoy a high reputation. Population (1880), 2969; (1890), 6321; (1900), 7419, of whom 1408 were foreign-born.

Wausau, a city of Wisconsin, U.S.A., capital of Marathon county. It is situated in 44° 57′ N. and 89° 36′ W., on both sides of the river Wisconsin, and on the Chicago and North-Western and the Chicago, Milwaukee and St Paul railways, in the central part of the state, at an altitude of 1219 feet. The city is regularly laid out on gentle slopes towards the river, the business streets are paved, and the city has an ample water-supply. It is in the region of white pine timber, and its industries are largely connected with wood-working. It has saw-mills, planing-mills, box and furniture factories, besides flour-mills, tanneries, &c. Population (1880), 4277; (1890), 9253; (1900), 12,354, of whom 3747 were foreign-born.

Waverly, a village of Tioga county, New York, U.S.A. It is situated in 42° 00′ N. and 76° 32′ W., on the river Chemung, at the mouth of Cayuta creek, and near the southern boundary of the state, at an altitude of 825 feet. It is on the Delaware, Lackawanna, and Western, the Erie, and the Lehigh Valley railways, and is the shipping-point for a large dairy-farming region. Population (1880), 2767; (1890), 4123; (1900), 4465.

Wavre, a town of Belgium, in the province of Brabant, 16 miles south-east of Brussels, with a station on the line from Louvain to Nivelles. It has numerous manufactures, but is chiefly memorable as the scene of an engagement between the Prussians and a French corps on the day of the battle of Waterloo. Although Grouchy, the French commander, was victorious, he could not, on account of this engagement, reach the main army in time to be of service. He learnt here the news of Napoleon's defeat. Population (1890), 7575; (1899), 8200.

Waycross, a town of Georgia, U.S.A., capital of Ware county, in the south-eastern part of the state. It is an important railway junction, three lines crossing at this place. Population (1890), 3364; (1900), 5919, of whom 46 were foreign-born and 2899 negroes.

Waynesboro, a borough of Franklin county, Pennsylvania, U.S.A., on the Western Maryland and the Cumberland Valley railways, in the southern part of the state. Population (1890), 3811; (1900), 5396.

Wazirabad, a town of British India, in the Gujranwala district of the Punjab, near the left bank of the river Chenab, with a railway station, 62 miles north of Lahore. Population (1881), 16,462; (1891), 15,786; municipal income (1897–98), Rs.20,017. It is an important railway junction. The main line of the North-Western Railway here crosses the Chenab by the Alexandra bridge, opened by the Prince of Wales in 1876. The branch to Sialkot has been extended to Jamu (51 miles); another branch follows the line of the Chenab canal towards Mooltan. There is extensive boat-building, as well as manufactures of steel and iron. There are three high schools—Scottish mission, Mahommedan, and Sikh.

Waziristan, a section of the mountain districts of the north-west frontier of India, lying between the Tochi (or Dawar) river on the north and the Gomul on the south. It is independent, geographically as well as politically, both of British India and of contiguous tribal states. The Tochi valley is ethnically included in Waziristan, the Dawaris being related to Waziri clans; but the Gomul now offers a trade route into Afghanistan, which is open to all tribes, the blackmailing of the Waziris having been suppressed since the British occupation of Wana, on its northern flank. The Tochi and the Gomul rivers enclose Waziristan, their affluents rising to the west of that country in the upland valleys of Shawál and Birmal, and flowing north and south to a junction with the main streams. Between the two rivers stretches the central dominating range of Waziristan from north-east to south-west, geologically connected with the great limestone ranges of the Sulimani hills to the south, and dominated by the great peaks of Shuidar (Sheikh Haidar) and Pirghal, both of them between 11,000 and 12,000 feet above the sea, and hardly inferior to the Khaisargarh peak of the Takht-i-Suliman. From these peaks westwards a view is obtained across the grass slopes and cedar woods of Birmal and Shawál (lying thousands of feet below) to the long, serrated ridges of the central watershed which shuts off the plains of Ghazni from the hill states of the frontier. To the eastward several lines of drainage strike away for the Indus, breaking through parallel folds and flexures of the mountains, of which the conformation is here distinctly observable, although not so marked as it is south of the Gomul. These lines of drainage are, as usual, the main avenues of approach to the interior of the country. They are the Khaisora and the Shakdu on the the north, which, uniting, join the Tochi south of Bannu, and the Tank Zam (which is also called Khaisor near its head) on the south. The two former lead from the frontier to Rasmak and Makin, villages of some local importance, situated on the slopes of Shuidar; and the latter leads to Kanigoram, the Waziri capital, and the centre of a considerable iron trade. Kanigoram lies at the foot of the Pirghal mountain.

Amongst the mountains of Waziristan there is much fine scenery and a delightful climate. Thick forests of ilex clothe many of the spurs, which reach down to the grassy deodar-covered uplands of Birmal on the west; and the spreading poplar attains magnificent dimensions amongst the flats and plateaus of the eastern slopes. The indigenous trade of the country is inconsiderable, although Waziri iron is much esteemed. The agricultural products are poor, and the general appearance of the priest-ridden people is significant of the endurance of many hardships, even of chronic starvation. The most notable product of the country is the Waziri breed of horses and donkeys. The latter especially deserve to rank as the best of their kind on the Indian frontier, if not in all India.

Geology.

The geological formation of Waziristan is the same as that of the contiguous frontier. Recent subaqueous deposits have been disturbed by a central upheaval of limestone; the lower hills are soft in composition and easily weather-worn, the slopes are rounded, and large masses of detritus have collected in the nullah beds and raised their level. Through these deposits heavy rain-floods have forced their way with many bends and curves to the plains, enclosing within each curve a "wam" or "raghza," which slopes gradually to the hills and affords the only available space for irrigation and agriculture. A "wam" is a gently sloping open space, generally raised but slightly above the river level. A "raghza" differs from a "wam" in being on a higher level and often beyond the reach of irrigation. Pasture is found abundantly in the hills, but cultivation only on the borders of the main streams. Passing up and down these main water-courses, there is an appearance of great fertility and wealth, which is entirely due to these thriving strips of verdure, their restricted and narrow limits being hardly visible from the river beds. From above, when viewed from the flanking ridges, the vast extent of hill country, neither high, nor imposing, nor difficult of access, but invariably stony and rough, compares strongly with the narrow bands of enclosed cultivation winding about like green ribbons, and marking the course of the main streams from the snow-covered peaks to the plains. The physiography of Waziristan is that of the Kuram to the north rather than that of the Sulimani hills to the south.

Population.

The Wazirs (or Waziris) are divided into two important clans, each subdivided into many smaller sections or "khel." The Mahsúd Wazirs occupy all the central portions of the country; the Darwah Khel extend round its western borders, holding the Gomul tributaries, the valleys of Shawál and Birmal, and spreading into the Tochi on the north. The occupation of the heights of the main range and of the upland valleys at its western foot is, however, dependent on the season and the pasturage; the permanent settlements of the country, belonging chiefly to the Mahsúds, are on the eastern slopes facing the Indus. Although not to be compared in physical development with the Ghilzai povindahs (the Suliman Khel, Nasir Khel, and others who migrate yearly between Afghanistan and India), the Waziris are nevertheless a hardy, independent race of mountaineers, fully capable of holding their own with the Afghans on their borders, and of giving the British much trouble.

History.

Expeditions into Waziristan were undertaken in 1860 and 1881, the former under General Chamberlain, and the latter under Generals Kennedy and John Gordon. On the first occasion the resistance was stubborn and determined, and a fierce night attack was with difficulty repulsed. In 1881 no very great stand was made against the advancing troops, and guerilla tactics alone were adopted. The demarcation of a boundary between Waziristan and Afghanistan in 1895 and the occupation of Wana (an upland valley in the south-west of Waziristan) led to another outbreak, when a night attack was directed with great skill against the camp of the brigade supporting the demarcation parties, and with such determination that a partial success was achieved, and the Waziri actually reached the centre of the camp. This led to a punitive expedition directed against the Mahsúds in southern Waziristan and the permanent occupation of Wana. In June 1897, after the boundary demarcation was completed, another outbreak occurred in the Tochi, when the Mada Khel, a section of the Darwah Khel, treacherously attacked the escort of the political agent at Maizar and killed several of the military officers. This again led to a punitive expedition, in which no stand was made by the enemy, who dispersed amongst the upper valleys of the Shuidar range, or across the boundary into Afghanistan. Since then the Tochi valley has been occupied by British troops.

Tochi.

The Tochi is a wide, well cultivated, and open valley (except at its debouchment into the plains near Bannu), and it undoubtedly was once a much used highway between Ghazni and the Indian border. At present it is little utilized as a *khapila* route, excepting for purely local trade. It has a bad reputation for unhealthiness, and the inhabitants of the valley (known as Dawari and disowned by the Waziri) enjoy a reputation for depravity which is unique even amongst border Pathan tribes.

Information about Waziristan is to be found only in the gazetteers and survey reports of the Indian Government. Nothing like an exhaustive description of the country or of its people has yet been attempted. (T. H. H*.)

Wazzán, a small picturesque hillside town, Morocco, 60 miles north-west by north of Fez. It has grown up about the tomb of a sainted Idrisi Sharif (17th century), and is famous as a religious centre, but is otherwise unimportant. It is the headquarters of its founder's descendants. There are no European residents. Population, 10,000.

Webb City, a city of Jaspar county, Missouri, U.S.A., on the St Louis and San Francisco, the Missouri Pacific, and the Kansas City, Fort Scott, and Memphis railways, in the south-western part of the state, at an altitude of 969 feet. It is in the rich lead and zinc region of south-western Missouri and south-eastern Kansas, and its industries are connected with mining and shipping these metals. Population (1880), 1588; (1890), 5043; (1900), 9201, of whom 248 were foreign-born.

Weber, Wilhelm Eduard (1804–1891), German physicist, was born at Wittenberg on the 24th of October 1804, and was a younger brother of Ernst Heinrich Weber of Weber's Law. He studied at the University of Halle, where he took his doctor's degree in 1826 and became extraordinary professor of physics in 1828. Three years later he removed to Göttingen as professor of physics, and remained there till 1837, when he was one of the seven professors who were expelled from their chairs for protesting against the action of the King of Hanover (Duke of Cumberland) in suspending the constitution. A period of retirement followed this episode, but in 1843 he accepted the chair of physics at Leipzig, and six years later returned to Göttingen, where he died on 23rd June 1891. Weber's name is especially known for his work on electrical measurement. Until his time there was no established system either of stating or measuring electrical quantities; but he showed, as his colleague Gauss did for magnetic quantities, that it is both theoretically and practically possible to define them, not by reference to other arbitrary quantities of the same kind, but absolutely in terms in which the units of length, time, and mass are alone involved. He also carried on extensive researches in the theory of magnetism; and it is interesting that in connexion with his observations in terrestrial magnetism he not only employed an early form of mirror galvanometer, but also, about 1833, devised a system of electromagnetic telegraphy, in which a distance of some 9000 feet was worked over. In conjunction with his elder brother he published in 1825 a well-known treatise on waves, *Die Wellenlehre auf Experimente gegründet;* and in 1833 he collaborated with his younger brother, the physiologist Eduard Friedrich (1806–1871), in an investigation into the mechanism of walking.

Webster, a town of Worcester county, Massachusetts, U.S.A., situated in the southern part of the state. It has an area of 16 square miles of hill and valley country, interspersed with ponds. It contains several villages, the largest of which bears the same name as the town, is situated on the French river, and on lines of the Boston and Albany, and the New York, New Haven, and Hartford railways. It is largely engaged in the manufacture of cotton and woollen goods and boots and shoes. The town was incorporated in 1832. Population (1880), 5696; (1890), 7031; (1900), 8804, of whom 3562 were foreign-born.

Wednesbury, a municipal (since 1886) and parliamentary borough and market town, in the Handsworth parliamentary division of Staffordshire, England, 8 miles north-west of Birmingham by rail. An overhead electric tramway connects the town with Walsall. The town hall was improved in 1891. Adjoining is an art gallery, erected in the same year. A drill hall was built in 1893, a new fire brigade station in 1899, and an isolation hospital in the same year. Stoneware potteries are now important; the neighbourhood furnishes limestone and clay. Population (1891), 25,347; (1901), 26,544.

Weighing Machines.—The theory of weighing machines is simple; but a great amount of skill and ingenuity has been used in constructing them so as to combine convenience and cheapness with efficiency, and this has given rise to an immense variety of forms and to a number of practical problems which find no place in the general theory. With few exceptions, weighing machines belong to one or other of the following types:—

Equal-armed balances, which may be divided into
  (1) Scale-beams or balances in which the scale-pans are below the beam.
  (2) Counter machines and balances on the same principle, in which the scale-pans are above the beam.
Unequal-armed balances, which may be divided into
  (1) Balances consisting of a single steelyard.
  (2) Balances formed by combinations of unequal-armed levers and steelyards, such as platform machines, weighbridges, &c.
Spring balances.

Equal-armed Balances.

Scale-beams are the most accurate balances, and the most generally used. When constructed for purposes of extreme accuracy they will turn with the one-millionth part of the load weighed, though to ensure such a result the knife-edges and their bearings must be extremely hard (either hardened steel or agate) and worked up with great care. The beam must be provided with a small ball of metal which can be screwed up and down a stem on the top of the beam for the purpose of accurately adjusting the position of the centre of gravity, and there should be a small adjustable weight on a fine screw projecting horizontally from one end of the beam for the purpose of accurately balancing the arms.

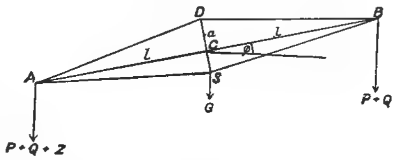


Fig. 1.

The theory of the scale-beam is well stated by Weisbach in his *Mechanics of Machinery and Engineering,* as follows:—In Fig. 1 D is the fulcrum of the balance, S the centre of gravity of the beam alone without the scales, chains, or weights; A and B the points of suspension of the chains. If the length of the arms AC = BC = l, CD = a, SD = s, the angle of deviation of the balance from the horizontal = ϕ, the weight of the beam alone = G, the weight on one side = P, that on the other = P + Z, and lastly the weight of each scale with its appurtenances = Q; then

$$\tan\phi = \frac{Z.l}{\{2(P+Q)+Z\}.a + G.s}.$$

From this it is inferred that the deviation, and therefore the sensitiveness, of the balance increases with the length of the beam, and decreases as the distances, a and s, increase; also, that a heavy balance is, *ceteris paribus,* less sensitive than a light one, and that the sensitiveness decreases continually the greater the weight put upon the scales. In order to increase the sensitiveness of a balance, the line AB joining the points of suspension and the centre of gravity of the balance must be brought nearer to each other. Finally, if a is made extremely small, so that practically $\tan\phi = \frac{Z.l.}{G.s}$, the sensitiveness is independent of the amount weighed by the balance. Weisbach also shows that if Gy^2 is the moment of inertia of the beam, the time, t, of a vibration of the balance is

$$t = \pi\sqrt{\frac{2(P+Q)(l^2+a^2)+G.y^2}{g\{2(P+Q).a+Gs\}}}.$$

This shows that the time of a vibration increases as P, Q, and l increase, and as a and s diminish. Therefore with equal weights a balance vibrates more slowly the more sensitive it is, and therefore weighing by a sensitive balance is a slower process than with a less sensitive one.

The conditions which must be fulfilled by a scale-beam in proper adjustment are:—(1) The beam must take up a horizontal position when the weights in the two scale-pans are equal, from nothing to the full weighing capacity of the machine. (2) The beam must take up a definite position of equilibrium for a given small difference of weight in the scale-pans. The sensitiveness, *i.e.*, the angle of deviation of the beam from the horizontal after it has come to rest, due to a given small difference of weight in the scale-pans, should be such as is suited to the purposes for which the balance is intended. Bearing in mind that with ordinary trade balances there is always a possibility of the scale-pans and chains getting interchanged, these conditions require: (*a*) That the beam without the scale-pans and chains must be equally balanced and horizontal; (*b*) that the two scale-pans with their chains must be of equal weight; (*c*) that the arms of the beam must be exactly equal in length; *i.e.*, the line joining the end knife-edges must be exactly bisected by a line drawn perpendicular to it from the fulcrum knife-edge. By testing the beam with the scale-pans attached and equal weights in the pans, and noting carefully the position which it takes up; and then interchanging the scale-pans, &c., and again noting the position which the beam takes up, a correct inference can be drawn as to the causes of error; and if after slightly altering or adjusting the knife-edges and scale-pans in the direction indicated by the experiment, the operation is repeated, any required degree of accuracy may be obtained by successive approximations. The chief reason for testing balances with weights in the scale-pans rather than with the scale-pans empty, is that the balance might be unstable with the weights though stable without them. This is not an unfrequent occurrence, and arises from the tendency on the part of manufacturers to make balances so extremely sensitive that they are on the verge of instability. In Fig. 2 let ABCD be the beam of a scale-beam, Z the fulcrum knife-edge, and X, Y the knife-edges on which the scales are hung. In order to ensure a high degree of sensitiveness, balances are sometimes constructed so that Z is slightly below the line joining X and Y, and is only slightly above H, the centre of gravity of the beam with the scale-pans and chains attached. The addition of weights in the scales will have the effect of raising the point H till it gets above Z, and the balance, becoming unstable, will turn till it is brought up by a stop of some kind.

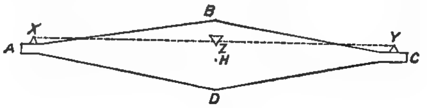


Fig. 2.

For the weighing of very small quantities with balances of great delicacy, the following method is adopted:—If the balance be in perfect adjustment, and l be the length of each arm, and w a very minute difference of the weights in the two scale-pans, by which the beam is deflected from the horizontal by a very small angle ϕ, it can easily be shown that $\tan\phi$, or ϕ, varies as $w \times l$. Therefore the angle of deflection which would be produced by a grain weight hung at the distance $\frac{l}{10}$ (for example) from the centre is the same as would be produced by $\frac{1}{10}$th of a grain in the scale-pan at the distance l. Therefore by graduating the top of the beam and shifting a rider grain weight till the beam is horizontal, it is easy to ascertain the small difference of weight in the scale-pans which caused the deflection to the $\frac{1}{100}$th or $\frac{1}{1000}$th part of a grain without using a weight smaller than a grain.

With such delicate machines as scale-beams, the fitting of the knife-edges is of great importance. In ordinary trade balances a triangular piece of hard steel, with a finely-ground edge, is driven through a triangular hole in the beam and jammed tight. This forms the knife-edge, and the scale-pans are hung from the two projecting ends of the piece of steel. Similarly the two projecting ends of the central piece of steel which forms the fulcrum take bearing on two cheeks of the stand, between which the beam sways. It is clear that errors will arise if the pieces of steel are not truly perpendicular to the plane of the beam, and the adjustment for great accuracy would be very tedious. Therefore for balances of precision the end knife-edges are fixed on the top of the beam so as to present a continuous unbroken knife-edge, and the fulcrum knife-edge is also made continuous, the beam being cored out or cut away to admit of the introduction of the stand bearing. With this arrangement the knife-edges can be easily adjusted and examined, and the system is now rapidly extending to the better class of trade balances.

The knife-edges of weighing machines are the parts that wear out soonest, but very little is known about them experimentally, and the knife-edges made by different makers vary extremely in their angles. Those made by some of the best makers for the most delicate machines are formed to an angle of about 80° between the sides, with the finished edge ground to an angle varying from 110° to 120°. The following may be taken as the maximum loads per inch of acting or efficient knife-edge allowed by the best makers:—

(1) For scale-beams of the highest accuracy—From ½ ℔ per inch for a machine of ½ ℔ capacity, to 25 ℔ per inch for a machine of 80 ℔ capacity.

(2) For ordinary trade scale-beams, counter machines, and dead-weight machines—From 20 ℔ per inch for a machine of 7 ℔ capacity, to 600 ℔ per inch for a machine of ½ ton capacity.

(3) For platform machines and weighbridges—From 120 ℔ per inch for a machine of 4 cwt. capacity, to 1 ton per inch for a machine of 25 tons capacity.

The sensitiveness of scale-beams depends entirely upon the skill and care used in their construction. With balances of the highest precision it may be as high as $\frac{1}{1000000}$ of the load weighed, while with trade balances when new it would be about $\frac{1}{2000}$ of the load.

In Emery's testing machine there are no knife-edges, but their function is performed by thin steel plates, which are forced under a very heavy pressure into slots formed in the parts that are to be connected, so that the parts are united by the plate. In this case there is no friction and no sensible wear, so that very great permanency of condition and constancy of action might be expected. But the resistance to bending of the steel plates would render this arrangement unsuitable for scale-beams, in which the movement is large. In some respects it would appear to be very suitable for weighbridges, in which the movement of the lever is very small, but for general convenience of adjustment the knife-edges appear preferable.

Counter machines have an advantage over scale-beams in not being encumbered with suspension chains and the beam above. They are usually made with two beams, each with its three knife-edges, rigidly tied together or cast in one piece and some distance apart, so that the scale-pans being carried on two knife-edges, each is prevented from tipping over sideways. To prevent them from tipping over in the direction of the beams a vertical leg is rigidly fastened to the under side of each pan, the lower end of which is loosely secured by a horizontal stay to a pin in the middle of the frame. In using these machines there is seldom any question of determining the weight to any great nicety, and rapid action is generally of high importance. Hence they are very commonly made unstable, or "accelerating," *i.e.*, they are constructed with the fulcrum knife-edges lower than the line joining the end knife-edges, and they are arranged so that the beam is horizontal when the stop of the weights-pan is hard down on its bearings. This arrangement is well adapted for weighing out parcels of goods of a definite weight, though not for ascertaining the correct weight of a given article. For the latter purpose machines are used of which the beams are made stable, or "vibrating," by constructing them with the fulcrum knife-edges above the line joining the end knife-edges.

"Accelerating" machines can be used to the advantage of the vendor in two ways. Firstly, in using them to determine the weight of a given article. For with unstable balances, although the smallest excess of weight in the goods-pan will cause it to descend till it is brought up by its stop, yet being in this position, a very much greater weight than the difference which brought it there will be required in the weights-pan to enable it to mount again. If W be the weight in each pan when the goods-pan commenced to sink, l the length of each arm, m the distance of the fulcrum below the line joining the end knife-edges, and β the angle at the fulcrum which defines the range of sway of the beam, it can easily be shown that w, the additional weight required in the weights-pan to enable the goods-pan to rise from its stop, is given by the equation $w = \mathrm{W}\frac{2m\tan\beta}{l - m\tan\beta}$. So that if, for example, a fishmonger uses such a machine to ascertain the weight of a piece of fish which he places in the goods-pan, and thereby depresses it down upon its stop, and then places weights in the weights-pan till the goods-pan rises, the customer is charged for more than the real weight of the fish. Secondly, in using them out of level, with the goods end of the machine lower than the weights end. If θ be the angle of tilt of the machine, and the other symbols be as before, it may be shown that the additional weight, w, which is needed in the weights-pan to enable the goods-pan to rise off its stop, is given by the equation $w = \mathrm{W}\frac{2m\tan(\beta - \theta)}{l - m\tan(\beta - \theta)}$. When θ is negative, as it is when the goods end of the machine is lower than the weights end, the value of w may be very appreciable. With "vibrating" machines the value of m is in general so extremely small that w is of no practical importance in either of the above cases.

If a counter machine be made with a large flat goods-pan, as in Fig. 3, an error may be caused by placing the goods eccentrically on the pan, as at D or E. Using the symbols of the diagram, it can be shown that the effect of placing the weight W at E

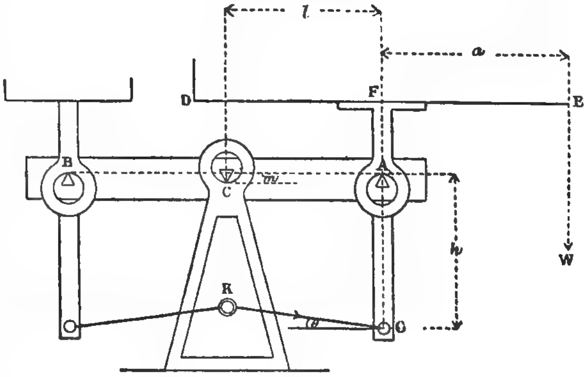


Fig. 3.

instead of F is to cause the end of the beam to descend, as if under the action of an additional weight, w, at F such that

$$w = W \cdot \frac{a}{h}\left(\frac{m}{l} + \tan\theta\right).$$

The condition that must exist in order that the balance may weigh correctly for all positions of the weight W is $w = o$, or $\tan\theta = -\frac{m}{l}$; that is, the stay KG must be adjusted parallel to the line joining the points A and C. From the equation for w, it is seen that the larger h is the smaller w will be. Therefore for the larger counter machines, where it is not convenient to have the scale-pans raised high above the counter, and for "dead-weight" machines on the same principle, where it is not convenient to have the scale-pans raised high above the floor, there is an advantage in adopting the "inverted counter machine" arrangement (Fig. 4), because the vertical leg can be produced upwards as high as is required. This arrangement is very common. As will be readily understood from the construction of the machines, there is more friction in counter machines than in scale-beams. The "sensitiveness" error allowed by the Board of Trade for counter machines is five times as great as that allowed for scale-beams.

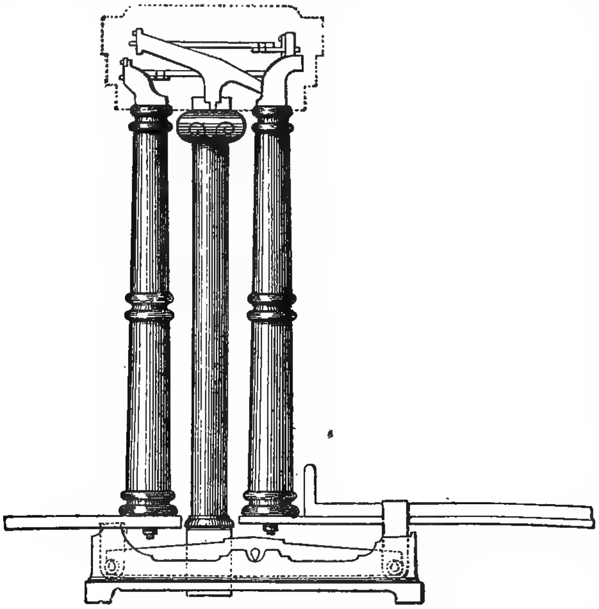


Fig. 4.

The torsion balance made by the United States Torsion Balance and Scale Company of New York is a counter machine made without knife-edges, and is very sensitive. It is constructed with two similar beams, one above the other, which are coupled together at the ends to form a parallel motion for carrying the pans upright. The coupling is effected by firmly clamping the ends of the beams upon the top and bottom respectively of a loop of watch-spring, which is tightly stretched round the casting carrying the pan, as is shown in the end view in Fig. 5. At their middles the beams are similarly clamped upon the top and bottom of a loop of watch-spring which is tightly stretched round a casting which is bolted upon the bedplate. When the case which holds the machine is adjusted horizontally by means of its footscrews, and the weights in the pans are equal, the beams remain perfectly horizontal; but with the slightest difference of weight in the pans the beams are tilted, and the elastic resistance of the springs to torsion allows the beams to take up a definite position of equilibrium. The lower beam carries on a saddle a scale which is raised nearly to the top of the glass case in which the machine is enclosed, and as the beams sway this scale plays past a scratch on the glass, which is so placed that when the zero point on the scale coincides with the scratch the beams are horizontal. With proper care this machine should be very permanent in its action.

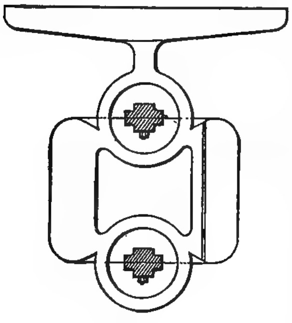


Fig. 5.

Unequal-armed Balances.

Steelyards are simple, trustworthy, and durable, but unless special contrivances are introduced for ascertaining the position of the travelling poise with very great accuracy, there will be a little uncertainty as to the reading, and therefore steelyards are not in general so accurate as scale-beams. When carefully nicked they are well adapted for weighing out definite quantities of goods, such as 1 ℔, 2 ℔, &c., as in such cases there is no question of estimation. The ordinary way of using a steelyard is to bring it into a horizontal position by means of movable weights, and to infer the amount of the load from the positions of these. But it is sometimes convenient to use a fixed weight on the long arm, and to infer the amount of the load from the position of the steelyard. The rule for graduation is very simple. The simplest form is that which has a single travelling poise. The more elaborate ones are made either with a heavy travelling poise to measure the bulk of the load with a light travelling poise for the remainder, or else with a knife-edge at the end of the steelyard, on which loose weights are hung to measure the bulk of the load, the remainder being measured with a light travelling poise. The advantage of the first arrangement is that the weights on the steelyard are always the same, and inconsistencies of indication are avoided, while in the second arrangement the loose weights are lighter and handier, though they must be very accurate and consistent among themselves, or the error will be considerable, by reason of the great leverage they exert.

Steelyards, like other weighing machines, will be "accelerating" or "vibrating" according to the arrangement of the knife-edges. In Fig. 6 let Z be the fulcrum knife-edge, X the knife-edge on which the load R is hung, and H the centre of gravity of the weights to the right of Z, viz., the weight, W, of the steelyard acting at its centre of gravity, G, the travelling poise, P, acting at M, and the weights, Q, hung on the knife-edge at Y. Then if Z be below the line joining X and H, the steelyard will be "accelerating"; *i.e.*, with the smallest excess of moment on the left-hand side of the fulcrum, the end C of the steelyard will rise with accelerating velocity till it is brought up by a stop of some sort; and with the smallest excess of moment on the right-hand side of the fulcrum, the end C of the steelyard will drop, and will descend with accelerating velocity till it is brought up by a similar stop. If Z be above the line XH, the steelyard is "vibrating"; *i.e.*, it will sway or vibrate up and down, ultimately coming to rest in its position of equilibrium. Steelyards, again, are frequently arranged as counter machines, having a scoop or pan resting on a pair of knife-edges at the short end, which is prevented from tipping over by a stay arrangement similar to that of other counter machines.

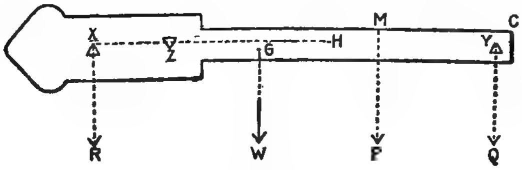


Fig. 6.

Steelyards are largely used in machines for the automatic weighing out of granular substances. The principle is as follows:—The weighing is effected by a steelyard with a sliding poise which is set to weigh a definite weight of the material, say 1 ℔. A pan is carried on the knife-edges at the short end, and is kept from tipping over by stays. A packet is placed on the pan to receive the material from the shoot of a hopper. A rod, connected at its lower end with the steelyard, carries at its upper end a horizontal dividing knife, which cuts off the flow from the shoot when the steelyard kicks. When the filled packet is removed, the steelyard resumes its original position, and the filling goes on automatically.

The automatic personal weighing machine found at most railway stations operates by means of a steelyard carrying a fixed weight on its long arm, the load on the platform being inferred from the position of the steelyard. In Fig. 7 the weight on the platform is transferred by levers to the vertical steel band, A, which is wrapped round an arbor on the axle of the disc-wheel, B, to which is rigidly attached the toothed segment, C. The weight, D, is rigidly attached to the axle of the wheel, B, and the counterbalance, E, is hung from the wheel, B, by means of a cord wrapped round it. When the pull of the band, A, comes upon the wheel, B, it revolves through a certain angle in the direction of the arrow until the three forces, viz., the pull of A, the weight, D, and the counterbalance, E, are in equilibrium. The toothed segment, C, actuates the pinion, F, which carries the finger, G, and this finger remains fixed in position so long as the person is standing on the platform. If now a small weight, as a penny, be passed through the slot, H, it falls into the small box, I, and causes the lever, J, to turn; the lever, J, which turns in friction wheels at K, and is counterbalanced at O, carries a toothed segment, L, which actuates a small pinion on the same axle as F, and is free to turn on that axle by a sleeve. This small pinion carries a finger, M, which is arranged to catch against the finger, G, when moved up to it. Consequently as the lever J, turns, the finger, M, revolves, and is stopped when it reaches G. The sleeve of the pinion which carries M also carries the dial finger, and if the dial is properly graduated its finger will indicate the weight. The box, I, has a hinged bottom with a projecting click finger which, as the box descends, plays idly over the staves of a ladder arc. When the weight is removed from the platform, the counterbalance, E, causes the finger, G, to run back to its zero position, carrying with it the finger, M, and causing the click finger of the box, I, to trip open the bottom of the box and let the penny fall out. The lever, J, regains its zero position, and all is ready for another weighing. Since so small a weight as a penny has to move the lever, J, together with the dial finger, &c., it is evident that the workmanship must be good and the friction kept very low by means of friction wheels.

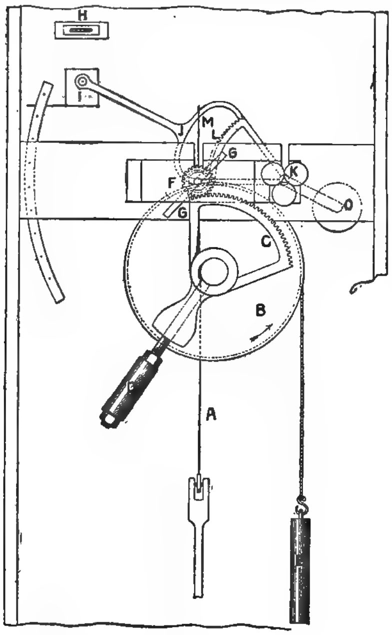


Fig. 7.

Some of the largest and most accurate steelyards are those made for testing machines for tearing and crushing samples of metals and other materials. They are sometimes made with a sliding poise weighing 1 ton, which has a run of 200 inches, and the steelyard can exert a pull of 100 tons.

Balances are frequently used as counting machines, when the articles to be counted are all of the same weight or nearly so, and this method is both quick and accurate. They are also used as trade computing machines, as in the case of the machine made by the Computing Scale Company, Dayton, Ohio, U.S.A. In this machine the goods to be priced are placed on the platform of a small platform machine whose steelyard is adjusted to balance exactly the weight of the platform, levers, and connexions. The rod which transmits the pull of the long body lever of the platform machine to the knife-edge at the end of the short arm of the steelyard is continued upwards, and by a simple mechanical arrangement transmits to an upper steelyard any additional pull of the long body lever due to the weight of goods placed on the platform. This upper steelyard is arranged as in Fig. 8, where A is the point where the pull of the long body lever due to the weight of the goods on the platform comes upon the steelyard; C is the fulcrum of the steelyard, which with the steelyard can be slid to and fro on the frame of the machine; and Q is a poise which can be slid along the upper bar of the steelyard. The steelyard is exactly in balance when there is no weight on the platform and Q is at the zero end of its run, at O. Suppose that the weight of the goods on the platform is (p) ℔, and that $\frac{1}{n}$th of this weight is transmitted by the long body lever to the point A, so that $\frac{p}{n}$ ℔ is the pull at A. Let the lower bar of the steelyard be graduated in equal divisions of length, d, each of which represents one penny, so that the distance $\overline{\text{CA}}=q\times d$ represents q pence. Then the number $p\times q$ represents the total value of the goods on the platform. If Q ℔ be the weight of the poise Q, the position of Q when the steelyard is exactly in balance is given by the equation $\frac{p}{n}\times q.\ d=\text{Q}\times\text{OQ}$, or $\text{OQ}=\overline{p\times q}\times\frac{d}{n\text{Q}}$. If therefore the upper bar be graduated in divisions, each of which is $\frac{d}{n\text{Q}}$, the indication of the poise Q, viz., $\overline{p\times q}$ graduations, gives correctly the value of the goods. Thus to ascertain the value of goods on the platform of unknown weight at a given price per ℔, it is only necessary to slide the steelyard till the weight acts at the division which represents the price per ℔, and then to move the poise Q till the steelyard is in balance; the number of the division which defines the position of the poise Q will indicate the sum to be paid for the goods. When the load on the platform is large, so that the value of the goods may be considerable, it is convenient to measure the larger part of the value by loose weights which, when hung at the end of the steelyard, represent each a certain money value, and the balance of the value is determined by the sliding poise Q.

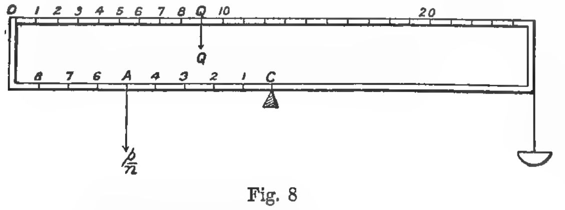


Fig. 8

In the machines commonly used to weigh loads exceeding 2 cwt. the power is applied at the end of the long arm of the steelyard and multiplied by levers from 100 to 500 times, so that the weights used are small and handy. The load is received upon four knife-edges, so that on the average each knife-edge receives only one-fourth of the load, and, as will be seen, it is immaterial whether the load is received equally by the four knife-edges or not, which is essential to the useful application of these machines.

In Fig. 9 AB is the steelyard. The platform and the load upon it are carried on four knife-edges, two of which, x_1 and x_2, are shown, and the load is transferred to the steelyard by the two levers shown, the upper one CD being known as the "long body," and the lower one EF as the "short body." If $z_1x_1=z_2x_2$, and $z_1t=z_2y_2$, then the leverage of any portion of the load applied at x_2 will be the same as the leverage of any part of the load applied at x_1, and the pressure produced at y_1 will be the same for equal portions of the load, whether they were originally applied at x_1 or x_2. Platform machines, like steelyards, may be arranged either on the "accelerating" principle or on the "vibrating" principle. If in Fig. 9 g_1 be the centre of gravity of the long body CD, and h_1 be the centre of gravity of the three vertical forces acting downwards at the points x_1, t, and g_1, considered as weights collected at those points; then if h_1 be above the line z_1y_1 it can be shown that this arrangement of the knife-edges of CD favours the "acceleration" principle, and is suited to act with and assist an "accelerating" steelyard, and similarly if the point h_2 be above the line z_2y_2 in the case of the short body EF. If the knife-edges be placed so that h_1 and h_2 are below the lines x_1y_1 and x_2y_2

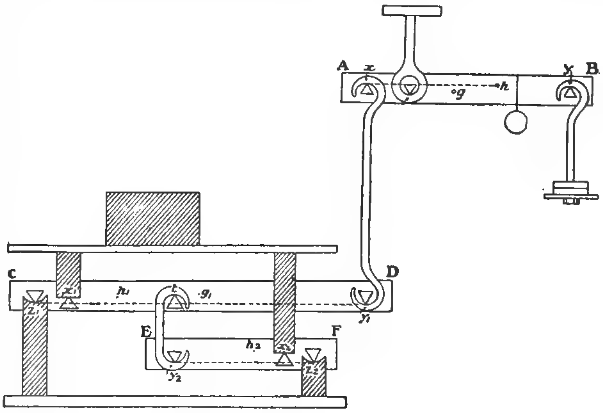
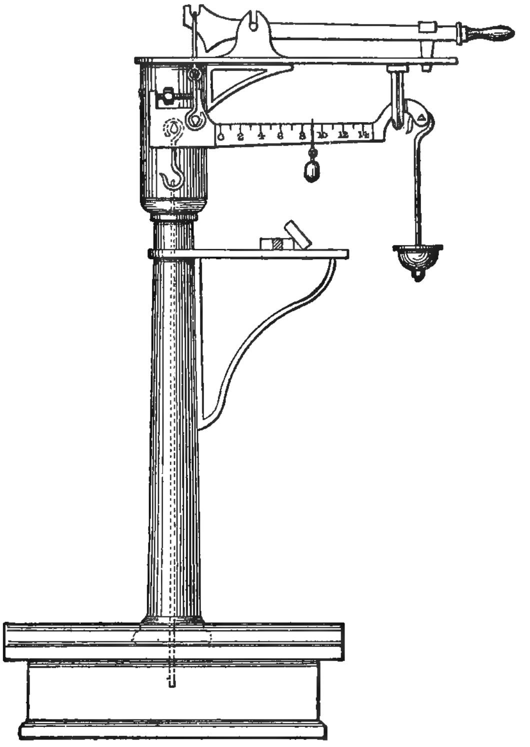
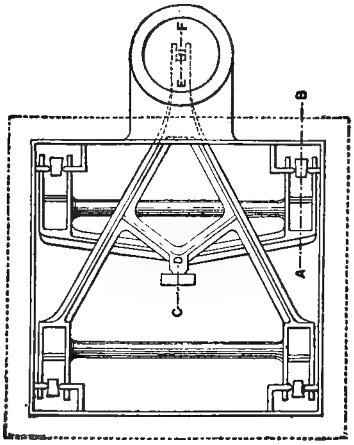


Fig. 9.

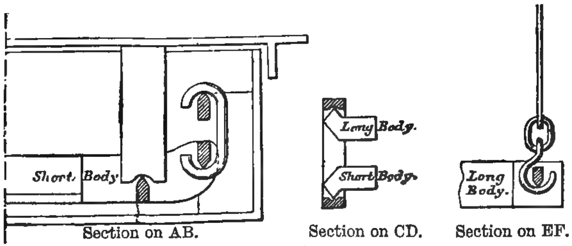
respectively, the arrangement will favour the "vibration" principle, and is suited to act with and assist a "vibrating" steelyard.



Elevation.



Plan with cover removed.



Section on AB. Section on CD. Section on EF.

Fig. 10.

It is very important that platform machines should be truly level. With accelerating machines a small amount of tilt in any direction considerably affects the accuracy of the weighing, and when the amount of tilt is considerable the action may be changed, so that a machine which was intended to act as an accelerating machine acts like a vibrating one. Vibrating machines are only slightly affected by being out of level in comparison with accelerating machines, and in this matter they have a distinct advantage. When a platform machine is in true adjustment, and the loose weights which are intended to be hung at the end of the steelyard are correct and consistent among themselves, a good and new machine, whose capacity is 4 cwt., should not show a greater error than 4 oz. when fully loaded. Platform machines are slightly affected by changes of temperature. In some cases they are made "self-recording" by the following arrangement:—The steelyard is provided with a large and a small travelling poise. Each of these poises carries a horizontal strip of metal, which is graduated and marked with raised figures corresponding to those on the steelyard itself. These strips pass under a strong punching lever arranged on the frame of the machine. A card prepared for the purpose is introduced through a slit in the frame between the punch and the strips. When the poises have been adjusted to weigh a load on the platform the punch is operated by a strong pull, and the impression of the raised figures is left on the card. Thus the weight is recorded without reading the positions of the poises. In another arrangement the self-recording parts are entirely enclosed in the travelling poise itself.

Fig. 10 shows the ordinary arrangement of the parts of a platform machine, but there are many types which differ greatly in detail though not in principle.

When the goods to be weighed are very heavy, portable weighbridges or platform machines are inapplicable and it is necessary to erect the weighbridge on a solid foundation. Some weighbridges are arranged in a manner similar to that of the platform machines already described, but having the long body lever turned askew, so that the end of it projects considerably beyond the side of the weighbridge casing, and the pillar and steelyard which receive its pull are clear of the waggon on the platform. In another arrangement two similar triangular levers take bearing on opposite sides of an intermediate lever which communicates their pressures to the steelyard; this is a very sound and simple arrangement for ordinary long weighbridges. Lastly, when the weighbridge is very long—and they are sometimes made 40 feet long, and are arranged to weigh up to 100 tons or more—it is practically composed of two platform machines end to end, each having its four knife-edges to receive the load, and the two long bodies take bearing on the opposite sides of an intermediate horizontal lever, the end of which is connected with the steelyard. When skilfully made they are very accurate and durable.

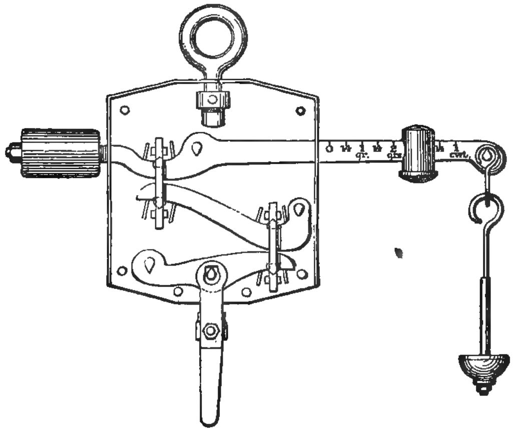


Fig. 11.

A useful application of weighbridges is to ascertain the exact weights on the separate wheels of locomotive engines, so that they may be properly adjusted. For this purpose a number of separate weighbridges of simple construction are erected, one for each wheel of the engine, with their running surfaces in exactly the same horizontal plane. The engine is moved on to them, and the pressures of all the wheels are taken simultaneously, each by its own weighbridge.

There are many kinds of weighing machines depending for their action on combinations of levers, and arranged to meet special requirements. Such are coal platform machines for weighing out coal in sacks, the levers of which are arranged as in the ordinary platform machines, but for the sake of compactness the steelyard is returned back over the long body, and when loaded with the proper weight indicates the correct weight of the coal in the sack by its end kicking up. Crane machines are used to weigh goods as they are hoisted by a crane; the lever arrangement is shown in Fig. 11.

A crane machine of peculiar construction, well adapted for weighing heavy loads, and extremely simple and compact, which does not properly come under any of the heads under which the machines have been classified, is the hydrostatic weighing machine. This machine is constructed with an open top cylinder, a stirrup strap being provided by which it may be suspended from a crane. The cylinder, which is filled with oil or other liquid, is fitted with a piston having a piston-rod passing downwards and terminating in an attachment for the goods to be weighed. As the goods are lifted by the crane the whole of their weight is taken by the liquid in the cylinder, and the pressure on the liquid, as indicated by a pressure gauge, gives the weight. The gauge has a plain dial, marked off to indications given by the application of standard tons and cwts.; it could probably be read to about ½ per cent. of the load weighed.

Spring Balances.

For many purposes spring balances are the most convenient of all weighing machines. They depend upon the extension of one or more spiral springs, and as this is proportional to the weight the graduation is very simple. The springs in general are accurate and uniform in their action, but as their range is necessarily limited it is often convenient to indicate the extension (and consequently the load) by means of a small rack and pinion which give motion to an index on a dial plate. Thus the correctness of the indications depends upon the condition of the rackwork and upon the friction, which vary with the wear, and although the errors would not be large for the purposes for which such machines are generally used, yet for satisfactory working they need to be tested with standard weights from time to time. The springs are also affected by temperature.

AUTHORITIES.—JULIUS WEISBACH. *Mechanics of Machinery and Engineering.* London, 1848.—ERNEST BRAUER. *Die Konstruktion der Waage.* Weimar, 1887.—H. J. CHANEY. *Our Weights and Measures.* London, 1897.—AIRY on "Weighing Machines," *Proc. Inst. C.E.*, vol. cviii.—W. H. BROTHERS on "Weighing Machinery," *Trans. Soc. Engineers*, vol. for 1890.

(W. AY.)

WEIGHTS AND MEASURES.

THIS subject may be most conveniently considered under three aspects—I. Scientific; II. Historical; and III. Commercial.

I. SCIENTIFIC.

1. *Units.*—In the United Kingdom two systems of weights and measures are now recognized—the imperial and the metric. The fundamental units of these systems are—of length, the yard and metre; and of mass, the pound and kilogram. The units of the imperial system have been referred to in an earlier volume of this work (*Ency. Brit.*, vol. xxiv. pp. 478–79). Of the metric units international definitions have been stated as follows:—

(*a*) The unit of volume for determinations of a high degree of accuracy is the volume occupied by the mass of 1 kilogram of pure water at its maximum density and under the normal atmospheric pressure; this volume is called litre.

(*b*) In determinations of volume which do not admit of a high degree of accuracy the cubic decimetre can be taken as equivalent to the litre; and in these determinations expressions of volumes based on the cube of the unit of linear measure can be substituted for expressions based on the litre as defined above.

(*c*) The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.[1]

(*d*) The term "weight" denotes a magnitude of the same nature as a force; the weight of a body is the product of the mass of the body by the acceleration of gravity; in particular, the normal weight of a body is the product of the mass of the body by the normal acceleration of gravity. The number adopted for the value of the normal acceleration of gravity is $980{\cdot}965\frac{\text{cm}}{\text{sec}^2}$.

2. *Standards.*—The metre (*mètre-à-traits*) is represented by the distance marked by two fine lines on an iridio-platinum bar ($t = 0°$ C.) deposited with the Standards Department. This metre (m.) is the only unit of metric extension by which all other metric measures of extension —whether linear, superficial, or solid—are ascertained.

The kilogram (kg.) is represented by an iridio-platinum standard weight, of cylindrical form, by which all other metric weights, and all measures having reference to metric weight, are ascertained in the United Kingdom.

From the above four units are derived all other weights and measures (W. and M.) of the two systems.

The gallon is the standard measure of capacity in the imperial system as well for liquids as for dry goods.

In the United Kingdom the metric standard of capacity is the litre, represented (Order in Council, 19th May 1890) by the capacity of a hollow cylindrical brass measure whose internal diameter is equal to one-half its height, and which at 0° C., when filled to the brim, contains one kg. of distilled water of the temperature of 4° C., under an atmospheric pressure equal to 760 millimetres at 0° C. at sea level and latitude 45°; the weighing being made in air, but reduced by calculation to a vacuum. In such definition an attempt has been made to avoid former confusion of expression as to capacity, cubic measure, and volume; the litre being recognized as a measure of capacity holding a given weight of water.

For the equivalent of the litre in terms of the gallon, *vide* III. *Commercial.*

In the measurement of the cubic inch it has now been found that[2] the specific mass of the cubic inch of distilled water freed from air, and weighed in air against brass weights ($\Delta = 8{\cdot}13$), at the temperature of 62° F., and under an atmospheric pressure equal to 30 inches (at 32° F.), is equal to 252·297 grains weight of water at its maximum density (4° C.). Hence a cubic foot of water would weigh 62·281 ℔ avoir., and not 62·321 ℔ as at present legally taken.

For the specific mass of the cubic decimetre of water at 4° C., under an atmospheric pressure equal to 760 mm., Dr Guillaume and Dr Chappuis of the Comité International des Poids et Mesures at Paris (C.I.P.M.) have obtained 0·9999707 kg.,[3] which has been accepted by the committee.

The two standards, the cubic inch and the cubic decimetre, may not be strictly comparable owing to a difference in the normal temperature (Centigrade and Fahrenheit scales) of the two units of extension, the metre and the yard.

For the weight of the cubic decimetre of water, as deduced from the experiments made in London in 1896 as to the weight of the cubic inch of water, Professor D. Mendeleeff (*Proc. Roy. Soc.*, 1895) has obtained the following results, which have been adopted in legislative enactments in the United Kingdom:—

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[1] *Troisième Conférence Générale des Poids et Mesures.* Paris, 1901. —*Metric Units Com. Roy. Soc.* 1898.

[2] *Phil. Trans. Roy. Soc.*, 1892; and *Proc. Roy. Soc.*, 1895, p. 143.

[3] *Proc. Verb. Com. Intern. des Poids et Mesures*, 1900, p. 84. Congrès International de Physique réuni à Paris en 1900.

Temperature on the Hydrogen Thermometer Scale.		Weight of Water *in vacuo.*		
C.	F.	Of a Cubic Decimetre in Grammes.	Of a Cubic Inch in Grains.	Of a Cubic Inch in Russian Dolis.
0°	32°·0	999·716	252·821	368·686
4	39·2	999·847	252·854	368·734
15	59·0	998·979	252·635	368·414
16⅔	62·0	998·715	252·568	368·316
20	68·0	998·082	252·407	368·083

In this no account is taken of the compressibility of water—that is to say, it is supposed that the water is under a pressure of one atmosphere. The weight of a cubic decimetre of water reaches 1000 grammes under a pressure of four atmospheres; but *in vacuo*, at all temperatures, the weight of water is less than a kilogram.

3. *National Standards.*—National standards of length are not legally now referred to natural standards or to physical constants,[1] but it has been shown by Professor A. A. Michelson that a standard of length might be restored, if necessary, by reference to the measurement of wave-lengths of light. Preliminary experiments have given results correct to ±0·5 micron, and it appears probable that by further experiments, results correct to $\pm 0{\cdot}1\mu$ may be obtained. That is to say, the metre might be re-determined or restored as to its length within one ten-millionth part, by reference to, *e.g.*, 1553163·5 wave-lengths of the red ray of the spectrum of cadmium, in air at 15° C. and 760 mm.

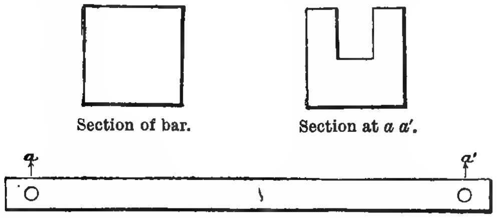

Fig 1.—Present Imperial Standard Yard, 1844.

Total length of bronze bar, 38 inches; distance *a a'*, 36 inches, or the imperial yard; *a a'*, wells sunk to the mid-depth of the bar, at the bottom of each of which is inserted a gold stud, having the defining line of the yard engraved on it.

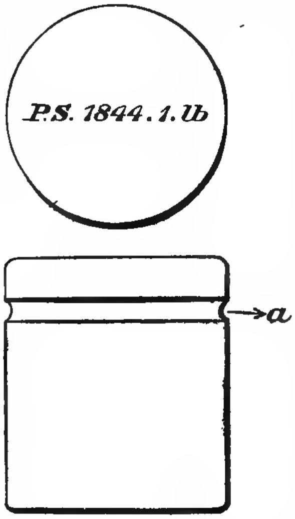

Fig. 2.—Imperial Standard Pound, 1844.

Platinum pound avoirdupois, of cylindrical form, with groove at *a* for lifting the weight.

In all countries the national standards of weights and measures are in the custody of the State, or of some authority administering the government of the country. The standards of the British Empire, so far as they relate to the imperial and metric systems, are in the custody of the Board of Trade. Scientific research is not, of course, bound by official standards.

For the care of these national standards the Standards Department was developed, under the direction of a Royal Commission [2] (of which the late Mr H. W. Chisholm was a leading member), to conduct all comparisons and other operations with reference to weights and measures in aid of scientific research or otherwise, which it may be the duty of the State to undertake. Similar standardizing offices are established at Berlin, St Petersburg, Paris, Vienna, Rome, Madrid, Lisbon, Brussels, Bucharest, and Constantinople, as well as at Washington, Ottawa, Melbourne, and Sydney. In India the standards are kept at the branch mints of Calcutta and Bombay. Verified "Parliamentary Copies" of the imperial standard are placed at the Royal Mint, with the Royal Society, at the Royal Observatory, and in the Westminster Palace.

The forms of the four primary standards representing the four units of extension and mass, already referred to (see *Ency. Brit.*, vol. xxiv. p. 480), are shown in Figs. 1 to 4.

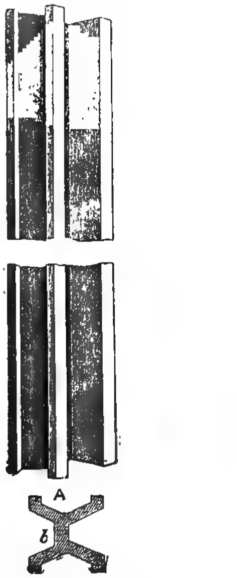

Fig. 3.—National Standard Metre, 1897.

Iridio-platinum bar of Tresca section as shown at A. The two microscopic lines are engraved on the measuring axis of the bar at *b*, one near to each end of the bar. The standard metre (*mètre-à-traits*) was supplemented by the delivery to Great Britain, in 1898, of an end standard metre (*mètre-à-bouts*) also made of iridio-platinum, and also verified by the C.I.P.M. A comparison of the yard with the metre was made by the C.I.P.M. in 1896, and of the pound and kilogram in 1883–85 (see III. *Commercial*).

A secondary standard measure for dry goods is the bushel of 1824, containing 8 imperial gallons, represented by a hollow bronze cylinder having a plane base, its internal diameter being double its depth.

The imperial standard measure of capacity is a hollow cylinder (Fig. 5) made of brass, with a plane base, of equal height and diameter; which when filled to the brim, as determined by a plane glass disc, contains 10 ℔ weight of water at $t=62^\circ$ F.B. $=30$ inches, weighed in air against brass weights.

4. *Atmospheric Pressure, and Materials.*—In the verification of a precise standard of length there may be taken into account the influence of the variation of atmospheric pressure. Taking the range of the barometer in Great Britain from 28 to 31 inches, giving a difference of 3 inches (76 millimetres), which denotes a variation of 103 grammes per square centimetre in the pressure of the atmosphere, the change caused thereby in the length of a standard of linear measurement would appear to be as follows:—

For the yard measure of the form shown in Fig. 1 a difference of length equal to 0·000002 inch is caused by the variation of atmospheric pressure from 28 to 31 inches. For the metre of the form shown in Fig. 3 the difference in length for a variation of 76 mm. in the barometer would be 0·000048 mm. on the metre.

With reference to the materials of which standards of length are made, it appears that the Matthey alloy iridio-platinum (90 per cent. platinum, 10 per cent. iridium) is probably of all substances the least affected by time or circumstance, and of this costly alloy, therefore, a new copy of the imperial yard has been made. There appears, however, to be some objection to the use of iridio-platinum for weights, as, owing to its great density ($\Delta=21{\cdot}57$), the slightest abrasion will make an appreciable difference in a weight; sometimes, therefore, quartz or rock-crystal is used; but to this also there is some objection, as owing to its low density ($\Delta=2{\cdot}65$) there is a large exposed surface of the mass. For small standard weights platinum ($\Delta=21{\cdot}45$) and aluminium ($\Delta=2{\cdot}67$) are used, and also an alloy of palladium (60 per cent.) and silver (40 per cent.) ($\Delta=11{\cdot}00$).

For ordinary standards of length Guillaume's alloy (*invar*) of nickel (35·7 per cent.) and steel (64·3 per cent.) is used, as it is a metal that can be highly polished, and is capable of receiving fine graduations. Its coefficient of linear expansion is only 0·0000008 for 1° C.[1]

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[1] *Valeur du Mètre*, A. A. Michelson, Paris, 1894; *Units*, Everett, Illustrations of C.G.S. System; *Unites et Étalons*, Guillaume, Paris, 1890; Lupton's Numerical Tables, 1892; Metric Equivalent Cards, 1901; *Dictionary of Metric Measures*, L. Clark, 1891; Glazebrook and Shaw's *Physics*, 1901.

[2] Report Standards Commission, 1870.

5. *Electrical Standards.*—Authoritative standards and instruments for the measurement of electricity, based on the fundamental units of the metric system, have been placed in the Electrical Laboratory of the Board of Trade.[2] These include

Current measuring instruments.	The standard ampere, and sub-standards from 1 to 2500 amperes.
Potential measuring instruments.	The standard volt, and sub-standards for the measurement of pressure from 25 to 3000 volts.
Resistance measuring instruments.	The standard ohm, sub-standards up to 100,000 ohms, and below 1 ohm to $\frac{1}{1000}$ ohm.

6. *Temperature.*—In the measurement of temperature the Fahrenheit scale is still followed for imperial standards, and the Centigrade scale for metric standards. At the time of the construction of the imperial standards in 1844, Sheepshanks's Fahrenheit thermometers were used; but it is difficult to say now what the true temperature then, of 62° F., may have been as compared with 62° F., or 16·667° C., of the present normal hydrogen scale. For metrological purposes the C.I.P.M. have adopted as a normal thermometric scale the Centrigrade scale of the hydrogen thermometer, having for fixed points the temperature of pure melting ice (0°) and that of the vapour of boiling distilled water (100°), under a normal atmospheric pressure; hydrogen being taken under an initial manometric pressure of 1^{m}·, that is to say, at $\frac{1000}{760} = 1·3158$ of the normal atmospheric pressure. This latter is represented by the weight of a column of mercury 760^{mm}· in height; the specific mass of mercury being now taken as 13·5950, after Volkmann and Marek, and at the normal intensity followed under this pressure. The value of this intensity is equal to that of the force of gravity at the Bureau International, Paris (at the level of the Bureau), divided by 1·000332; a coefficient which allows for theoretical reduction to the latitude 45° and to the level of the sea. The length of the metre is independent of the thermometer so far that it has its length at a definite physical point, the temperature of melting ice (0° C.), but there is the practical difficulty that for ordinary purposes measurements cannot be always carried out at 0° C.

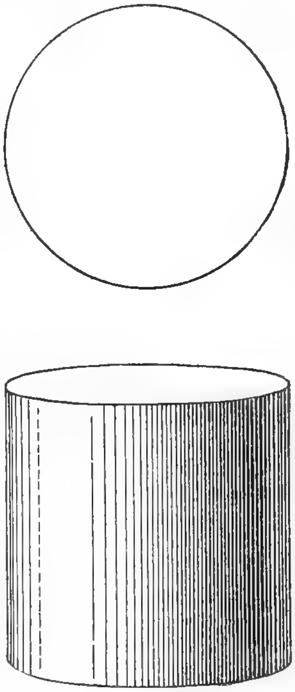

FIG. 4.—National Standard Kilogram, 1897.

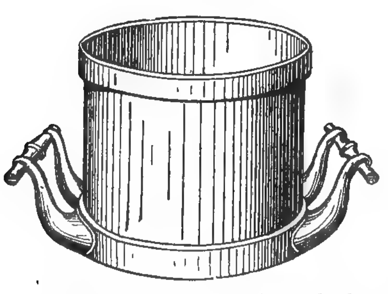

FIG. 5.—Present Imperial Standard Gallon, 1824.

The International Geodetic Committee have adopted the metre as their unit of measurement. In geodetic measurements the dimensions of the triangles vary with the temperature of the earth, but these variations in the same region of the earth are smaller than the variations of the temperature of the air, less than 10° C. Adopting as a coefficient of dilatation of the earth's crust 0·000002, the variations of the distances are smaller than the errors of measurement.

7. *Standardizing Institutions.*—Besides the State departments dealing with weights and measures, there are other standardizing institutions of recent date. In Germany, *e.g.*, there is at Charlottenburg (Berlin) a technical institute (Physikalisch-technische-Reichsanstalt) established under Dr W. Förster in 1887, which undertakes researches with reference to physics and mechanics, particularly as applied to technical industries.[3] In England a National Physical Laboratory (N.P.L.) has been established, based on the German institute, and has its principal laboratory at Bushey House, near Hampton, Middlesex. Here is carried out the work of standardizing measuring instruments of various sorts in use by manufacturers, the determination of physical constants, and the testing of materials. The work of the Kew Observatory, at the Old Deer Park, Richmond, has also been placed under the direction of the N.P.L. (see III. *Commercial*).[4] The C.I.P.M. at Paris, the first metrological institution, also undertakes verifications for purely scientific purposes. A descriptive list of the verifying instruments of the Standards Department, London, has been published.[5] In the measurement of woollen and other textile fabrics, as to quality, strength, number of threads, &c., there exists at Bradford a voluntary standardizing institution known as the Conditioning House (Bradford Corporation Act, 1887), the work of which has been extended to a chemical analysis of fabrics.

II. HISTORICAL.

1. *Standards of 1758–60.*—A "troy pound" and a new standard yard, as well as secondary standards, were constructed by direction of Parliament in 1758–60, and were deposited with the Clerk of the House of Commons. When the Houses of Parliament were burned down in 1834, the pound was lost and the yard was injured. It may here be mentioned that the expression "imperial" first occurs in the Weights and Measures Act of 1824. The injured standard was then lost sight of, but it was in 1891 brought to light by the Clerk of the Journals, and has now been placed in the lobby of the residence of the Clerk of the House, together with a standard "stone" of 14 ℔.[6]

2. *Ancient Standards of England and Scotland.*—In the measurement of liquids the old "wine gallon" (231 cubic inches) was in use in England until 1824, when the present imperial gallon (Fig. 5) was legalized; and the wine gallon of 1707 is still referred to as a standard in the United States. Together with the more ancient standard of Henry VII. and of Queen Elizabeth, this standard is

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[1] *Rapport du Yard*, Dr Benoit, 1896.

[2] Orders in Council, 1894.

[3] *Wissenschaftliche Abhandlungen der physikalischen Reichsanstalt*, Band ii., Berlin, 1900. *Denkschrift betreffend die Thätigkeit der K. Nor., Archungs Kommn.*, 1869–1900.

[4] Treasury Committee on National Physical Laboratory, Parliamentary Paper, 1898.

[5] Descriptive List of Standards and Instruments, Parliamentary Paper, 1892.

[6] Report on Standards deposited in House of Commons, 1st November 1891.

deposited in the Jewel Tower at Westminster. They are probably of the Norman period, and were kept in the Pyx Chapel at Westminster, now in the custody of the Commissioners of Works. A sketch of these measures is given in Fig. 6.[1]

Besides these ancient standards of England (1495, 1588, 1601) there are at the council chambers of Edinburgh and Linlithgow some of the interesting standards of Scotland, as the Stirling jug or Scots pint, 1618; the choppin or half-pint, 1555 (Fig. 7); the Lanark troy and tron weights of the same periods (Fig. 8).[2]

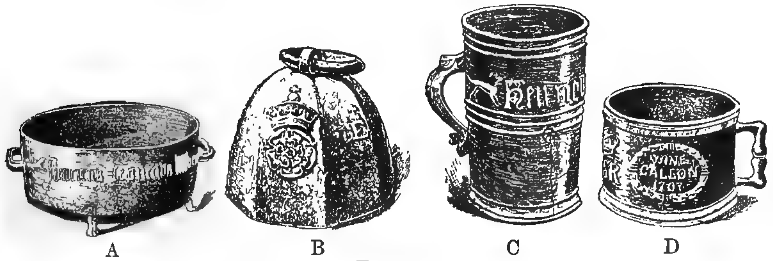

Fig. 6.

A, Winchester Bushel of Henry VII.; B, Standard Hundredweight (112 ℔) of Elizabeth; C, Ale Gallon of Henry VII.; D, the old Wine Gallon.

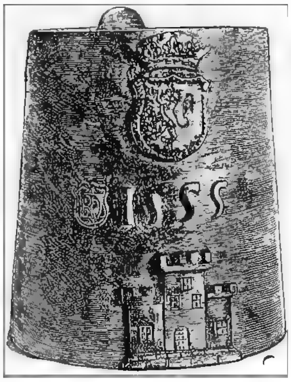

Fig. 7.—The Scots Choppin or Half-Pint, 1555.

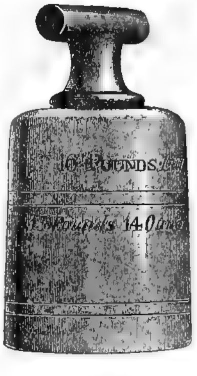

Fig. 8.—Lanark Stone Troy Weight, 1618.

3. *Standards of the East.*—Arabic glass weights of ancient origin are preserved at the British Museum, and many of the coin cabinets of Europe contain a few glass discs closely resembling such Arabic coins in size, weight, and inscription. Of these a catalogue has been prepared by Mr Stanley Lane Poole.[3] These ancient weights are in the form of small glass discs used by the Arabs (A.D. 717 to 1130) mainly in testing the accuracy of current coins, and have sometimes inscribed on them benedictory phrases, as well as the denominations of the coins whose weights they represent—as, "God's measure" (translated); "God ordains honesty"; "weight of deenár," "weight of nine keerats," "kharroobeh," "dirhem," "fels," &c. Closely allied to glass weights are the curious glass stamps found on measures of capacity and wine vessels (A.D. 870–932), known as bottle stamps, inscribed "kist," &c.

In connexion with the most ancient use of gold, the cow or ox unit has been followed in measuring value in primitive times. Professor Ridgeway has set out in an interesting treatise the origin of metallic currency. He states the values of the primitive cow or ox unit, which formed the first gold unit, in the weight standards, to be as follows:[4]—

Ox unit—Homeric	=	130 to 135	Grains of gold.
Roman	=	135	
Sicilian	=	135	
Ancient German	=	120	

Relative to the uncertain connexion of length, capacity, and weight in the ancient metrological systems of the East, Sir Charles Warren, R.E., F.R.S., has obtained by deductive analysis a new equivalent of the original cubit.[5] He shows that the length of the cubit arose through the weights; that is to say, the original cubit of Egypt was based on the cubic double—cubit of water—and from this the several nations branched off with their measures and weights. For the length of the building cubit Sir C. Warren has deduced a length equivalent to 20·6109 English inches, which compares with a mean Pyramid cubit of 20·6015 inches as hitherto found. By taking all the ancient cubits, there appears to be a remarkable coincidence throughout with 20·6109 inches.

Sir C. Warren has derived a primitive unit from a proportion of the human body, by ascertaining the probable mean height of the ancient people in Egypt, and so thereby has derived a standard from the stature of man. The human body has furnished the earliest measure for many races,[6] as the foot, palm, hand, digit, nail, pace, ell (*ulna*), &c. It seems probable, therefore, that a royal cubit may have been derived from some kingly stature, and its length perpetuated in the ancient buildings of Egypt, as the Great Pyramid, &c.

So far this later research appears to confirm the opinion of Bockh that fundamental units of measure were at one time derived from weights and capacities. It is curious, however, to find that an ancient nation of the East, so wise in geometrical proportions, should have followed what by modern experience may be regarded as an inverse method, that of obtaining a unit of length by deducing it through weights and cubic measure, rather than by deriving cubic measure through the unit of length.

A curious Babylonian weight has been added to the collection of the British Museum, bearing an inscription in cuneiform: "One maneh standard weight, the property of Merodach-sarilami, a duplicate of the weight which Nebuchadnezzar, king of Babylon, the son of Nabopollassar, king of Babylon, made in exact accordance with the weight (prescribed) by the deified Dungi, a former king." (By Professor Sayce, *Academy*, 19th December 1891.) Dungi lived about 3000 B.C. Professor W. M. Flinders Petrie has found this weight to be equal to 15,097 grains, and estimates that its original weight was 15,112 grains. It is a green stone weight of conical form, and was found in Egypt.

III. Commercial.

1. *Denominations.*—The denominations of trade weights and measures at present used in the United Kingdom are represented by "Board of Trade standards," by which are regulated the accuracy of the common weights and measures handled in shops, &c.:[7]—

Imperial Measures of Length.—100 feet, 66 feet or a chain of 100 links, rod, pole, or perch, measures from 10 feet to 1 foot; 18 inches; yard of 36 inches, ½, ¼, ⅛, 1/16 yard, nail, inch, and duodecimal, decimal, and binary parts of the inch.

Imperial Measures of Capacity.—Liquid measures from 32 gallons to 1 gallon, quart, pint, ½ pint, gill, ½ gill, ¼ gill. Dry measures of bushel, ½ bushel, peck, gallon, quart, pint, ½ pint.

Apothecaries' Measures.—40 fluid ounces to ½ fl. oz., 16 fluid drachms to ½ fl. dr., 60 minims to 1 minim.

Avoirdupois Weights.—Cental (100 ℔), 56 ℔ (½ cwt.), 28 ℔, 14 ℔ (stone), 7, 4, 2, 1 ℔; 8, 4, 2, 1, ½ ounce (8 drams); 4, 2, 1, ½ drams.

Troy Weights.—The ounce (480 gr.) and multiples and decimal parts of the ounce troy from 500 ounces to 0·001 oz.

Apothecaries' Weights.—10 oz. to 1 oz. (480 gr.); 4 drachms to ½ oz.; 2, 1 drachms; 2 scruples to ½ scruple; and 6 grains to ½ grain.

Pennyweights.—20 dwt. (480 grains), 10, 5, 3, 2, 1 dwts.

Grain Weights.—4000, 2000, 1000 gr. (making 7000 gr. or 1 ℔), 500 to 0·01 gr.

2. The international trade metric weights and measures (1897) handled in shops, &c., of which there are also Board of Trade standards, are set out as follows, and illustrations of these are given in Fig. 9:—

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[1] *The Art Journal*, August 1900, Mr S. Fisher.

[2] *Ancient Scotch Standards*, Buchanan.

[3] *Catalogue of Arab Glass Weights*, S. Lane Poole, 1891.

[4] *Origin of Metallic Currency*, Prof. Ridgeway, Cambridge, 1892.

[5] *Palestine Exploration Fund Quarterly*, April, July, October, 1899.

[6] *The Coming of the Kilogram*, H. O. Arnold-Forster, 1898.

[7] Board of Trade Model Regulations, 1892; Weights and Measures Acts, 1878, 1889, 1892, 1893.

Length.—Decametre or 10 metres; double metre; metre or 1000 millimetres; decimetre or 0·1 metre; centimetre or 0·01 metre; millimetre.

Capacity.—20 litres; 10 litres or decalitre; 5, 2, 1, 0·5, 0·2, 0·1 (decilitre); 0·05, 0·02, 0·01 (centilitre); 0·005, 0·002, 0·001 (millilitre) litres.

Cubic Measures.—1000 (litre), 500, 200, 100, 50, 20, 10, 5, 2 cubic centimetres, 1 c.c. or 1000 cubic millimetres.

Weights.—20, 10, 5, 2, 1 kilograms; 500 to 1 gramme; 5 to 1 decigram; 5 to 1 centigram; 5 to 1 milligram. (Series 5, 2, 2[1], 1, *i.e.*, with a duplicate weight of "2.")

3. *Equivalents.*—The metric equivalents of the units of the metric system in terms of the imperial system, as recalculated in 1897, are as follows:[2]—

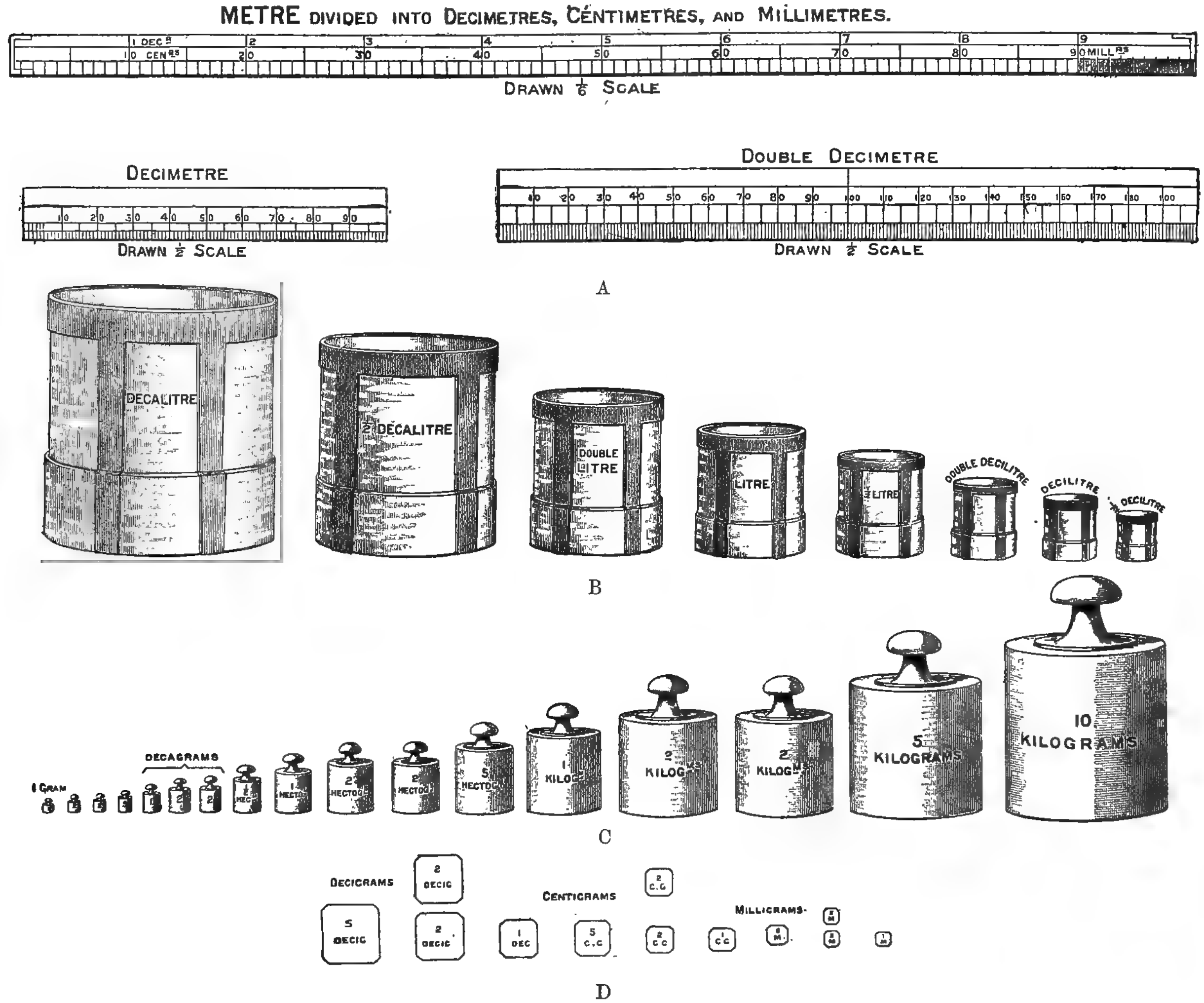

Fig. 9.—International Metric Trade Weights and Measures, 1897. A, Linear; B, Capacity; C and D, Weights.

Imperial to Metric.

1 yard	=	0·914399 m.
1 square yard	=	0·836126 m².
1 cubic inch	=	16·387 c.c.
1 gallon[1]	=	4·5459631 l.
1 pound (7000 grains)	=	0·45359243 kg.
1 ounce troy (480 gr.)	=	31·1035 grammes.
1 fluid drachm	=	3·552 millilitres (ml.).
1 fluid ounce	=	2·84123 centilitres (cl.).

Metric to Imperial.

1 metre (m.) at 0° C.	=	39·370113 inches at 62° F.
1 square metre (m²)	=	10·7639 square feet.
1 cubic decimetre (c.d.) or 1000 cubic centimetres (c.c.)	=	61·024 cubic inches.
1 litre (l.)	=	1·7598 pints.
1 kilogram (kg.)	=	2·2046223 lb avoir.
1 gramme (g.)	=	15·4323564 grains or 0·7716 scruple.

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[1] The equivalent of the litre in gallons may also be derived as follows:—

Let

$$P\left(1-\frac{p}{d}\right)=P^1\left(1-\frac{p}{d^1}\right),$$

where P is the weight of the water contained in the gallon when weighed in London—

g. London = g. Paris (45°) × 1·000577.

The correction for temperature, 62° F., is −0·0906 in.; hence 29·9094 inches. One inch = 25·4 mm.

$$29·9094 \times 25·4 = 759·69876.$$
$$759·698761 \times 1·000577 = 760·137 \text{ mm.}$$

P^1 is the weight of the brass weights (10 lb) $\Delta = 8·143$.

p, the density (0·001218738) of dry air, containing 4 vols. of carbonic acid in 10,000 vols.; $t = 16·667°$ C.; B = 760·137 mm. of mercury at 0°, lat. 45° and at sea-level. Coefficient of expansion of air = 0·00367; Δ mercury at 0° C. = 13·595.

d is the density of water at 62° F. (16·667° C.) = 0·9988611.

d^1, the density of the brass as above.

10 lb = 4·5359243 kg.

From the above it follows that

$$P = 4·5407857 \text{ kg.}$$

Therefore—

$$1 \text{ gallon} = \frac{P}{0·9988611} = 4·5459631 \text{ litres.}$$

[2] *Metric Equivalents*, King's Printers, 1898.

The equivalents of the Russian weights and measures, in terms also of the imperial and metric weights and measures, were re-calculated in 1897.[1] The following are the leading equivalents :—

$$1 \text{ Russian pound} = \begin{cases} 0{\cdot}025 \text{ pood.} \\ 96 \text{ zolotniks.} \\ 9216 \text{ dolis.} \end{cases}$$
$$= 0{\cdot}40951240 \text{ kg.}$$
$$= 0{\cdot}90282018 \text{ ℔ avoir.}$$
$$1 \text{ archinne} = \begin{cases} 0{\cdot}0006\dot{6} \text{ verst.} \\ 0{\cdot}3\dot{3} \text{ sagène.} \\ 16 \text{ verchoks.} \\ 280 \text{ liniias.} \end{cases}$$
$$= 0{\cdot}711200 \text{ metre.}$$
$$= 0{\cdot}777778 \text{ yard.}$$
$$1 \text{ vedro} = \begin{cases} 10 \text{ schtoffs} \\ = 100 \text{ tcharkas} \end{cases}$$
$$= 12{\cdot}299 \text{ litres}$$
$$= 2{\cdot}7056 \text{ gallons.}$$
$$1 \text{ tchetverte} = 8 \text{ tchetveriks}$$
$$= 2{\cdot}0991 \text{ hectolitres}$$
$$= 5{\cdot}7719 \text{ bushels.}$$

4. *Local Control.*—The necessary local inspection and verification of weights and measures in use for trade (as distinct from the verbal and written use of weights and measures) is in the United Kingdom undertaken by inspectors of weights and measures, who are appointed by the local authorities, as the county and borough councils. An inspector is required to hold a certificate of qualification, and for his guidance general regulations are made by his local authority as to modes of testing weights, measures, and weighing instruments.[2] In Europe the local inspection is generally carried out through the State, and a uniform system of local verification is thereby maintained.

5. *Errors.*—In the verification of weights and measures a margin of error is permitted to manufacturers and scale-makers, as it is found to be impossible to make two weights, or two measures, so identical that between them some difference may not be found either by the balance or the microscope. For common weights and measures this margin (tolerance, remedy, or allowance, as it is also called) has been set out by the Board of Trade for all the various kinds of weights and measures in use for commercial purposes in the United Kingdom, and similar margins of error are recognized in other countries. For instance, on 1 ℔ avoir. weight made of brass, 2 grains in excess are allowed ; on 1 oz. troy or apothecaries' weight, +0·2 grain is allowed ; on 1 pint pot, 4 fluid drachms is permitted ; on 1 brass yard, 0·05 inch in excess or 0·02 inch in deficiency in length is allowed for ordinary trade purposes.

6. *Foreign Weights and Measures.*—Throughout the British Empire the imperial system of weights and measures is legal.

In Russia, as in the United Kingdom and the United States, the national weights and measures are followed (§ 3 above), although the use of metric weights and measures is permissive.

In India the native weights, &c., ancient and arbitrary, are still followed (see *Ency. Brit.*, vol. xxiv. p. 490). In 1889 the British yard was adopted for the whole of India (Measures of Length Act) at a normal temperature of 85° F. as standardized to the imperial yard at 62° F. The metric system was also introduced, mainly for railway purposes, in 1870 and 1871 (Indian Acts). Certified measures of the yard, foot, and inch are kept by the Commissioners of Police at Calcutta, Madras, and Bombay.

In standardizing a weight for use in India, correction has to be made for the weight of air displaced by the material standard, and for such purpose the normal temperature of 85°, atmospheric pressure 29·8 inches, latitude 22° 35′ 6·5″ (Calcutta), $g = \left\{ \begin{matrix} g \\ 45^\circ \end{matrix} \; 0{\cdot}9982515 \right\}$ are taken. The "tola" (180 grains) is properly the Government unit of weight for currency ; and 80 tolas make the "Government seer."

7. *Customary Weights and Measures.*—In some districts of the United Kingdom, as well as in provincial districts of other countries, old local and customary denominations of weights and measures are still found to be in use, although their use may have been prohibited by law. So powerful is custom with the people.[3]

8. *Legislation.*—In everyday transactions with reference to weights and measures, the British legislature also exercises control in industrial pursuits. For instance, in weighing *live* cattle, owners of markets are now required to provide adequate accommodation.[4] Useful statutes have also been passed to protect the working class, as in checking the weighing instruments used in mines in Great Britain, over which instruments wages are paid, and in the inspection of similar instruments used in factories and workshops. The Merchandise Marks Act, 1887, makes it an offence also to apply in trade a false description, as to the number, quantity measure, gauge, or weight of goods sold ; and this Act appears to reach offences that the Weights and Measures Acts may perhaps not reach.

9. *Pharmaceutical Weights and Measures.*—By the Medical Act of 1858, and the Act of 1862, the General Council of Medical Education and Registration of the United Kingdom are authorized to issue a "Pharmacopœia" with reference to the weights and measures used in the preparation and dispensing of drugs, &c. The British Pharmacopœia issued by the Council in 1898 makes no alteration in the imperial weights and measures required to be used by the Pharmacopœia of 1864. For all pharmaceutical purposes, however, the use of the metric system alone is employed in all paragraphs relating to analysis, whether gravimetric or volumetric. For measures of capacity the Pharmacopœia continues to use imperial measuring vessels graduated at the legal temperature of 62° F. The official names of the metric capacity units are defined at 4° C., as generally on the Continent. The new Pharmacopœia also follows foreign practice, and employs metric measures of capacity and volumetric vessels graduated at 15·5° C., or 60° F. Specific gravity bottles are also adjusted at 60° F., the figures indicating specific gravities being quotients obtained by dividing in each instance the weight of the solid or liquid by the weight of an equal bulk of water, both taken at 60° F.[5]

10. *Gauges.*—"Gauges," as understood at one time, included only those used in the measurement of barrels, casks, &c., and hence the term "gauger." For engineering and manufacturing purposes the more important linear gauges are, however, now used, adjusted to some fundamental unit of measure as the inch ; although in certain trades, as for wires and flat metals, gauges continue to be used of arbitrary scales and of merely numerical sizes, having no reference to a legal unit of measure ; and such are rarely accurate. A standard gauge, however, exists (Order in Council, August 1883), based on the inch, but having numbered sizes from 7/0 (0·5 inch) to No. 50 (0·001 inch) to meet the convenience of certain trades.[6]

11. *Screws.*—The screw is an important productive measuring instrument, whether used as a micrometer-screw of less than an inch in length, or as a master-screw of 20 feet in length. The probable errors and eccentricities of small micrometer-screws have been carefully investigated to ±0·00001 inch ; but the accuracy of leading screws used in workshops has not been sufficiently verified. For some engineering purposes it would appear to be desirable to produce master-screws to an accuracy of $\frac{1}{2000}$ of an inch to the foot of screw, so as to serve indirectly for the verification of "guiding-screws" for general use in workshops.[7] Attempts in this direction

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[1] *C.I.P.M. Procès-Verbaux*, 1897, p. 155.

[2] Regulations, Birmingham, Glasgow, London, Manchester, &c.

[3] Report Select Committee, 1892 ; *Merchant's Handbook*, W. A. Browne, 1892 ; Reports H.M. Representatives Abroad, Foreign Office, 1900–1901.

[4] Markets and Fairs (Cattle) Acts, 1887, 1891 ; Coal Mines Regulation Act, 1887 ; Factory and Workshop Act, 1878.

[5] *Pharmacopœia*, 1901 ; Calendar Pharmaceutical Society, 1902.

[6] Order in Council, 26th August 1881.

[7] *Systématique des Vis horlogères*, Thury, Geneva, 1878. Bulletin Soc. d'Encouragement pour l'Industrie Nationale, Paris, 1894. Report of British Association on Screw-threads, 1900.

were originally made by Whitworth, Clement, Donkin, Rogers, Bond, and others, but we still need a higher accuracy in screw-threads.

12. *Educational.*—Ordinary arithmetic books often contain references to local and customary weights and measures and to obsolete terms of no practical use to children. It appears to be desirable, as the Committee of Council on Education have done, to recognize only the legal systems of weights and measures—the imperial and metric. The Education Code of Regulations for 1900 prescribes that the tables of weights and measures to be learned include those only which are in ordinary use, viz., in all classes or forms above the third the tables of

Weight—ton, cwt., stone, lb, oz., and dr.,
Length—mile, furlong, rod or pole, chain, yd., ft., and inch,
Capacity—quarter, bushel, pk., gall., qt., and pt.

In Code standards above the fifth, in addition to the foregoing, the tables of

Area—sq. mile, acre, rood, pole, yd., ft., and inch,
Volume—cubic yard, foot, and inch.

Instruction in the principles of the metric system, and in the advantages to be gained from uniformity in the method of forming multiples and sub-multiples of the unit, are, under this Code, to be given to the scholars in Standards IV., V., VI., and VII. As a preparation for this it is stated in the Code that it will be useful to give in Standard III. (arithmetic) elementary lessons on the notation of decimal fractions.

(H. J. C.)

TABLE OF THE PRINCIPAL FOREIGN WEIGHTS AND MEASURES NOW IN USE, AND OF THEIR EQUIVALENTS IN IMPERIAL OR IN METRIC WEIGHTS AND MEASURES.

Almude	Portugal	16·8 litres.
Anoman	Ceylon	0·699 quarter (dry measure).
Ara	Italy	1 metric are.
Archin, or Arshin	Turkey	1 new archin (Law 1881) = 1 metre (39·37 inches) = 10 parmaks (decimetres). 1 parmak = 10 khats (centimetres). 1 mill = 1000 archins (kilometre). Pharoagh = 10 mills. Another pharoagh = 2 hours' journey.
Archin	Bulgaria	0·758 metre (masons). 0·680 metre (tailors).
Archine, or Archinne	Russia	28 inches, or 0·7112 metre.
Ardeb	Egypt	5·447 bushels (Customs). 5 bushels (old measure).
Are		= 100 sq. metres = 119·6 sq. yds.
Area	Spain	1 metric are.
Arpent	France Canada	Legal arpent was equal to 100 sq. perches = 51·07 metric ares. In Quebec = 180 French feet.
Arroba	Portugal	14·68 to 15 kilogrammes.
	Spain	Mayor = 3·55 gallons, or 1 cantara.
Artaba	Persia	1·809 bushel. Menor = 2·76 gallons (liquids).
Aune	Belgium	1 metre. Formerly 1·312 yard.
	France	1·885 metre (1812).
	Jersey	4 feet.
Barilo	Rome	12·834 gallons.
Bat, or Tical	Siam	234 grains.
Batman	Persia	$6\frac{1}{2}$ lb. av.; varies locally.
	Turkey	= 10 ocks.
Behär	Arabia	439·45 lb. av., nearly.
Berri	Turkey	1·084 mile (old measure).
Boisseau	Belgium	15 litres.
Boutylka	Russia	1·353 pint (wine bottle).
Braça	Portugal	2·22 metres.
Braccio	Spain	0·670 metre (commercial).
	Rome	Braccio-d' ara = 29·528 inches.
Brasse	France	5·328 feet.
Braza	Argentina	5·682 feet.
Bu, or tsubo	Japan	3·0306 square metres.
Bushel	U. States Canada	2150·42 cubic inches, about 0·96944 imperial bushel. 1 bushel = 8 gallons = 32 quarts = 64 pints.
Bunder	Netherlands	2·471 acres (old hectare).
Cabot	Jersey	10 pots, or 4 gallons, 1 quart 3 gills imperial measure.
Candy	Bombay	560 lb. av.
	Madras	493·7 lb. av.
Cantar	Turkey	124·7 lb. av. (old weight).
Cantara piccolo	Italy	74·771 lb. av.
Capicha	Persia	0·58 gallon.
Catty	China	$1\frac{1}{3}$ lb. av. See *Tael.*
	N. Borneo	$1\frac{1}{3}$ lb. av.
	Siam	2·675 lb. av., or $\frac{1}{80}$ hap.
Cawnie	Madras	1·322 acre.
Cental	U. States Canada	100 lb. av. (As in Great Britain.)
Centigramme		= $\frac{1}{100}$ grm. = 0·154 grain.
Centilitre		= $\frac{1}{100}$ litre = 0·07 gill.
Centimetre		= 0·394 inch = $\frac{1}{100}$ m.
Centimetre, cubic (c.c.)		= 0·061 cubic inch, or 1 c.c.
Centimetre, square		= 0·155 square inch.
Centner	Austria	110·231 lb. av.
	Denmark	50 kilogrammes.
	Switzerland	50 kilogrammes.
Chain	Canada	66 feet.
	Cyprus	0·33 pic.
Chang	China	10 ch'ih = 141·0 inches (Treaty).
	Siam	2·675 lb.
Chapah	N. Borneo	$1\frac{4}{5}$ lb. av.
Chee. See *Tahil.*		
Chek	Hong Kong	$14\frac{5}{8}$ inches.
Chenica	Persia	0·289 gallon.
Ch'ien	China	$58\frac{1}{3}$ grains (silver weight).
Ch'ih	China	Varies throughout China from 11 to 15·8 inches. For Customs purposes the Treaty ch'ih = 14·1 inches, and 5 ch'ih = 1 pu.
	Peking	= 12·3 = 12·5 public works. = 12·4 statistics. = 12·6 architects. = 12·7 common. = 13·1 tribunal of mathematics.
	Shanghai	13·2 Board of Revenue. 14·1 Customs.
Chilogramme	Italy	1 kilogramme.
Chin or Catty	China	$1\frac{1}{3}$ lb. av. (Treaty).
Ching	China	121 sq. feet (Treaty).
Ch'ing	China	72,600 sq. feet (Treaty).
Chittack	Bengal	5 tolas, or 900 grains.
Ch'ok	Corea	$7\frac{3}{4}$ in. (linear); $12\frac{1}{8}$ in. (building).
Chüo	China	1815 sq. feet (Treaty).
Chupah	Singapore	$1{\cdot}6\dot{6}$ lb. av. of water at 62° F., as a measure of capacity.
	Malacca	144 oz. av. of water.
Chupak	Straits Settlements	8 gills.
Collothun	Persia	1·809 gallons.
Coss	Bengal	1·136 metre.
Covado	Portugal	$0{\cdot}6\dot{6}$ metre.
Covid, or Cubit	Madras	18 to 21 inches.
	Bombay	18 inches.
	Siam	18 inches.
Covido	Arabia	18 inches approximately.
Covido (Great)		27 inches.
Cuartillo	Spain	1·16 litre (dry); 0·504 litre (liquid).
Daktylon (Royal)	Greece	1 centimetre.
Daribah	Egypt	43·58 bushels (Customs).
Decagramme		10 grms. = 5·64 drams av.
Decalitre		= 10 litres = 2·2 gallons.
Decametre		= 10·936 yards.
Déçïatina	Russia	= 2400 square sagènes.
Decigramme		= $\frac{1}{10}$ grm. = 1·54 grain.
Decilitre		= $\frac{1}{10}$ litre = 0·176 pint.
Decimetre		= 3·937 inches – 0·1 metre.
Decimetre, cubic		= 1000 c.c. = 61·024 cub. in.
Decimetre, square		= 100 sq. centm. = 15·5 sq. in.
Denaro	Rome	18·17 grains (old weight).
Deunam	Turkey	1 metric are.
Diraa, or Drâa, or Pic	Egypt	27 inches usually. 21·3 inches Nile measure.
	Turkey	27 inches (old measure of pike).
Dirhem	Egypt	1·761 dram av. (Customs). 3·0884 grammes (Cairo).
Djerib	Turkey	1 hectare.
Dolïa, or Dola	Russia	0·686 grain. 96 doli = 1 zolotnick.
Drachma	Netherlands	3·906 grammes.
	Turkey	154·324 grains.

Drachmé (Royal)	Greece	1 gramme (gold weight).
	Constantinople	=57·871 grains. See *Ock.*
Dram. See *Oke.*		
Ducat	Vienna	53·873 grains.
Duim	Netherlands	1 centimetre.
Eimer	Austria	12·448 gallons.
El	Netherlands	1 metre. (Old ell=27·08 inches.)
Ell	Jersey	4 feet.
Ella	N. Borneo	1 yard.
Elle	Switzerland	0·6561 yard.
Endaseh, or Hindâzi	Egypt	Usually 25 inches.
Faltche	Moldavia	1 hectare, 43 ares, 22 centiares.
Fanega	Argentina	3·773 bushels.
	Portugal	55·364 litres.
	Spain	1·526 bushel.
	Peru	1½ bushel.
		1·615 acre, but varies locally.
Fass	Germany	1 hectolitre.
Feddan	Egypt	1·038 acre (Masri). Also 1·127 acre locally.
		1·266 acre (old).
Fen	China	5·83 grains (silver weight).
Fjerdingkar	Denmark	0·9564 bushel.
Fod	Denmark	1·0297 foot.
	Norway	0·3137 metre.
Foglietto	Rome	0·8 pint.
Foot	U. States	12 inches.
	Canada	French foot=12·8 inches.
	Amsterdam South Africa Old Rhenish	11·147 in. 12·356 in. old measure.
Fot	Sweden	11·689 in. 10 fot=1 stöng. 1 ref =10 stänger. 1 mil=360 ref.
Founte, or Funt, or Livre	Russia	0·90282 lb. av.
Foute, or Pied	Russia	1 English foot.
Frasco	Argentina	2⅜ litres.
Fuss	Vienna	12 zolls=1·037 foot.
	Switzerland	3⅓ fuss=1 metre.
		See *Stab.*
Gallon	U. States Canada	231 cubic inches=8·3389 lb. av. of water at t. 39·8° Fahr. At 62° Fahr.=0·8325 imp. gallon.
Gantang	Straits Settlements	32 gallons.
	N. Borneo	144 oz. av. weight of water as measure of capacity.
Garnetz	Russia	0·3607 peck.
Gin. See *Kati.*		
Gisla	Zanzibar	Measure of 360 lb. av. of rice.
Go	Japan	180·39 cubic centimetres.
Grain	Russia	0·960 grain (apothecaries).
Gramme (gr.)		=15·4323564 grains av. troy.
		=0·2572 drachm, or 0·7716 scruple.
		0·03215 oz. troy.
Grammé (Royal)	Greece	1 millimetre.
Gramo	Spain	1 gramme.
Grano	Rome	0·757 grain.
Grao	Portugal	0·768 grain ; also measure 0·18 in.
Grein	Netherlands	=0·065 gramme.
Guz	India : Bengal	36 inches.
	,, Bombay	27 inches.
	,, Madras	33 inches, Government Survey.
	Persia	The guz, gueza, or zer varies from 24 to 44 inches. A guz of 40·95 inches (Guz, Azerbáiján) is common. Government standard guz=36½ inches. There is a guz for retail trade of 25 inches.
	Arabia	25 inches to 37 inches (Bassorah).
Hat'h, or Moolum, or Cubit	Bengal	18 inches.
	Bombay	18 inches, or cubit.
Hectare		=100 ares, or 2·471 acres.
Hectogramme		100 grm.=3·53 oz. av.
Hectolitre		100 litres=2·75 bushels.
Hectometre		=109·36 yards.
Hiyaka-me	Japan	5797·198 grains.
Hiyak-kin	Japan	132½ lb. av.
Hoon. See *Tahil.*		
Hu	China	12½ gallons, nearly.
Immi	Switzerland	1·5 litre.
Joch	Austria-Hungary	1·422 acre.
Kaima	Sweden	0·576 gallon.
Kan	Netherlands	1 litre.
	Hong Kong	1⅓ lb. av.
Kanne or Kanna	Germany	1 litre, or formerly 1·762 pint.
	Sweden	0·576 pint.
Kantar, or Cantaro	Egypt	99·0492 lb. av.=100 rotls (Customs). 45 kilogrammes of cotton. 44·5 kilogrammes other produce.
Karwar	Persia	100 batman.
Kassabah	Egypt	3·8824 yards (Customs).
Kati, Catty, or Gin	China, Straits Settlements	1⅓ lb. av.
Keila, or Pishi	Zanzibar	Measure of 6 lb. av. of rice.
Ken	Japan	1·81 metre.
Kerât	Turkey	1⅛ inch measure (old).
		3·09 grains weight (old).
Kette, or Chain	Germany	14·994 ellen, or 10·936 yards.
Keu	Siam	40 inches.
Khat (New)	Turkey	1 centimetre.
Kile	Cyprus	8 gallons.
Killow	Turkey	0·97 bushel.
Kilogramme		1000 grm.=2·2046223 lb. av.
Kilometre		=0·6214 mile.
Kin	Japan	0·601 kilogramme.
Klafter	Austria	=2·0740 yards.
	Switzerland	1·9685 yard.
Köddi	Arabia	1·67 gallon.
Koilon (Royal)	Greece	1 hectolitre. Old koilon=33·16 litra.
Koku	Japan	=10 to.
Kon	Corea	1⅓ lb. av.
Korn-tonde	Norway	138·97 litres.
	Sweden	3·821 bushels.
Korn-top Maal	Norway	160 litres.
Korrel	Netherlands	1 decigramme.
Kotyle (Royal)	Greece	1 decilitre.
Kouza	Cyprus	9 quarts.
Koyan	Straits Setts.	5333⅓ lb. av.
Krina	Bulgaria	12·8 litres.
Kung	China	78·96 inches (Treaty).
Kup	Siam	10 inches.
Kwan or Kuwan	Japan	3·75652 kilogrammes.
Kyat	Burma	100 kyats=3·652 lb. av.
Lak't	Bulgaria	0·650 metre.
Last	Netherlands	30 hectolitres.
Léang	China	583⅓ grains (silver weight).
Lèkhà	Bulgaria	229·83 sq. metres.
Li	China	about ⅓ mile=360 pu. Varies with length of ch'ih.
		A small weight 0·583 grain.
Liang	China	16 liang=1 chin=1⅓ lb. av.
Libbra	Italy	0·7477 lb. av.
Libra	Argentina	1·0127 lb. av.
Libra (Castilian)	Spain	1·014 lb.
Libra, or Arratel	Portugal	1·012 lb. av.
Line or Ligne	Paris	1/12 point, or 0·089 inch.
Liniia	Russia	0·1 inch. 1 archine=280 liniias.
Litra (Royal)	Greece	1 litre=100 mystra.
Litre	Cyprus	2⅘ quarts.
Litre (metric)		=1·7598 pint.
Litro	Spain Italy	1 litre.
Livre (lb)	Russia	0·90282 lb. av. Apoth. livre= 11·5204 oz. troy.
	Belgium	Kilogramme.
Livre-poids	France	0·4895 kilogramme.
Loth	Germany	New loth=1 decagramme. Old loth, nearly ½ oz. av.
	Switzerland	15·625 grammes.
	Vienna	270·1 grains. Postal loth, 257·2 grains.
Maass	Austria	1·245 quart.
	Switzerland	2·64 gallons.
Maatze	Netherlands	1 decilitre.
Mace	China	58⅓ grains.
	N. Borneo	93⅓ lb. av.
Mahud	Arabia	2·04 lb. av.

Maik	Burmah	3 maik = cubit = $19\frac{1}{2}$ inches.
Marc, or Mark	France	0·2448 kilogramme (old weight).
	Sweden	0·4645 lb. av.
	Vienna	4331·37 grains = 24 karato.
Marco	Portugal	= 8 oncas = 229·5 grammes.
	Spain	3550·54 grains.
Maund	India	82·286 lb. av., Government.
		$72\frac{1}{3}$ lb. (old bazaar).
		74·67 lb. av., factory.
		28 lb. nearly, Bombay.
		25 lb. nearly, Madras.
		37 to 44 lb., Juggerat.
		Local maunds vary on either side of 80 lb.
Megametre (astronomy)		1,000,000 metres.
Metre (m.)	U. States	39·37 inches.
	Great Britain	39·370113 inches = 1 m.
Metre, cubic		= 1000 c.d. = 35·315 cubic feet.
Metre, square		= 100 square decimetres = 10·764 square feet.
Metro	Spain	1 metre.
	Italy	
Metz	Austria	1·691 bushel.
Micron (μ)		= $\frac{1}{1000}$ millimetre.
Miglio	Rome	0·925 mile.
Mijle	Netherlands	1 kilometre.
Mil, or Mill	Turkey	1000 archins (new mil).
	Denmark	4·680 miles.
Mile	France	Nautical mile = 1852 metres.
	Germany	
Mile (postal)	Austria	4·714 miles.
Milha	Portugal	1·296 mile.
Mille	France	1·949 kilometre.
Milligramme		= $\frac{1}{1000}$ gramme = 0·015 grain.
Millilitre		= $\frac{1}{1000}$ litre.
Millimetre		= 0·03937 inch = $\frac{1}{1000}$ m.
Miscal	Persia	71 grains.
Mkono	East Africa	45·72 centimetres.
Mna	Greece	$1\frac{1}{2}$ kilogramme = 1·172 oka.
Momme	Japan	$\frac{1}{1000}$ kwan.
Morgen	Denmark	0·631 acre.
	Norway	
	Prussia	
Mou	China	Commonly 806·65 sq. yds. Varies locally. Shanghai = 6600 sq. ft. (Municipal Council). By Customs Treaty = 920·417 sq. yds., based on ch'ih of 14·1 inches.
Mud	Netherlands	1 hectolitre.
Myriagramme		= 10 kilogrammes = 22·046 lb. av.
Ngoma	East Africa	$7\frac{1}{2}$ keilas.
Nin	Siam	$\frac{10}{12}$ inch.
Obolos	Greece	1 decigramme.
Ock	Turkey	Legal ock (1881) = 100 drachmas. New batman = 10 ocks, and kantar = 10 batmans ock = 1 kilogramme.
Octavillo	Spain	0·29 litre.
Oitavo	Portugal	1·730 litre.
Oke	Bulgaria	1·28 litre (for liquids).
		1·282 kilogramme (old).
	Cyprus	$2\frac{4}{5}$ lb. av. = 400 drams (Cyprus).
	Egypt	2·751 lb. av. (Customs). 2·805 lb. (Alexandria).
	Greece	1·282 kilogramme.
		1·33 litre.
	Turkey	1·1518 pint. 2·834 lb. av. (old weight).
Onça	Portugal	28·688 grammes.
Once	France	30·59 grammes (old).
Oncia	Rome	436·165 grains.
Onze	Netherlands	1 hectogramme. 10 onzen = pond.
Ounce	U. States	Av. ounce = 437·5 grains.
Packen	Russia	1083·382 lb. av.
Palamé (Royal)	Greece	1 decimetre.
Palm	Holland	1 decimetre.
Palmo	Portugal	0·22 metre.
	Spain	8·346 inches.
Para	N. Borneo	90 lb. av.
Parah	Ceylon	5·59 pints.
Parasang. See *Persakh.*		
Parmak. See *Archin.*		
Passeree	Bengal	5 seers.

Pé	Portugal	$\frac{1}{3}$ metre (old).
Pecheus (Royal)	Greece	1 metre = 1·543 old pecheuse.
Pecul	China	$133\frac{1}{3}$ lb. av.
Perche	France	22 square pieds de roi. In Quebec 18 French feet.
	Canada	
Persakh, or Parasang	Persia	Probably 3·88 miles = 6000 guz.
Pfund	Germany	= 16 unzen = 32 loth 1·01 to 1·23 lb. av. } old weight.
		Zoll. pfund (1872) = 500 grammes.
	Prussia	Old zoll. lb. = 1·1023 lb. av.
	Switzerland	500 grammes = 16 unze.
		Apoth. pf. = 375 grammes.
	Vienna	Pfund = 560·06 grammes.
		Zoll. pfund (1871) = 500 grammes.
Pharoagh. See *Archin.*		
Pic	Cyprus	2 feet.
Picul	Japan	$133\frac{1}{3}$ lb. av.
	Straits Settlements	
	Siam	13·75 lb.
	North Borneo	A measure of 180 lb. weight of water.
Picki	Greece	0·648 metre.
	China	25 gallons (dry measure).
Pie	Rome	11·73 inches.
Pie de Burgos	Spain	11·13 inches.
Pied	Belgium	11·81 inches = 10 pounces.
	Canada	12·79 inches.
Pied de Roi	Paris	0·3248 metre.
Pike	Turkey	See *Dir'aa.*
Pint	U. States	0·8325 imperial pint.
Pinte	France	0·931 litre.
Pipa	Portugal	534 litres (Oporto).
		420 litres (Lisbon).
		500 litres (officially).
Pipe	Gibraltar	105 to 126 gallons.
Pishi. See *Keila.*		
Poide de Marc	France	0·2448 kilo = 8 onces.
Polegada	Portugal	27·77 millimetres.
Pond	Netherlands	1 kilogramme. Apothecaries pond = 375 grammes.
Pot	Denmark	1·7 pint = 4 pægle.
	Switzerland	2·64 pints or 1·5 litre.
	Belgium	$1\frac{1}{2}$ litre (dry). $\frac{1}{2}$ litre (liquid).
	Norway	0·965 litre.
Pouce	France	1·066 inch (old measure).
	Russia	1 inch.
Poud, or Pood	Russia	0·016122 ton.
Pound	U. States	Standard troy lb. = 5760 grains. Avoir. lb. = 7000 grains.
	Russia	0·90282 lb. av. (0·4095 kilogramme).
	Jersey	7561 grains = 16 oz. Jersey = 1 livre.
Pu	China	70·5 inches = 5 ch'ih.
Puddee	Madras	2·89 pints. 100 cubic inches = Government puddee.
Pulgada	Spain	0·927 inch.
Pund	Denmark	1·1023 lb. av., or 500 grammes.
	Norway	0·4981 kilogramme.
	Sweden	6560 grains. Varies locally.
		5500·5 grains (apoth.).
Quart	U. States	See *Bushel.*
Quarto	Rome	2·024 bushels.
	Portugal	3·46 litres.
Quintal	Spain	100 libras (Castilian).
	Portugal	58·752 kilogrammes, or $129\frac{1}{2}$ lb. av.
	Argentina	100 libras, or 101·27 lb. av.
Quintal (metric)	France	= 100 kilogrammes = 1·968 cwt.
Quintale	Italy	1 metric quintal.
Ratel	Persia	1·014 lb. av.
Rattel, or Rottle	Arabia	1·02 lb. av., nearly (dry measure).
		17·219 lb. av. weight.
Ri	Japan	2·440 miles (itinerary). 2·118 miles (natural).
Rode	Denmark	3·762 metres.
Roede	Netherlands	1 dekametre.
Rotl, or Rottolo	Egypt	0·9905 lb. av. (Customs). 0·9805 lb. av. (Govt.).
	Cairo	2·206 lb. great rottolo.
		0·715 lb. less rottolo.
	Alexandria	2·124 lb. great rottolo. Rottolo mina = $\frac{5}{8}$ oka.
Rottol	Turkey	2·513 pints (old measure).
Rubbio	Spain	1·012 quarter (dry measure).

Sagène	Russia	7 feet.
Scheffel	Germany	50 litres, formerly 14·56 metzen (Prussia).
Schepel	Netherlands	1 decalitre.
Schoppen	Germany	$\frac{1}{2}$ litre, formerly 0·11 gallon.
	Switzerland	0·375 litre.
Se	Japan	118·615 square yards (·9918 are).
Seer	India	Government seer = $2\frac{2}{35}$ lb. av. Bengal, 80 tolas weight of rice (heaped measure), about 60 cubic inches (struck measure). Southern India = weight of 24 current rupees. Madras, 25 lb. nearly. Juggerat, weight of 40 local rupees. Bombay, old seer, about 28 lb.
	Ceylon	Measure of 1·86 pint.
	Persia	16 miscals, or 1136 grains weight (Sihr).
	Note.—In India the seer, like the maund, varies considerably; usually 40 seers go to a maund.	
Seidel	Austria	0·6224 pint.
Sen	Siam	44·4 miles, nearly.
Ser	India	1 litre (Indian Law, 1871).
Shaku	Japan	0·30 metre, also 9·18273 square decimetres; also 18·039 cubic centimetres.
Sheng	China	2 pints, nearly.
Shôô	Japan	1·804 litre.
Skaal-pund	Sweden	435·076 grammes, or 0·959 lb. av.
	Norway	0·4981 kilogramme, or officially $\frac{1}{2}$ kilogramme.
Skeppe	Denmark	17·39 litres.
Skjeppe	Norway	17·37 litres.
Stab	Germany	1 metre, or 3·$\frac{1}{3}$ old fuss, but varied.
Stadron (Royal)	Greece	1 kilometre.
Stere (metric)		1 cubic metre.
Stero	Italy	1 metric stere.
Streepe	Holland	1 millimetre.
Stremma	Greece	1 metric are. 238·1 square pecheus (Constantinople).
Strich	Germany	1 millimetre.
Striche	Switzerland	$3\frac{1}{3}$ strich = 1 millimetre.
Stunde	Germany	Old itinerary measure, 2·3 to 3·4 miles.
	Switzerland	4·8 kilometres. Stunder = 5 stunden, or 24 kilometres.
Sultchek	Turkey	Cubic measure (1881) whose sides equal a parmak (decimetre)
Sung	Corea	4 lb. av., nearly.
Tael	Siam	$936\frac{1}{4}$ grains.
	Hong Kong	$1\frac{1}{3}$ oz. av.
	China	Silver weight, $1\frac{1}{3}$ oz. av.
	Japan	10 momme.
	(No current *coin* of the tael.)	
Tahil	Straits Settlements	$1\frac{1}{3}$ oz. av. = 10 chee = 100 hoon.
Tam	Hong Kong	$133\frac{1}{3}$ lb. av.
Tan	China	= 25 gallons. Also $133\frac{1}{3}$ lb. weight.
Tang	Burma	2 miles, nearly.
Tank	Bombay	$17\frac{1}{72}$ grains, or 72 tanks = 30 pice.
Tcharka	Russia	0·866 gill.
Tchetverte	Russia	5·772 bushels = 8 tchetveriks, or 2·099 hectolitres.
Teng	Burma	Burmese measures of capacity depend on the teng or basket. Officially a basket is 2218·2 cubic inches, but the teng varies locally:— Akyab = 23 lb. of rice. Bassein = 51 lb. of rice. Moulmein = 48 lb. of rice. Rangoon = 48 to 50 lb. of rice.
Thanan	Siam	1·5 pint.
Thangsat	Siam	4·688 gallons.
To	Japan	18·0391 litres.
Toise	France	2·1315 yards.
Tola	India	180 grains. Legal weight of rupee.
Tomand	Arabia	187·17 lb. av. of rice.
Ton	U. States	2240 lb. av., also a net ton of 2000 lb.
Tönde	Denmark	131·392 litres (liquid measure). 139·121 litres (dry measure).
Tonne, or Millier	France Germany	1000 kilogrammes.
Tonne (metric)		1000 kilogrammes = 0·9842 ton.
Tonnelada	Portugal	793·15 kilogrammes.
Tonos	Greece	29·526 cwt.
Tou	China	2·5 gallons approximately.
Tovar	Bulgaria	128·2 kilogrammes.
T'sun	China	1·41 inch (Treaty measure).
Tu	China	100·142 miles = 25 li, based on the ch'ih of 14·1 inches.
Vara	Peru	33 inches.
	Spain	2·782 feet.
	Argentina	2·841 feet.
	Portugal	1·11 metre.
Vat	Holland	1 hectolitre.
Vedro	Russia	2·7056 gallons = 10 schtoffs, or 12·3 litres.
	Bulgaria	12·8 litres.
Verchok	Russia	1·75 inch.
Versta, or Verst	Russia	0·66288 mile.
Vierkanteroede	Holland	1 metric are.
Viertel	Denmark	1·7 gallons.
	Switzerland	15 litres.
Viss	Rangoon	$3\frac{21}{140}$ lb. av.
Wa	Siam	80 inches.
Wigtje	Netherlands	1 gramme.
Wisse	Netherlands	1 metric stere.
Yard	U. States	36 inches.
	Mexico	838 centimetres.
Zac	Netherlands	1 hectolitre.
Zer (Persia). See *Guz*.		
Zoll	Switzerland	$3\frac{1}{3}$ zoll = 1 decimetre. Old zoll nearly one inch. (See also *Pfund*.)
Zolotnik	Russia	65·8306 grains, or 96 doli.

Weihaiwei, a British naval and coaling station, situated on the north-east coast of the Shantung peninsula, China, about 40 miles east of the treaty port of Chefoo. It was formerly a Chinese naval station strongly fortified, but was captured by the Japanese in February 1895, and occupied by their troops, pending the payment of the indemnity, up till May 1898. Port Arthur having in the spring of that year been acquired by the Russian Government under a lease from China for twenty-five years, a similar lease was granted of Weihaiwei to the British Government, and on the withdrawal of the Japanese troops the British fleet took possession, the flag being hoisted on 24th May 1898. No period was fixed for the termination of the lease, but it was stipulated that it should continue so long as Russia continued to hold Port Arthur. The harbour is formed by an island named Liukung-tao running east and west across the mouth of a small bay, leaving an entrance at each end. Towards the mainland the water shoals, and the best anchorage is under the lee of the island. The cession comprises, besides the harbour and island, a belt of the mainland, 10 English miles wide, skirting the whole length of the bay. The coast line of the bay is some 10 miles, and the area thus leased extends to about 120 square miles, and contains a native population which may be estimated at 200,000. Within this area Great Britain has exclusive jurisdiction; and she has, besides, the right to erect fortifications, station troops, and take any other measures necessary for defensive purposes at any points on or near the coast of all that part of the peninsula which lies east of 121° 40′ E. Chinese war-vessels are at liberty to use the anchorage, notwithstanding the lease; and Chinese jurisdiction may continue to be exercised within the walled city of Weihaiwei, so far as not inconsistent with military requirements. Weihaiwei was made the headquarters of a native Chinese regiment in the pay of Great Britain, and organized and led by British officers; but this regiment was disbanded in 1902.

Weimar, a town of Germany, capital of the grand-duchy of Saxe-Weimar, 14 miles east of Erfurt. In 1896 the Goethe–Schiller archives, containing MSS. by Goethe, Schiller, Herder, Wieland, Immermann, Fritz Reuter, Mörike, Otto Ludwig, and others, were opened. Weimar possesses also natural science, archæological, and ethnographical collections, the Liszt Museum, grand-ducal school of art, geographical institutes, a technical school, commercial school, music school, teachers' seminaries, and deaf and dumb and blind asylums. Population (1885), 21,565; (1900), 28,509.

Weinberge, or more correctly KÖNIGLICHE WEINBERGE (Czech, *Vinohrady Královské*), the chief town of a government district in Bohemia, Austria, and a suburb of Prague, with which it is now practically merged. Population (1890), 34,531; (1900), 52,483. Of all Bohemian towns, this and the other three suburbs of Prague show the largest increase of population within the last half of the 19th century.

Weinheim, a town of Germany, grand-duchy of Baden, 11 miles north of Heidelberg, on the "Mountain Road" (*Bergstrasse*), at the foot of the Odenwald. The town hall, Berkheim and Windeck castles, the house of the Teutonic Knights, and the churches are the principal buildings. The town dates from the middle of the 8th century. It has various manufactures (leather, machinery, chemicals, &c.), and cultivates fruit and wine. Population (1885), 7595; (1900), 11,168.

Weipert, a town in the government district of Kaaden, north-west Bohemia, Austria, on the slope of the Erzgebirge, 20 miles north-north-east of Karlsbad. Silver and cobalt ores were formerly mined. The town is now the chief centre of the Austrian lace and fringe making industry, both by machine and hand, and has also manufactures of small-arms, paper, &c. Population (1890), 8351; (1900), 10,037.

Weismann, August (1834– ——), German biologist, was born at Frankfort-on-Main on the 17th of January 1834, and studied medicine in Göttingen. After spending three years in Rostock, he visited successively Vienna (1858), Italy (1859), and Paris (1860), and from 1861 to 1862 he acted as private physician to the Archduke Stephen of Austria at Schaumburg Palace. In 1863 he went to Giessen to devote himself to biological study under Leuckart, and in 1866 he was appointed extraordinary professor of zoology at Freiburg, becoming ordinary professor a few years later. His earlier work was largely concerned with purely zoological investigations, one of his earliest works dealing with the development of the Diptera. Microscopical work, however, became impossible to him owing to impaired eyesight, and he turned his attention to wider problems of biological inquiry. Between 1868 and 1876 he published a series of papers in which he attacked the question of the variability of organisms; these were published in an English translation by Professor R. Meldola in 1882, under the title *Studies in the Theories of Descent*, Darwin himself contributing a preface in which the importance of the nature and cause of variability in individuals was emphasized. Weismann's name, however, is best known as the author of the germ-plasm theory of heredity, with its accompanying denial of the transmission of acquired characters—a theory which on its publication met with considerable opposition, especially in England, from orthodox Darwinism. A series of essays in which this theory is expressed was collected and published in an English translation (*Essays upon Heredity and Kindred Biological Problems*, vol. i. 1889, vol. ii. 1892). Weismann has published many other works devoted to the exposition of his biological views, among them being *Die Dauer des Lebens; Vererbung; Ewigkeit des Lebens; Die Kontinuität des Keimplasmas als Grundlage einer Theorie der Vererbung; Das Keimplasma; Die Allmacht der Naturzüchtung; Aeussere Einflüsse als Entwicklungsreize; Neue Gedanken zur Vererbungsfrage*, and *Germinal-Selektion.* For an account of the doctrines he advocates, the reader is referred to the articles on HEREDITY, REGENERATION, and REPRODUCTION, in these new volumes.

Weissenburg, a town of Germany, in Alsace-Lorraine, district of Lower Alsace, 42 miles by rail north-north-east of Strasburg. The church of St Peter and St Paul, Early Gothic (1294), contains old stained glass of the 13th–15th centuries, and also a museum of antiquities. Weissenburg grew around a Benedictine abbey of the 7th century, and became a free imperial city in 1305. The production of matches, paper, &c., and lithography are carried on, and wine and fruit are cultivated. Population (1885), 5968; (1900), 6946, including garrison of 2004. WEISSENBURG has been the scene of two memorable battles. The famous "Weissenburg lines," consisting of entrenched works extending along the Lauter, and having a length of 12 miles, were in October 1793 stormed by the Prussians and Saxons under the Austrian general Wurmser. The Allies were, however, in their turn dispossessed by Picheqru on the 16th of December and forced to retreat behind the Rhine. These lines, as well as the fortifications of Weissenburg, have been now dismantled. On the 4th of August 1870 the Germans under the Crown Prince of Prussia gained a decisive victory over a French corps (part of the army commanded by Macmahon) under General Douay, who was killed at the commencement of the engagement.

Weissenburg-am-Sand, a town of Bavaria, Germany, district of Middle Franconia, 33 miles by rail south by west of Nuremberg. It is still surrounded by old walls and towers, and has a couple of Gothic churches and a Gothic town hall. A Roman castle has recently been discovered, and there is a collection of antiquities in the modern school. The old fortalice of Wülzburg (2060 feet) overlooks the town. Gold and silver fringe, cloth, &c., are manufactured. Weissenburg dates from the 8th century, and in the 14th was made a free imperial town. Population (1885), 6025; (1900), 6550.

Weissenfels, an industrial town of Prussia, in the government of Merseburg on the Saale, at the junction of the Halle-Bebra-Frankfort-on-Main and Weissenfels-Zeitz lines of the Prussian state railways, 20 miles south-west of Leipzig. It is at the centre of extensive fields of brown coal, and has a lively trade in various manufactured articles, notably electric plant, paper, and boots, the last-named employing nearly 3000 hands. Population (1885), 21,766; (1895), 25,681; (1900), 28,201.

Weisskirchen, or MÄHRISCH-WEISSKIRCHEN (Czech, *Hranice*), the chief town of a government district in Moravia, on the Betschwa, a tributary of the March, 3 miles east of Olmütz. The manufactures comprise cloth, flannel, liqueurs, chocolate, and preserves; also dyeing, corn-milling, and the manufacture of hemp. Population (1890), 7795; (1900), 7821, mostly Czech.

Wekerle, Alexander (1848– ——), Hungarian statesman, was born on the 14th of November 1844 at Móór, in the comitat of Stuhlweissenburg. After studying law at the university of Budapest he graduated *doctor juris.* He then entered the Government service, and after a period of probation was appointed to a post in the ministry of finance. He still, however, continued an academic career by lecturing on political economy at the university. In 1886 Wekerle was elected to the House of Deputies, became in the same year financial secretary of state, and in 1889 succeeded Tisza as minister of finance. He immediately addressed himself to the task of improving the financial position of the country, carried out the conversion of the State loans, and succeeded, for the first time in the history of the Hungarian budget, in avoiding a deficit. In November 1892 Wekerle succeeded Count Szapáry as premier, though still retaining the portfolio of finance. At the head of a strong Government he was enabled, in spite of a powerful opposition of Catholics and Magnates, to carry in 1894 the Civil Marriage Bill (see HUNGARY). The continued opposition of the Clerical party, however, brought about his resignation in 1895, when he was succeeded by Banffy.

Welding, Electric.—In electric welding and metal working the heat may be communicated to the metal by an electric arc, or by means of the electric resistance of the metal, as in the Thomson process. Arc welding is the older procedure, and it appears to have been first made use of by De Meritens in 1881 for uniting the parts of storage-battery plates. The work-piece was placed upon a support or table, and connected with the positive pole of a source of current capable of maintaining an electric arc. The other pole was a carbon rod directed by the hand of the operator so as first to make contact with the work-piece, and then to effect the proper separation to maintain the arc. The heat of the arc was partly communicated to the work and partly dissipated in the hot gases escaping into the surrounding air. The result was a fusion of the metallic lead of the storage-battery plate, which united various parts of the plate. The process was somewhat similar to the operation of lead-burning by the hydrogen and air blowpipe, as used in the formation of joints in chemical tanks made of sheet-lead. The method of De Meritens has been modified by Bernardos and Olszewski, Slavienoff, Coffin, and others.

Arc welding.

In the Bernardos and Olszewski process the work is made the negative pole of a direct current circuit, and an arc is drawn between this and a carbon rod, to which a handle is attached for manipulating. As this rod is the positive terminal, particles of carbon may be introduced as a constituent of the metal taking part in the operation, making it hard and brittle, and causing cracks in the joint or filling; the metal may, in fact, become very hard and unworkable. The Slavienoff modification of the arc-welding process consists in the employment of a metal electrode in place of the carbon rod. The metal electrode gradually melts, and furnishes fused drops of metal for the filling of vacant spaces in castings, or for forming a joint between two parts or pieces.

In arc welding, with a current source at practically constant potential, a choking resistance in series with the heating arc is needed to secure stability in the arc current, as in electric arc lighting from constant potential lines. Little effective work can be done by the Bernardos and Olszewski method with currents much below 150 amperes in the arc, and the value in some cases ranges above 500 amperes. The potential must be such that an arc of 2 to 3 inches in length is steadily maintained. This may demand a total of about 150 volts for the arc and the choking resistance together. In the Slavienoff arc the potential required will be naturally somewhat lower than when a carbon electrode is used, and the current strength will be, on the other hand, considerably greater, reaching, it appears, in certain cases, more than 4000 amperes. In some recent applications of the arc process the polarity of the work-piece and the arc-controlling electrode has, it is understood, been reversed, the work being made the positive pole and the movable electrode the negative. More heat energy is thus delivered to the work for a given total of electric energy expended.

The arc method is essentially a fusing process, though with due care it is used for heating to plasticity the edges of iron sheets to be welded by pressure and hammering. It has been found applicable in special cases to the filling of defective spots in iron castings, by fusing into blow-holes or other spaces small masses of similar metal, added gradually, and melted into union with the body of the piece by the heat of the arc. Similarly, a more or less complete union between separate pieces of iron plate $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness has been effected by fusing additional metal between them. The range of operations to which the arc process is applicable is naturally somewhat limited, and depends to a large extent upon the skill acquired by the operator, who necessarily works with his eyes well screened from the glare of the large arc. Unless the space in which the work is carried on is large, the irritating vapours which rise from the arc stream add to the difficulty. Strong draughts of air which would disturb the arc must also be avoided. These factors, added to the relative slowness of the work and the uncertainty as to its result, have tended to restrict the application of arc welding in practice. Moreover, much heat-energy is dissipated in the arc flame and passes into the air, while, owing to the time required for the work, the metal undergoing treatment loses much heat by radiation. Yet the method requires little special machinery. The current may be taken from existing electric lighting and power circuits of moderate potential without transformation, and may be utilized with simple appliances, consisting chiefly of heavy wire leads, a carbon or metal electrode with a suitable handle for its manipulation, a choking or steadying resistance, and screen of dark glass for the operator's eyes.

In 1874 Werdermann proposed to use, as a sort of electric blowpipe, the flame gases of an electric arc blown or deflected by an air jet or the like—a suggestion recently revived by Zerener for arc welding. The arc in this instance is deflected from the space between the usual carbon electrodes by a magnetic field. The metal to be heated takes no part in the conduction of current, the heat is communicated by the gases of the arc, and, to a small extent, by the radiation from the hot carbon electrodes between which the arc is formed. The process is scarcely to be called electric in any true sense. Another curious operation, resembling in some respects the arc methods, has been proposed for the heating of metal pieces before they are brought under the hammer for forging or welding. The end of a metal bar is plunged into an electrolytic bath while connected with the negative pole of a lighting or other electric circuit having a potential of 100 to 150 volts. The positive pole is connected with a metal plate as an anode immersed in the electrolyte, or forming the side of the containing vat or tank. A solution of sodium or potassium carbonate is a suitable electrolyte. That part of the bar which is immersed acts as a cathode of limited surface, and is at once seen to be surrounded by a luminous glow, with gas bubbles arising from it. The immersed end of the bar rapidly heats, and may even melt under the liquid of the bath. It is probable that an arc forms between the surface of the metal and the adjacent liquid layer, the intense heat of which is in part communicated to the metal and in part lost in the solution, causing thereby a rapid heating of the bath. This singular action appears to have been first made known by Hoho and Lagrange. It is distinctly a form of electric heating, having no necessary relation to such subsequent operations as welding, and is, moreover, wasteful of energy, as the heat is largely carried off in the liquid bath.

The Thomson process, first brought to public notice in 1886, has since that time been applied commercially on a large scale to various metal-welding operations. The metal pieces to be united are held in massive clamps and

Thomson process.

pressed together in firm contact; and a current is made to traverse the proposed joint, bringing it to the welding temperature. The union is effected by forcing the pieces together mechanically. The characteristic feature of the process is the fact that the heat is given out in the body of the metal. The voltage does not usually exceed two or three, though it may reach four or five volts; but as the resistance of the metal pieces to be joined is low, the currents are of very large values, sometimes reaching between 50,000 and 100,000 amperes. Even for the joining of small wires the current is rarely less than 100 amperes. Such currents cannot, of course, be carried more than a few feet without excessive loss, unless the conductors are given very large section. With alternating currents, also, the effectiveness of the work speedily diminishes, on account of the inductive drop in the leads, if they are of any considerable length. The carrying of the welding currents over a distance of several feet may, in fact, lead to serious losses. These difficulties are overcome in the Thomson welding transformer, which resembles the step-down transformers used in electric lighting distribution by alternating currents, with the exception that the secondary coil or conductor, which forms part of the welding circuit, usually consists of only one turn of great section, S S (Fig. 1). This is often made in the form of a copper casing, which surrounds or encloses the primary coil P P in whole or in part. The primary coil is of copper wire of many turns. The secondary casing, with the primary enclosed, is provided with the usual laminated iron-transformer core, I, constituting a closed iron magnetic circuit threading both primary and secondary electric circuits. The terminals of the single-turn secondary serve as connexions and supports for the welding clamps C D, which hold the work. The clamps are variously modified to suit the size, shape, and character of the metal pieces, M N, to be welded, and the proportions of the transformer itself are made proper for the conditions existing in each case. The potential of the primary circuit may be selected at any convenient value, provided the winding of the coil P P is adapted thereto, but usually 300 volts is employed, and the periodicity is about 60 cycles. Inasmuch as only the proposed joint and a small amount of metal on each side of it are concerned in the operation, the delivery of energy is closely localized. The chief electrical resistance in the welding circuit is in the projections between the clamps, where the electric energy is delivered and appears as heat. A portion of the energy is, as usual, lost in the transformation and in the resistance of the circuits elsewhere, but, by proper proportioning, the loss may be kept down to a moderate percentage of the total, as in other electric work.

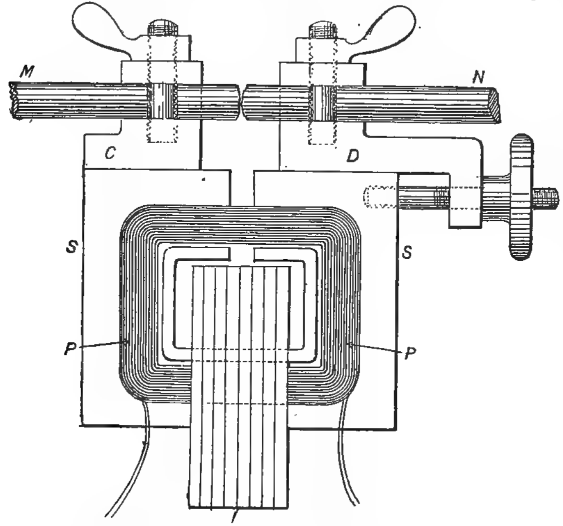

Fig. 1.—Thomson Welding Transformer.

The pieces are set firmly in the welding clamps, with the ends to be joined in abutment and in electric contact. The projection of each piece from the clamp varies with the section of the pieces, their form and the nature of the metal, and the time in which a joint is to be made; but it rarely exceeds the thickness or diameter of the pieces, except with metals of high heat conductivity such as copper. When the pieces are in place the current is turned into the primary coil of the transformer, sometimes suddenly and in full force, but more often gradually. Switches and regulating devices in the primary circuit permit complete and delicate control. At least one of the clamps, D (Fig. 1), is movable through a limited range towards and from the other, and is thus the means of exerting pressure for forcing the softened metal into complete union. In large work the motion is given by a hydraulic cylinder and piston, under suitable control by valves. At about the time the current is cut off, it is usual to apply increased pressure. The softened metal is upset or pressed outwards at the joint and forms a characteristic burr, which may be removed by filing or grinding, or be hammered down while the metal is still hot. Sometimes the burr is not objectionable, and is allowed to remain. Lap welds may be made, but butt welds are found to be satisfactory for most purposes. The appearance of round bars in abutment before welding is shown in Fig. 2 at A; and at B they are represented as having been joined by an electric butt weld, with the slight upset or burr at the

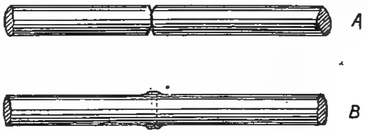

Fig. 2.

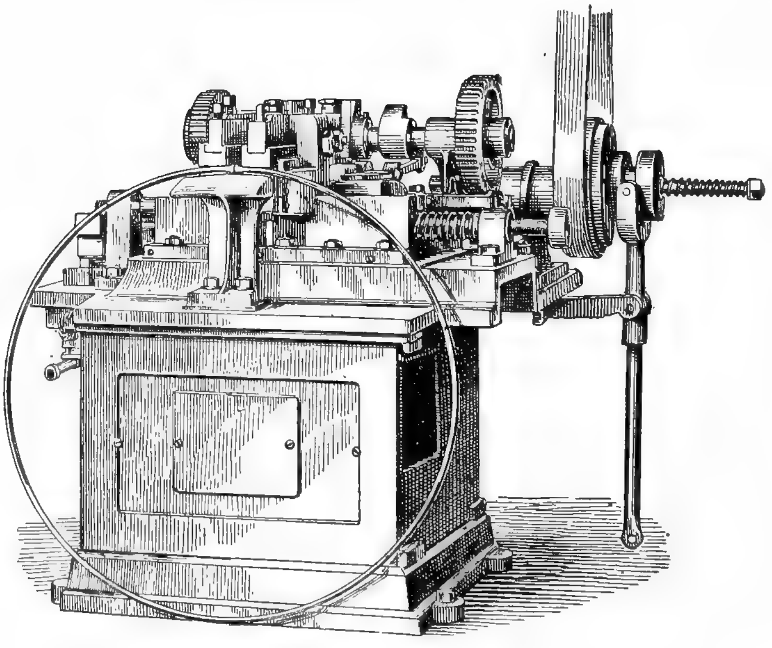

Fig. 3.—Automatic Welder.

joint. Before the introduction of the Thomson process a few only of the metals, such as platinum, gold, and iron, were regarded as weldable; now nearly all metals and alloys may be readily joined. Such combinations as tin and lead, copper and brass, brass and iron, iron and nickel, brass and German silver, silver and copper, copper and platinum, iron and German silver, tin and zinc, zinc and cadmium, &c., are easily made; even brittle crystalline metals like bismuth and antimony may be welded, as well as different metals and alloys whose fusing or softening temperatures do not differ too widely.

If the meeting ends conduct sufficiently to start the heating, it is not necessary that they should fit closely together, nor is it necessary that they should be quite clean, the effect of the incipient heating being to confer conductivity upon the scale and oxide at the joint. In some cases the application of a flux, such as borax, enables the welding to be accomplished at a lower temperature, thus avoiding risk of injury by excessive heating. While the pieces are heating, the increase of temperature may raise the specific resistance of the metal so that the current required will be lessened per unit of area, while on the other hand the growing perfection of contact during welding, by increasing the conducting area at the joint, compensates for this in that it tends to the increase of current. With some alloys like brass and German silver, which have a low temperature coefficient, this compensating effect is nearly absent. The increase of specific resistance of the metals with increase of temperature has another valuable effect in properly distributing the heating over the whole section of the joint. Any portion which may be for the moment at a lower temperature than other portions will necessarily have a lower relative resistance, and more current will be diverted to it. This action rapidly brings any cooler portion into equality of temperature with the rest. It also prevents the overheating of the interior portions which are not losing heat by radiation and convection. The success of the electric process in welding metals which were not formerly regarded as weldable is probably due in a measure to this cause, and also to the ease of control of the operation, for the operator may work within far narrower limits of plasticity and fusibility than with the forge fire or blowpipe. The mechanical pressure may be automatically applied and the current automatically cut off after the completion of the weld. In some more recent types of welders the clamping and releasing of the pieces are also accomplished automatically, and nothing is left for the operator to do but to feed the pieces into the clamps. Repetition-work is thus rapidly and accurately done. The automatic welder represented in Fig. 3 has a capacity of nearly 1000 welds per day. The pressure required is subject to considerable variation: the more rigid the material at the welding temperature, the greater is the necessary pressure. With copper the force may be about 600 pounds per square inch of section; with wrought iron, 1200 pounds; and with steel, 1800 pounds. It is customary to begin the operation with a much lighter pressure than that used when all parts of the pieces at the joint have come into contact. The pressure exerted in completing the weld has the effect of extruding from the joint all dross and slag, together with most of the metal, which is rendered plastic by the heat. The strongest electric welds are those effected by this extrusion from the joint, in consequence of heavy pressure quickly applied at the time of completion of the weld. The unhammered weld, as ordinarily made by the electric process, has substantially the same strength as the annealed metal of the bar, the break under tensile strain, when the burr at the weld is left on, usually occurring a little to one side of the joint proper, where the metal has been annealed by heating. Hammering or forging the joint while the metal cools, in the case of malleable metals such as iron or copper, will usually greatly toughen the metal, and it should be resorted to where a maximum of strength is desired. The same object is partially effected by placing the weld, while still hot, between dies pressed forcibly together so as to give to the weld some desired form, as in drop-forging.

The amount of electric energy necessary for welding by the Thomson process varies with the different metals, their electric conductivity, their heat conductivity, fusibility, the shape of the pieces, section at the joint, &c. In the following table are given some results obtained in the working of iron, brass, and copper:—

Energy used in Electric Welding.

Section, Sq. In.	Watts in Primary of Welder.	Time in Secs.	Watt-seconds.
Iron and Steel.			
0·5 . . .	8,500	33	280,500
1·0 . . .	16,700	45	751,500
1·5 . . .	23,500	55	1,292,500
2·0 . . .	29,000	65	1,885,000
2·5 . . .	34,000	70	2,380,000
3·0 . . .	39,000	78	3,042,000
3·5 . . .	44,000	85	3,740,000
4·0 . . .	50,000	90	4,500,000
Brass.			
·25 . . .	7,500	17	127,500
·5 . . .	13,500	22	297,000
·75 . . .	19,000	29	551,000
1·0 . . .	25,000	33	825,000
1·25 . . .	31,000	38	1,178,000
1·5 . . .	36,000	42	1,512,000
1·75 . . .	40,000	45	1,800,000
2· . . .	44,000	48	2,112,000
Copper.			
·125 . .	6,000	8	48,000
·25 . . .	14,000	11	154,000
·375 . .	19,000	13	247,000
·5 . . .	25,000	16	400,000
·625 . .	31,000	18	558,000
·75 . . .	36,500	21	766,500
·875 . .	43,000	22	946,000
1·0 . . .	49,000	23	1,127,000

The figures are of course only approximate, and refer to one condition alone of time-consumption in the making of each weld. The more rapidly the work is done, the less, as a rule, is the total energy required; but the rate of output of the plant must be increased with increase of speed, and this involves a larger plant, the consequent expense of which is often disadvantageous. If in the foregoing table the watts for a given section be multiplied by the time, the relation between the total energy required for different sections of the same metal, or for the same section of the different metals, is obtained. These products are given under the head of watt-seconds. It will be seen that the energy increases more rapidly than the sections of the pieces — doubtless because the larger pieces take a longer time in welding, with the result of an increased loss by conduction of heat along the bars back from the joint. If the time of welding could be made the same for various sections, it is probable that the energy required would be more nearly in direct proportion to the area of section for any given metal. This relation would, however, only hold approximately, as there is a greater relative loss of heat by radiation and convection into the air from the pieces of smaller section. The total energy in watt-seconds for any given section of copper will be found to be about half as much again as that for the same section of iron, while the amounts of energy required for equal sections of brass and iron do not greatly differ.

In practice, joints in solid bars or in wires are the most common, but the process is applicable to pieces of quite varied form. Joints in iron, brass, or lead pipe are readily made; strips of sheet metal are joined, as in band saws; bars or tubes are joined at various angles; sheet metal is joined to bars, &c. One of the more interesting of the recent applications of electric welding is the longitudinal seaming of thin steel pipe. The metal or skelp is in long strips, bent to form a hollow cylinder or pipe, and the longitudinal seam moves through a special welder, which passes a current across it. The work is completed by drawing the pipe through dies. The welding of a ring formed by bending a short bar into a circle affords an excellent illustration of the character of the currents employed in the Thomson process. Notwithstanding the comparatively free path around the ring through the full section of the bent bar, the current heats the abutted ends to the welding temperature. In this way waggon and carriage wheel tyres, harness rings, pail and barrel hoops, and similar objects are extensively produced. The process is also largely applied to the welding of iron and copper wires used for electric lines and conductors, of steel axles, tyres and metal frames used in carriage work, and of such parts of bicycles as pedals, crank hangers, seat posts, forks, and steel tubing for the frames. The heat, whether it be utilized in welding or brazing, is so sharply localized that no damage is done to the finish of surfaces a short distance from the weld or joint. Parts can be accurately formed and finished before being joined, as in the welding of taper shanks to drills, the lengthening of drills, screw taps, or augers, and the like. Electric welding is applicable to forms of pieces or to conditions of work which would be impracticable with the ordinary forge fire or gas blowpipe. A characteristic instance is the wire bands which hold in place the solid rubber tyres of vehicles. The proximity of the rubber forbids the application of the heat of a fire or blowpipe, but by springing the rubber back from the proposed joint and seizing the ends of wire by the electric welding clamps, the union is rapidly and easily made. When the rubber of the tyre is released, it covers the joint, regaining its complete form. Special manufactures have in some cases arisen based upon the use of electric welding.

The welding clamps, and the mechanical devices connected with them, vary widely in accordance with the work they have to do. A machine for forming metal wheels is so constructed that the hubs are made in two sections, which when brought together in the welder are caused to embrace the radiating iron or steel spokes of the wheel. The two sections are then welded, and hold the spokes in solid union with themselves. Another machine, designed for the manufacture of wire fences, makes several welds automatically and simultaneously. Galvanized iron wires are fed into the machine from reels in several parallel lines about a foot apart, and at intervals are crossed at right angles by wire sections cut automatically from another reel of wire. As the wire passes, electric welds are formed between the transverse and the parallel lines. The machine delivers a continuous web of wire fencing, which is wound upon a drum and removed from time to time in large rolls. In the United States, street railway rails are welded into a continuous metal structure. A huge welding transformer is suspended upon a crane, which is borne upon a car arranged to run upon the track as it is laid. The joint between the ends of two contiguous rails is made by welding lateral strap pieces, covering the joint at each side and taking the place of the ordinary fish-plates and bolts. The exertion of a greatly increased pressure at the finish of the welding seems to be decidedly favourable to the permanence and strength of the joints. When properly made, the joint is strong enough to resist the strains of extension and compression during temperature changes. For electric railways the welded joint obviates all necessity for "bonding" the rails together with copper wires to convert them into continuous lines of return conductors for the railway current. In railway welding the source of energy is usually a current delivered from the trolley line itself to a rotary converter mounted on the welding car, whereby an alternating current is obtained for feeding the primary circuit of the welding transformer. Power from a distant station is thus made to produce the heat required for track welding, and at exactly the place where it is to be utilized. In this instance the work is stationary, while the welding apparatus is moved from one joint to the next. Welding transformers are sometimes used to heat metal for annealing, for forging, bending, or shaping, for tempering, or for hard soldering. Under special conditions they are well adapted to these purposes, on account of the perfect control of the heating or energy delivery, and the rapidity and cleanliness of the operation.

Armour-plate annealing.

Divested of its welding clamps, the welding transformer has found a unique application in the armour-annealing process of Lemp, by means of which spots or lines are locally annealed in hard-faced ship's armour, so that it can be drilled or cut as desired. Before the introduction of this process, it was practically impossible to render any portion of the hardened face of such armour workable by cutting tools without detriment to the hardness of the rest. A very heavy electric current is passed through the spot or area which it is desired to soften, so that, notwithstanding the rapid conduction of heat into the body of the plate, the metal is brought to a low red heat. In order that the spot shall not reharden, it is requisite that the rate of cooling shall be slower than when the heating current is cut off suddenly; the current therefore undergoes gradual diminution, under control of the operator. The welding transformer has for its secondary terminals simply two copper blocks fixed in position, and mounted at a distance of an inch or more apart. These are placed firmly against the face of the armour plate, with the spot to be annealed bridging the contacts, or situated between them. As in track welding, the transformer is made movable, so that it can be brought into any position desired. When the annealing is to be done along a line, the secondary terminals, with the transformer, are slowly and steadily slid over the face of the plate, new portions of the plate being thus continually brought between the terminals, while those which had reached the proper heat are slowly removed from the terminals and cool gradually. (E. T.)

Wellesley, a town of Norfolk county, Massachusetts, U.S.A., on the Boston and Albany Railroad, in the eastern part of the state. It is chiefly known as the seat of Wellesley College, a non-sectarian college for women, opened in 1875. In 1900 it had 84 instructors and was attended by 716 students. In 1899 its property was valued at $1,745,975, and its income from all sources was $226,448. Population (1890), 3600; (1900), 5072, of whom 1306 were foreign-born.

Wellhausen, Julius (1844-——), Bible scholar and Orientalist, was born at Hameln, Westphalia, on the 17th of May 1844. Having studied at the University of Göttingen, he established himself there in 1870 as *privat-docent* for Old Testament history. In 1872 he was appointed to the chair of theology in Greifswald. Resigning in 1882 owing to conscientious scruples, he became in the same year professor extraordinary in the faculty of philology at Halle, was elected ordinary professor of Oriental languages at Marburg in 1885, and was transferred in a like capacity to Göttingen in 1892. Wellhausen made his name famous by his critical investigations into Bible history, and the uncompromising scientific attitude he adopted in testing its problems brought him into antagonism with the older school of Biblical interpreters. The best known of his works are *De Gentibus et familiis Judaeis* (Göttingen, 1870); *Die Pharisäer und Sadducäer* (Greifswald, 1874); *Prolegomena zur Geschichte Israels* (Berlin, 1878; English translation, 1885); *Muhammed in Medina* (Berlin, 1882); *Die Komposition des Hexateuchs und die historischen Bücher des Alten Testaments.*

Wellingborough, an urban district (1894) and market town in the Eastern parliamentary division of Northamptonshire, England, 10½ miles east-north-east of Northampton by rail, on the London and North-Western and Midland railways. The church of All Saints' was enlarged in 1890, and a chapel-of-ease (St Barnabas's) to the parish church was built in 1893. The town has grown rapidly, its staple industry, the leather trade, having increased enormously since the manufacture of shoe-uppers was introduced. The iron industry is also flourishing. Population (1881), 13,794; (1901), 18,412.

Wellington, a town of New South Wales, Australia, 248 miles north-west of Sydney, in the county of Wellington, on the left bank of the river Macquarie, which is here spanned by a fine bridge. Many new buildings have been erected, and there is an excellent water-supply. Stock-rearing and agriculture are extensively carried on, and rich gold-bearing reefs are known to exist. From the celebrated caves in the neighbourhood great quantities of fossil bones were sent to England for examination by Professor Owen. Population (1901), 2988.

Wellington, the capital and most central seaport of New Zealand, Hutt county, North Island, 158 miles S. by E. of New Plymouth. Since 1885 it has made more progress than any other town in the colony. Its population rose from 27,833 in 1886 to 46,638 (or with suburbs 49,344) in 1901. The town is supplied with electric light, and has tramways. Much land has been reclaimed from the harbour, and on this and in the central streets many substantial brick buildings have been erected. The rambling, unhealthy, Parliamentary buildings have been rebuilt and a fitting library added. The Wellington school of art is perhaps the best in the colony. A good public library, a new public park formed and levelled on the crest of a hill overlooking the centre of the town, and an adequate system of drainage are other improvements. Wellington is in touch by railway with Napier and New Plymouth. By vote taken in 1901 the municipality decided thenceforth to levy urban rates on the unimproved value of land in the city. The tonnage of vessels entering in 1900 was 213,874; cleared, 277,503. The harbour board's receipts were £86,551, its expenditure £117,887. The total trade in 1893 was £2,815,758; in 1896, £3,079,112; in 1901, £4,990,670.

Wells, a cathedral city, municipal borough, and market town in the Wells parliamentary division of Somersetshire, England, 135 miles west of London by rail, at the foot of the Mendip Hills. The recreation grounds, six acres in area, near the bishop's palace, were laid out in 1888. Population (1891), 4822; (1901), 4849.

Wells, Charles Jeremiah (1798(?)–1879), English poet, was born in London, probably in the year 1798. He was educated at Cowden Clarke's school at Edmonton, with Tom Keats, the younger brother of the poet, and with R. H. Horne. He became acquainted with John Keats, and was the friend "who sent me some roses," to whom Keats wrote a sonnet on the 29th of June 1816:—

> When, O Wells! thy roses came to me,
> My sense with their deliciousness was spelled;
> Soft voices had they, that, with tender plea,
> Whisper'd of peace and truth and friendliness unquelled."

Unfortunately, Wells soon afterwards played a cruel practical joke on the dying Tom Keats, and reappears in the elder poet's correspondence as "that degraded Wells." Both with Keats and Reynolds, Wells was in direct literary emulation, and his early writings were the result of this. In 1822 he published *Stories after Nature*—or rather, in the manner of Boccaccio, tempered by that of Leigh Hunt—a curious little volume of brocaded prose. At the close of 1823, under the pseudonym of H. L. Howard, appeared the Biblical drama of *Joseph and his Brethren* (dated 1824). For the next three years Wells saw Hazlitt, as he said, "every night," but in 1827 the two men were estranged. When Hazlitt died, in September 1830, Wells took Horne to see his dead friend, and afterwards raised a monument to the memory of Hazlitt in the church of St Ann's, Soho. His two books passed almost unnoticed, and although Hazlitt said that *Joseph and his Brethren* was "more than original, aboriginal, and a mere experiment in comparison with the vast things" Wells could do, he forebore to review it, and even dissuaded the young poet from writing any more. Wells was now practising as a solicitor in London, but he fancied that his health was failing, and proceeded to South Wales, where he occupied himself with shooting, fishing, and writing poetry until 1835, when he removed to Broxbourne, in Hertfordshire. In 1840 he left England, never to set foot in it again. He settled at Quimper, in Brittany, where he lived for some years. A story called *Claribel* appeared in 1845, and one or two slight sketches later, but several important tragedies and a great deal of miscellaneous verse belonging to these years are lost. Wells stated in a letter to Horne (November 1877) that he had composed eight or ten volumes of poetry during his life, but that, having in vain attempted to find a publisher for any of them, he burned the whole mass of MSS. at his wife's death. The only work he had retained was a revised form of *Joseph and his Brethren,* which was praised in 1838 by Wade, and again, with great warmth, by Horne, in his *New Spirit of the Age,* in 1844. The drama was then once more forgotten, until in 1863 it was read and vehemently praised by D. G. Rossetti. The tide now turned at last; *Joseph and his Brethren* became a kind of shibboleth—a rite of initiation into the true poetic culture—but still the world at large remained indifferent. Finally, however, Mr Swinburne wrote an eloquent study of it in the *Fortnightly Review* in 1875, and the drama itself was reprinted in 1876. The old man found it impossible at first to take his revival seriously, but he woke up at length to take a great interest in the matter, and between 1876 and 1878 he added various scenes, which are in the possession of Mr Buxton Forman, who published one of them in 1895. After leaving Quimper, Wells went to reside at Marseilles, where he held a professorial chair. He died on the 17th of February 1879.

From R. H. Horne, the author of *Orion*, the present writer received the following account of the personal appearance of Wells in youth. He was short and sturdy, with dark red hair, a sanguine complexion, and bright blue eyes; he used to call himself "the cub," in reference to the habitual roughness of his manners, which he was able to resolve at will into the most taking sweetness and good-humour. Wells's wife, who had been a Miss Hill, died in 1874. Their son, after his father's death, achieved a notoriety which was unpoetical, although recorded in popular song, for he was the once-famous "man who broke the bank at Monte Carlo."

The famous *Joseph and his Brethren*, concerning which criticism has recovered its self-possession, is an overgrown specimen of the pseudo-Jacobean drama in verse which was popular in ultra-poetical circles between 1820 and 1830. Its merits are those of rich versification, a rather florid and voluble eloquence, and a subtle trick of reserve, akin to that displayed by Webster and Cyril Tourneur in moments of impassioned dialogue. Mr Swinburne has said that there are lines in Wells "which might more naturally be mistaken, even by an expert, for the work of the young Shakespeare, than any to be gathered elsewhere in the fields of English poetry." This may be the case, but even the youngest Shakespeare would have avoided the dulness of subject-matter and the slowness of evolution which impede the reader's progress through this wholly undramatic play. *Joseph and his Brethren*, in fact, although it has been covered with eulogy by the most illustrious enthusiasts, is less a poem than an odd poetical curiosity. (E. G.)

Wells, Sir Thomas Spencer, 1st Bart. (1818–1897), English surgeon, was born at St Albans, 3rd February 1818, and was given a medical education in Leeds, Dublin, and St Thomas's Hospital, London (M.R.C.S. 1841). From 1841 to 1848 he served as a surgeon in the navy, and in 1848 he went to Paris to study pathology. In 1853 he settled in London, and took up ophthalmic surgery, interrupting his work to go out to the East in the Crimean war. In 1854 he became surgeon to the Samaritan Free Hospital for Women and Children, London. His reputation in surgery had obtained for him in 1844 the fellowship of the Royal College of Surgeons, and he subsequently became a member of council, Hunterian professor of surgery and pathology (1878), President (1882), and Hunterian Orator (1883). In 1883 he was made a baronet. His name is best known in connexion with his successful revival of the operation of ovariotomy, which had fallen into disrepute owing to the excessive mortality attending it; and in his skilful hands, assisted by modern surgical methods, the operation lost almost all its danger. His book on *Diseases of the Ovaries* was published in 1865. Sir Spencer Wells married in 1853 Miss Elizabeth Wright, and had a son and daughters. He died 31st January 1897. His estate at Golder's Hill, Hampstead, was sold after his death to the London County Council and converted into a public park.

Wellston, a city of Jackson county, Ohio, U.S.A. It is at the intersection of the Baltimore and Ohio South-Western, the Cincinnati, Hamilton, and Dayton, the Hocking Valley, and the Ohio Southern railways, in the southern part of the state. Population (1890), 4377; (1900), 8045, of whom 311 were foreign-born.

Wellsville, a city of Columbiana county, Ohio, U.S.A., on the Ohio river and the Pennsylvania Railroad, in the eastern part of the state, at an altitude of 687 feet. It is in a farming and coal-mining region, has railway works, rolling-mills, boiler works, and other manufactures. Population (1880), 3377; (1890), 5247; (1900), 6146, of whom 475 were foreign-born and 113 negroes.

Wels, the chief town of a government district in Upper Austria, and formerly the capital of that archduchy, on the river Traun, about 17 miles by railway from Linz. The parish church is a restored Gothic structure, supposed to date from the 9th century. In 1519 the Emperor Maximilian died in the old castle, now private property. There is a Protestant church, erected by the Gustavus Adolphus Association in 1849–1850, a theatre, a handsome town hall, and a fine park. The town draws a supply of natural gas, used for lighting, heat, and motive power, from deep artesian borings first made in 1891. It has an important trade in corn, timber, horned cattle, pigs, and horses, fowls, dairy produce, and lard; and considerable manufactures, including machinery, cast-iron, copper and brass goods, calico, gunpowder, oil, paper, articles in felt, flour, leather, and biscuits. Population (1890), 10,118; (1900), 12,187, including garrison of 1268 men.

Wener (Swedish, *Vener* or *Väner*), the largest lake in Sweden and the third largest in Europe. It has an area of 2149 square miles; a maximum length of 112 miles; a breadth of 56 miles; a maximum depth of 295 feet; an altitude above sea-level of 144 feet, though the surface sometimes rises as much as 10 feet or more, for the lake is the recipient of the waters of numerous streams, the largest being the Klar, which drains the forests of Vermland and Kopparberg to the north. It is almost divided into two basins by two peninsulas and a group of islands, the western half being known as Lake Dalbo. The northern shores are high, rocky, and in part wooded, the southern open and low, though isolated hills occur, such as the far-famed Kinnekulle (774 feet above Lake Wener). Several islands break the surface, such as Leck, Kalland, and Thor. This lake and Lake Wetter contain degenerate species of marine fauna, left after the retreat of the ice of the Glacial period. The principal outflow is the Göta, discharging into the Cattegat. By means of the Dalsland canal the lake, which is the scene of a busy traffic in timber, iron, and agricultural produce, has communication with Frederikshald in Norway; by the Göta canal with the Cattegat, and also by the same canal with Lake Wetter, and so with the Baltic. On the shores of the lake stand the towns of Carlstad, Venersborg, Christinehamn, Mariestad, and Lidköping.

Upon the relations of these lakes to the Baltic, see Professor Credner in *Geogr. Zeitschrift*, 1895.

Wenersborg, or Venersborg, a lake port of Sweden, county Elfsborg, on a tongue of land between the Göta and the Vassbotten, the southernmost bay of Lake Wener, 54 miles by rail north-north-east of Gothenburg. A canal 2½ miles long, with two sluices, made in 1604–11, cuts through the peninsula, thus avoiding the falls of Rånnum in the river. The town is further connected with Frederikshald in Norway by the Dalsland canal (1863–68). It was founded in 1642, but has been repeatedly burnt down. It possesses a museum, a bridge (1642), a technical school, a deaf and dumb school, and iron foundries, tanneries, and match and paper factories. The port (on Lake Wener) is entered and cleared by an aggregate of over 320,000 tons annually. Population (1880), 5482; (1900), 6395.

"CAPITULATION OF SEDAN." By ANTON VON WERNER.

(From a Photograph by the Berlin Photographic Co.)

Wenlock, a municipal borough (including the market towns of Much Wenlock, Madeley, and Ironbridge), Shropshire, England, in the Ludlow parliamentary division, 12 miles south-east of Shrewsbury, with a station on the Great Western Railway. The district is not only important agriculturally, but includes coal-mines at Madeley, limestone quarries, and iron-works at Madeley and Coalbrookdale. A drinking fountain was erected in 1897 as a memorial of the Diamond Jubilee of Queen Victoria. Population (1881), 17,557; (1901), 15,866.

Wennerberg, Gunnar (1817–1901), Swedish poet, musician, and politician, was born at Lidköping, of which place his father was parish priest, on the 2nd of October 1817. He passed through the public school of Skara, and in his twentieth year became a student at Upsala. He was remarkable from the first, handsome in face and tall in figure, with a finely-trained singing voice, and brilliant in wit and conversation. From the outset of his career he was accepted in the inner circle of men of light and leading for which the university was at that time famous. In 1843 he became a member of the musical club who called themselves "The Juvenals," and for their meetings were written the trios and duets, music and words, which Wennerberg began to publish in 1846. In the following year appeared the earliest numbers of *Gluntarne* (or "The Boys"), thirty duets for baritone and bass, which continued to be issued from 1847 to 1850. The success of these remarkable productions, masterpieces in two arts, was overwhelming: they presented an epitome of all that was most unique and most attractive in the curious university life of Sweden. In the second volume of his collected works Wennerberg gave, long afterwards, a very interesting account of the inception and history of these celebrated duets. His great personal popularity, as the representative Swedish student, dip not prevent him, however, from pursuing his studies, and he became an authority on Spinoza; in 1849 he was appointed lecturer in philosophy at Skara College. In 1850 he first travelled through Sweden, singing and reciting in public, and his tour was a long popular triumph. In 1860 he published his collected trios, as *The Three*. In 1865, at the particular wish of the king, Charles XV., Wennerberg entered public life as the official representative of elementary education. He succeeded Fahlcrantz in 1866 as one of the Eighteen of the Swedish Academy, and in 1870 became Minister for Religion in the Adlerscreutz Government, upon the fall of which in 1875 he retired for a time into private life. He was, however, made lord-lieutenant of the province of Kronoberg, and shortly afterwards was elected to represent it in the Landsthing. His active parliamentary life continued until he was nearly eighty years of age. In 1881 and 1885 he issued his collected works, mainly in verse. In 1893 he was raised to the Upper House. He preserved his superb appearance in advanced old age, and he died, after a very short illness, on the 24th of August 1901, at the royal castle of Leckö, where he was visiting his brother-in-law, Count Axel Rudenschöld. His wife, the Countess Hedvig Cronstedt, whom he married in 1852, died in 1900. Wennerberg was the most remarkable type which our age has seen of the lyrical, ardent Swedish aristocrat, full of the joy of life and the beauty of it. In the long roll of his eighty-four years there was scarcely a crumpled rose-leaf. His poems, to which their musical accompaniment is almost essential, have not ceased, in half a century, to be universally pleasing to Swedish ears; outside Sweden it would be difficult to make their peculiarly local charm intelligible. (E. G.)

Wepener. See ORANGE RIVER COLONY.

Werdau, a town of Germany, on the Pleisse, 5 miles by rail west of the town and in the circle of Zwickau, kingdom of Saxony. The industries include wool-spinning, dyeworks, the building of carriages, chemical works, the making of spinning and electric lighting machinery. Population (1885), 14,638; (1900), 19,352.

Werden, a town of Prussia, in the Rhine province, on the river Ruhr, 6 miles by rail south of Essen. It has an interesting church (Roman Catholic), which belonged to the Benedictine abbey founded about 796 by St Ludger, whose stone coffin is preserved in the crypt. The abbey buildings are used as a prison. The manufacture of cloth, woollens, shoes, and paper, steam hammers, tanneries, dyeworks, distilleries, breweries, coal and iron mining, and stone quarrying are the principal industries. The Gothic *Codex Argenteus* of Ulphilas (now in Upsala University library) was discovered here in the 16th century. Population (1895), 9413; (1900), 10,701.

Werner, Anton Alexander von (1843–——), German painter, was born at Frankfort-on-the-Oder, 9th May 1843. He first studied painting at the Berlin Academy, pursued his studies at Carlsruhe, and, having won a travelling scholarship upon the exhibition of his early works, he visited Paris in 1867, and afterwards Italy, where he remained for some time. On his return he received several State commissions, and on the outbreak of the Franco-Prussian war in 1870 he was sent with the staff of the third corps d'armée, and stayed in France till the close of the campaign. In 1873 he was appointed professor at the Berlin Academy, of which he afterwards became director. Among his more important works must be named "The Capitulation of Sedan" (see Plate), "Proclamation of the German Empire at Versailles," "Moltke before Paris," "Moltke at Versailles," "The Meeting of Bismarck and Napoleon III.," "Christ and the Tribute Money," "William I. visiting the Tombs," "The Congress of Berlin," and some decorations executed in mosaic for the Triumphal Arch at Berlin. Von Werner's work is chiefly interesting for the historic value of his pictures of the events of the Franco-German war. He is, in fact, the State painter of Germany, and has had such influence over the art of his country as might be expected from his position.

See *Kunst für Alle*, vol. i.—KNACKFUSS. *Künstler-Monographieen*, No. 9.

Wervicq, a town of Belgium, in the province of West Flanders, 35 miles south-west of Bruges, on the left bank of the river Lys. It is on the French border, and opposite a French village of the same name. Its station is on the line from Courtrai to Ypres. The tobacco manufactured here is noted. Population (1890), 7484; (1899), 8736.

Wesel, a fortified town of Prussia, in the Rhine province, at the confluence of the Lippe and the Rhine, 35 miles by rail north by west of Duisburg. The fortifications are being demolished; those adjacent to the Berlin gate were taken down in 1892. The church of St Willibrord was restored in 1882–96. Amongst its institutions are the Lower Rhenish Museum of Antiquities, &c., and a meteorological station. Population (1885), 20,677; (1900), 22,547.

Weser, one of the chief rivers of Germany, flowing for the most part through the Prussian province of Hanover. In the years 1890–95 the Fulda, one of the head streams of the Weser, was canalized between Cassel and Fulda for a distance of 17¼ miles, being at the same time widened to 263 feet and deepened to 5 feet. In that distance the river falls 58 feet (from 439 to 381 feet), and is provided with seven sluices, each 199 feet long, 28 feet wide, and 5 feet deep on the sill. (For the deepening and other improvements which have been effected in the river between Bremen and the sea, see BREMEN.) The total length is 270 miles, or including also the Werra, its principal affluent, 440 miles; area of its drainage basin, 18,530 square miles. Boats of 350 tons can ascend generally as far as Münden.

Wesley, Samuel Sebastian (1810–1876), English composer and organist, natural son of Samuel Wesley, the eminent composer, was born in London on 14th August 1810. He was one of the Children of the Chapel Royal from 1819, held various unimportant posts as organist from the age of fifteen, and in 1832 was appointed to Hereford Cathedral. His career as a composer began with his splendid anthem, "The Wilderness," which was probably written for the opening of the Hereford organ in that year. In 1834 it fell to him to conduct the Festival of the Three Choirs, and in the following year he resigned Hereford for Exeter Cathedral; and during the next six years his name became gradually more and more widely known. In 1842 Dr Hook, afterwards Dean of Chichester, offered him a large salary to become organist of Leeds parish church, and at Leeds much of his finest work as a composer was done. In 1849 he quitted this post for Winchester, in order to secure educational advantages for his sons. He was at Winchester until 1865, when he offered himself as a candidate for Gloucester Cathedral, the last of his many posts. He again conducted the Three Choirs Festivals of 1865, 1868, 1871, and 1874. A civil list pension of £100 a year was conferred on him in 1873; he died at Gloucester 19th April 1876, and was buried at Exeter. Like his father, some of whose peculiarities he may have inherited, he was a very eccentric man, but his compositions show powers that are found in very few Englishmen of his date. If the list of his compositions is smaller than that of his father's, it must be remembered that his anthems, in which is contained his best work, are far more important and more extensive than most compositions so called: in many of them the whole anthem is no longer sung, but even the selections from them make up anthems of ordinary length. They are masterly in design, fine in inspiration and expression, and noble in character. His "Blessed be the God and Father," "The Wilderness," already mentioned, "Ascribe unto the Lord," "O Lord, Thou art my God," and many others, are masterpieces in their way, and in all of these, as in the service in E, published with a rather trenchant preface in 1845, there is a happy combination of the modern resources of harmony with the dignified cathedral style, a combination which naturally alarmed the orthodox party of his time. (J. A. F. M.)

West Africa, French.—The name of French West Africa is semi-officially applied to a group of French colonies, constituted by decree of June 1895, reorganized by a decree of 17th October 1899, and now consisting of Senegal, three military territories, French Guinea, the Ivory Coast, and Dahomey. By the decree of 1899 the Middle Niger region, including the greater part within the bend of the river, was placed under separate military administration, while the western portion of the old Sudan province was united to Senegal under the administration of a civil governor. For the boundaries between French West Africa and the British sphere see NIGERIA.

WEST AUSTRALIA.

I. GEOGRAPHY AND STATISTICS.

THIS state occupies the whole of the continent of Australia to the westward of 129° E., and is thus bounded by the sea on the N., W., and S., and by South Australia and Northern Territory on the E. Very rapid developments have taken place during recent years, and a great amount of information in regard to the physical features of the country has been obtained, which has enabled many errors formerly current to be corrected, especially errors in regard to the characteristics of the country lying beyond the coastal fringe.

Geology.

Archæan Rocks.—A vast area of West Australia is occupied by metamorphic, gneissic, granitoid, and schistose rocks, which form the basis on which the newer strata have been laid down, and which have been declared by observers to be of true Archæan age. The so-called Archæan rocks may be classified in six great divisions. The first or western belt extends from the river Murchison to the south coast. The rocks of this belt are for the most part comparatively soft, consisting of clay slates, quartzites, and schists, with dykes of diorite and granite and veins of quartz containing lead, copper, zinc, iron pyrites, and ferruginous graphite. The second belt extends northwards from the south coast, forming the edge of the great plateau called the Darling Range, to the Murchison. The course of the river is followed for about 200 miles in a narrow belt, when it suddenly spreads out to the east and north-west from the Robinson Range to the Lyons Range, disappearing beneath the magnesian limestones to the northward. The rocks in this division are principally gneiss and schist, with dykes of diorite, granite, and felstone, and veins of quartz frequently auriferous. Tin is also found, the ore being derived from the disintegration of quartz-porphyry dykes, where it is associated with tourmaline and titanic iron. Large deposits of kaolin of good quality also occur, while near Bridgetown a bed of graphite 20 feet thick has been opened up. The third or granite belt is about 100 miles in width, and extends from the south coast to the river Murchison at a distance of 100 miles east from the west coast. It consists chiefly of gneiss or granite, the rocks in many cases rising to a height of 100 feet. The belt is entirely destitute of mineral veins, and it is through the existence of this barrier that the rich gold-fields of the east remained so long unprospected. The fourth or first auriferous belt lies to the eastward of the granite belt, and averages about 20 miles in width. Starting from the south coast at Phillips river, it extends northwards, by the Ravensthorpe Range, Parker's Range, Southern Cross, Golden Valley, Mount Magnet, Mount Kenneth, Austin's Lake, to Cue. Thence it bends to the north-east to Nannine and the Star of the East, where it strikes to the north and, skirting the heads of the Murchison and Gascoyne rivers, turns north-west and follows down the Ashburton valley to its junction with the Henry, finally disappearing beneath the Palæozoic formation. The rocks in this division consist chiefly of hornblende, mica, or talc schists, and are broken and faulted by granite and diorite dykes and quartz lodes containing gold, iron, and copper. There are also magnesia lode masses rich with fine gold, while many of the lodes contain large quantities of chlorite. The fifth or second granite belt extends from the south coast, following the line of the first auriferous belt to the north, where it dips under the Palæozoic tableland of the Fortescue. The sixth or second auriferous belt lies next, and has proved extremely rich in gold. It extends north from the Dundas Hills through Wagemulla, Coolgardie, Lady Carey, &c., and, following about the same line as the other belts, turns to the north-west by Nullagine, Marble Bar, Pilbarra, Egina, and Mallina on the north-west coast. The rocks in this division are generally similar to those in the first auriferous belt, but are much more faulted and disrupted; the lodes, however, are the richest yet discovered.

Cambrian Rocks extend in a north-east and south-west direction from the Burt Range and for some distance to the southward of Mount Dockrell. The Cambrian rocks of the Kimberley district are of considerable importance, as they form the matrices of the auriferous quartz reefs which have furnished rich yields of the precious metal.

It is claimed that the rocks of the Stirling Range, about 50 miles to the north of Albany, belong to the *Silurian Group*. The strata consists of quartzites, sandstones, and shales traversed by quartz veins, and show evidence in places of folding, contorting, and faulting.

The *Devonian Rocks* in the Kimberley district consist mainly of hard grits, indurated limestones, and shales and conglomerates. The strata rest unconformably upon schists and slates which are believed to be of Lower Silurian age, and are covered by basaltic lavas in turn overlaid by Carboniferous rocks. It has been calculated that the Devonian beds occupy an area of 2000 square miles, with a thickness of 10,000 feet. Besides *Spirifera*, *Orthoceras*, and *Goniatites*, the Kimberley beds contain such fossils as *Actinostroma clathratum*, *Pacypora tumida*, *Cyathophyllum virgatum*, *Rhynchonella cuboides*, and various others. Associated with these sedimentary strata are contemporaneous basalts, dolerites, anamesites, volcanic breccias, and ashes. The deposits of these eruptive rocks have been estimated to reach a depth of upwards of 1000 feet, and they extend over a considerable area of country.

The first mention of the occurrence of rocks of *Carboniferous* age in West Australia appears in the *Journal of Expeditions*, by Sir George Grey, published in 1841. In 1848 Dr F. von Sommer, the first Government geologist of the colony, traced the Carboniferous beds from the head of the Irwin river to the sources of the Moore for a distance of 160 miles. Fossiliferous strata of Carboniferous age have been proved in the colony in three distinct districts. In the Kimberley district the beds consist of widespread deposits of sandstones, grits, and conglomerates containing bands and nodules of hæmatite as well as magnesian and other limestones. In the Gascoyne district the deposits consist of a series of crystalline limestones rich in corals, dipping at an angle of 10° to the westward, while beneath them are beds of shale yielding Lower Carboniferous fossils. In the Irwin river district the Carboniferous strata are supposed to stretch in an easterly direction from Mingenew, covering an area of about 20 square miles, the greatest length from north to south being about 30 miles, and the width from east to west about 17 miles.

Mesozoic Rocks.—The character of the strata belonging to this period has been described as follows:—Beds of highly ferruginous claystone or shale, sandstones, grits, conglomerates, clays and limestone, placed in horizontal layers on the older rocks which originally they must have entirely covered, but through denudation have since been worn down so as to leave in places tablelands and cliffs with steep escarpments and slopes. There are two principal areas occupied by this formation. The first, which varies in width from 10 to 30 miles, extends from the neighbourhood of Gingin and Yatheroo to the Murchison, and probably farther northwards in a line more or less parallel to the coast. Eastwards it thins out and only exists as outliers and cappings on the hills. The second principal area of this formation embraces the country extending from near Cape Riche to beyond Phillips river. Boring operations near Geraldton have proved the Mesozoic beds to be of a thickness of at least 1100 feet.

Cainozoic Rocks occupy an extensive area. In the Eocene group are included the coralline and chalky limestones with flints extending along the whole length of the Australian Bight and for about 150 miles inland. To the Pliocene belong the "Pindan," large sandy plains developed on each side of the river Fitzroy, and stretching away to the southward into Warburton's Desert, and constituting also the great sandy plains of the interior which form one of the characteristic features of West Australia. The Pleistocene deposits include ancient river gravels and lake basins found in several places in the ranges, lower estuarine deposits found as far inland as Perth, and shelly limestones and sandstones containing fossils very similar to the living forms. The Recent deposits embrace the alluvium of the inland lake basins, which are in many instances covered with layers of salt and gypsum, the latter often occurring in the form of selenite crystals, river valley and estuarine deposits, coastal sand plains and raised beaches, and various marls, gravels, and other surface deposits.

Population.

West Australia attained the position of an independent colony with responsible government on 21st October 1890, and the first representative Parliament was opened on 30th December of that year. Population made very slow increase under the old conditions of settlement, and even when gold was discovered in 1882 at Kimberley, and five years later at Yilgarn, no great impetus was given to the colony, and at the census of 1891 the population was still under 50,000. The sensational gold finds at Coolgardie in 1892, however, had a most important influence in drawing population, and in three and a half years the population was doubled: during a portion of this time the rush of miners to the gold-fields was so great as to be reminiscent of the experience of the eastern colonies during the 'fifties. The slowness of the early growth and the more rapid strides of later years will be gathered from the following figures: Population (1860), 15,227; (1870), 25,084; (1880), 29,019; (1890), 46,290; (1895), 101,238; (1901), 194,889; the last total comprising 118,762 males and 76,127 females. West Australia has three towns whose populations exceed 5000—viz., Perth, 36,274; Fremantle, 20,444; and Kalgoorlie, 6652. Some of the other towns have populations approaching 3000; Boulder has 4601; but the number of people on all gold-field towns fluctuates very greatly. Coolgardie, for example, was returned in July 1894 as having within its municipal boundaries 12,000 people, and in March 1901 only 4249.

The births during 1901 numbered 5718 and the deaths 2519, the rates per thousand of population being respectively 30·32 and 13·36, showing a net increment of 16·96 per 1000. The birth-rates in five-yearly periods since 1861 were as follows:—

Years.	Birth-rate per 1000 of Population.	Years.	Birth-rate per 1000 of Population.
1861–65 . .	39·07	1881–85 . .	34·57
1866–70 . .	33·86	1886–90 . .	36·88
1871–75 . .	31·30	1891–95 . .	30·77
1876–80 . .	32·97	1896–1901	28·65

The decline in the birth-rates has been a common experience of all the Australian states; in West Australia it is due in a large degree to the decline in the proportion of females to males. In 1870 the females numbered 62 per cent. of the males, and in 1880 75 per cent., while in 1895 the proportion was only 45 per cent. The illegitimate births during the five years preceding 1901 were slightly in excess of 5 per cent. of the total births, and are increasing. The death-rate is higher than in the other states of Australasia, but much below the European standard. Grouping the deaths in five-yearly periods, from 1861 onwards, the rates were as follows:—

Years.	Deaths per 1000 of Population.	Years.	Deaths per 1000 of Population.
1861–65 . .	16·31	1881–85 . .	17·19
1866–70 . .	15·55	1886–90 . .	15·97
1871–75 . .	16·03	1891–95 . .	16·31
1876–80 . .	14·32	1896–1901 .	14·73

The large influx of young unmarried men in the years 1894–98 was followed by the arrival of a large number of single women, and the marriage-rates increased from 7 per 1000 in the five years 1891–95 to 10·7 per 1000 in 1897 and 9·6 in 1901. The rates for these latter years must be looked on as abnormal, and the probabilities point to a return to a rate of 7 per 1000 inhabitants for marriages, or 14 per 1000 for persons married. Except for a slight influx of population in the three years 1885–87, due to the gold discoveries at Kimberley, there was very little immigration to West Australia prior to 1891; in that year, however, there was a considerable inpouring of population from the eastern colonies, notably from Victoria and South Australia, and in the seven years which closed with 1897 the population of the colony gained nearly 110,000 by immigration alone. In 1898 there was still a large inflow of population, but the outflow was also great, and in 1898 and the following year the two streams balanced one another; but 1900 showed an excess of 6000, and 1901 of nearly 12,000, gained by immigration. West Australia is the most sparsely populated of all the states; only the coastal fringe and the gold-fields show any evidences of settlement, and if the area were divided amongst the population, there would be but ten persons to 52 square miles. In a country so sparsely settled municipal government has little scope for operation; the total area controlled by municipalities properly so-called is only 100 square miles. Besides the municipalities there are district roads boards, elected by the ratepayers of their respective districts to take charge of the formation, construction, and maintenance of the public roads throughout their districts. There were in 1900 eighty-eight such boards in existence, some of the districts being of enormous size, Pilbarra, for example, being 14,356 square miles in area, and the Upper Gascoyne 136,000 square miles: over areas so vast little effective work can be accomplished, but where the districts are small the administration is much the same as in the municipalities. The receipts from rates of all local districts in 1900 was £82,300, and the grants by the Government £60,028, making a total of £142,328. The population is almost exclusively of British origin, and only differs from that of the other states in that there is a larger body of Australian-born, who are not natives of the colony itself. About 45 per cent. of the population are members of the Church of England,

and one-fourth belong to other Protestant denominations; the Roman Catholic Church also claims one-fourth.

Instruction.—Attendance at school is compulsory upon all children over six years and under fourteen years of age. Instruction is imparted only in secular subjects, but the law allows special religious teaching to be given during half an hour each day by clergymen to children of their own denomination. Children can claim free education on account of inability to pay fees, of living more than a mile from school, or of having attended school for more than 400 half-days during the preceding year. The state expended in 1900 £78,030 on public instruction, the great bulk of which was devoted to primary schools. The number of schools supported by the state was 218, to which 513 teachers were attached, the net enrolment of scholars being 18,557 and the average attendance 14,663. There were in 1900 75 private schools, with 248 teachers and 5462 scholars, the average attendance being 4248. All schools therefore numbered 293, teachers 761, and scholars 24,019. Judged by the number of persons arrested, crime is more prevalent than in any other part of Australia. The goldfields have attracted some of the best and most enterprising of the Australian population; at the same time many undesirable persons flocked to the state expecting to reap a harvest in the movement and confusion of the gold diggings. These latter form a large part of the criminal population of the state. The arrests in 1900 numbered 13,880, of which 3644 were for serious offences, so that for every thousand of the population 59 were arrested for trivial and 19 for serious crimes.

Finance.—The discovery of gold and the settlement on the goldfields of a large population, for the most part consumers of dutiable goods, has entirely revolutionized the public finances of the state. In 1891 the revenue was £497,670, that is, £10 15s. per inhabitant; in 1895 it rose to £1,125,941, or £12 10s. per inhabitant; and in 1897 to £2,842,751, or £20 12s. 2d. per inhabitant. For 1901 the figures were £3,078,034, or £16 18s. 8d. per inhabitant. The chief sources of revenue in 1901 were: customs and excise, £992,216; other taxation, £144,103; railways, £1,347,089; posts and telegraphs, £210,126; public lands (including mining), £251,292; all other sources, £133,208; total, £3,078,034. The expenditure has risen with the revenue, but the treasurer has been able to keep within his income, and for the ten years ending with 1901 the total excess expenditure amounted to about £198,000. The chief items of expenditure in 1901 were: railway working expenses, £1,071,576; public works, £324,123; posts and telegraphs, £255,514; interest and charges upon debt, £486,800; other services, £1,027,231. These figures give a total of £3,165,244. The chief feature in the expenditure is the great increase in the sum devoted to the construction of public works. In 1890 the sum expended on this service was about £30,000; in 1895 it rose to £145,000, in 1897 to £931,000. The public debt is of comparatively recent creation. In August 1872 an Act was passed authorizing the raising of certain sums for the construction of public works; in 1881 the amount owing was not more than £511,000, and in 1891 only £1,613,000, or £30 5s. 8d. per inhabitant; from the year last named the indebtedness has increased by leaps and bounds, and in 1901 had mounted up to £12,709,430, a sum equal to £67 14s. 6d. per inhabitant, involving an interest charge of £486,800, or £2 12s. per inhabitant. The proceeds of the loans were used largely for the purpose of railway extension, the expenditure on this service at the middle of 1901 was £6,968,965; on water supply and sewerage works, £1,597,375; on telegraphs and telephones, £269,308; and on other works not revenue-yielding, £3,050,484. The return from works constructed out of loan funds, in excess of the working expenses, amounted in 1901 to £246,300, compared with the interest charge of £486,800, which reduces the actual annual burthen of the debt to £240,500.

Defence.—The actual strength of the defence forces is 2247 men, 54 paid and 2193 partially paid. Military works have been constructed for the defence of King George Sound and Princess Royal Harbour, and works have been commenced for the protection of Fremantle. The garrison of the batteries, King George Sound, is provided by West Australia, and the state bore one-fourth of the cost of construction and equipment, the other states contributing the remainder on a population basis. West Australia contributes £5100 towards the upkeep of the Australian Auxiliary Squadron.

Minerals.—Gold-mining is the main industry, and finds employment for 30,000 men in the actual work of mining, besides almost as large a number indirectly. Agriculture gives employment to about 12,000, and pastoral pursuits 2700, while about 1000 others are employed in forests and fisheries. West Australia makes an enumeration of its factories, but the number of hands employed therein can only be given for recent years. In 1885 there were 140 establishments, in 1890 175, and in 1900 632; the average number of hands employed in 1900 was 11,200. Gold, coal, tin, and copper are the chief minerals mined, the value of other minerals obtained was in 1900 less than £17,000. The production of gold in each year from 1888 onwards was:—

1888 . . .	£13,273	1895 . . .	£879,749
1889 . . .	58,874	1896 . . .	1,068,807
1890 . . .	86,663	1897 . . .	2,564,977
1891 . . .	115,182	1898 . . .	3,990,699
1892 . . .	226,282	1899 . . .	6,246,733
1893 . . .	421,386	1900 . . .	6,007,610
1894 . . .	787,098	1901 . . .	7,235,652

West Australia now ranks as the largest gold producer of the Australian group. Coal is worked at Collie, 25 miles east of Bunbury, and has been found in several other places. The future of the industry is uncertain, but it is probable the production of coal will be limited to the local demand. The export of copper in 1901 was valued at £110,769, and of tin £52,102.

Agriculture.—The agricultural resources are restricted, as the rainfall in the southern and temperate portion does not extend far from the coast, and the land where the fall is satisfactory is only good over small areas. The area cultivated in 1871 was 52,000 acres; in 1881 it was 53,000 acres, in 1891 64,000 acres, and in 1901 201,000 acres. The principal crops grown in the year last named were: wheat 74,000 acres, and hay (wheaten and oaten) 104,000 acres. The wheat yield, calculated over a period of ten years, was eleven bushels per acre, and the hay crop not quite a ton per acre. In 1901 the number of sheep depastured was 2,434,000, the cattle 338,600, and the horses 68,000. These figures show an increase for all classes of stock. There are more than 3000 camels. The number of sheep has increased during the ten years 1891–1900, while the weight of wool exported was considerably more in 1900 than in 1891. In 1871 2,000,000 ℔ of wool were exported, in 1881 4,100,000, in 1891 8,800,000, and in 1900 9,514,000; in each case the equivalent weight of greasy wool has been taken where washed wool was exported. West Australia has very extensive forests of timber, and it has been estimated that the forest surfaces cover more than 20 million acres, of which 8 million acres are jarrah; 1,200,000 acres, karri; 200,000 acres, tuart; 7 million acres, wandoo; and 4 million acres, York gum, yate, sandalwood, and jam. The principal timber exported is jarrah, karri, and sandalwood, and in 1900 the value of the export was: jarrah, £297,847; karri, £160,180; and sandalwood, £39,038. There were in operation fifty-one saw-mills, employing about 3400 hands.

Fisheries.—The pearl-shell fisheries in the north-west and in Shark Bay have been a considerable source of wealth, the exports of pearls and pearl shell being valued at £110,667 in 1899, £106,607 in 1900, and £130,730 in 1901. In 1892 the export was valued at £119,519.

Commerce.—All the great lines of steamers trading between Australia and Europe make one of the ports a place of call both on the inward and outward voyage; this makes the shipping tonnage very large compared with the population. In 1891 the tonnage entered and cleared equalled 21 tons per head, and in 1901 19·8 tons: these amounts were altogether beyond the requirements of the trade of the colony in the year named, as the total weight of imports and exports in 1901 was only 750,000 tons, equal to 3·8 tons per inhabitant. The increase of tonnage is shown by the following figures: 1881, tonnage entered 145,048; 1891, 533,433; and 1901, 1,842,236. There are three important ports, viz., Fremantle, Albany on King George Sound, and Geraldton. In 1900 the tonnage entering Fremantle was 522,152, and the imports were valued at £5,489,493 and the exports at £5,146,603; these figures include the trade of Perth. The shipping entering Albany had a tonnage of 1,032,435, and the imports were valued at £184,819 and the exports at £2,190,234. The trade of Geraldton was: imports £143,109, and exports £94,542; at no other port did the trade in 1900 reach the value of £230,000. The trade has increased very rapidly under the influence of the gold discoveries, as the following figures show:—

Year.	Imports.				Exports.			
	Total.	Per Head.			Total.	Per Head.		
		£	s.	d.		£	s.	d.
1861	147,913	9	9	8	95,789	6	2	10
1871	226,000	9	0	10	209,196	8	6	11
1881	404,831	13	14	3	502,770	17	0	8
1891	1,280,093	25	2	5	799,466	15	13	9
1901	6,454,171	34	4	5	8,515,623	45	3	0

About 54 per cent. of the trade is with Great Britain, and 21 per cent. with the other Commonwealth states. The principal articles of local production exported during 1901, with their values, were: gold, £6,749,638; pearls and pearl-shell, £130,730; sandalwood, £73,931; skins, £86,559; timber, £572,354; wool, £378,135; copper, £110,769; and tin, £52,102.

Communications.—West Australia is the only state of Australia in which there is any considerable length of railway lines not owned by the state. The total railway mileage is 1978, of which 623 miles are privately owned. The divergence of the policy of West Australia from that pursued by the other states was caused by the inability of the Government to construct lines at a time when the extension of the railway was most urgently required in the interests of settlement. Private enterprise was therefore encouraged by liberal grants of land to undertake the work of construction. Changed conditions have modified the state policy in respect of land grants, and in 1897 the Government acquired the Great Southern Railway, 243 miles in length, one of the two trunk lines in private hands. The cost of constructing and equipping the state lines open for traffic in 1901 was £7,098,240, and the earnings amounted to £1,353,704, which represents a return of 4·4 per cent. upon the capital cost. The interest paid by the state on its loans is 3·6 per cent., so that there was in 1901 a net profit of nearly 1 per cent. on the railways of the state, and this has in some years been greatly exceeded. The extension of railway facilities will be seen from the following figures: mileage open for traffic, 1876, 38 miles; 1881, 92 miles; 1891, 202 miles; and 1901, 1978 miles. The postal business has grown enormously since the gold discoveries. In 1900 there were 178 post offices, compared with 86 in 1891. The postal business for the years specified is shown in the following table:—

Year.	Letters.		Newspapers.	
	No.	Per Head.	No.	Per Head.
1881	995,000	34	715,000	24
1891	3,200,000	64	1,665,000	33
1900	13,163,000	74	6,993,000	40

In addition to the letters and newspapers, there were 3,413,000 packets, 36,600 parcels, and 459,000 post-cards delivered or despatched by the post offices during 1900. There were in the same year 161 telegraph stations, 6052 miles of line, and 8872 miles of telegraph wire in use, while the number of telegrams sent and received (counting each telegram once) was 1,167,197; this represents the large average of seven telegrams per inhabitant.

Banking.—There are six banks of issue, with seventy-one branches in various parts of the country. The liabilities of these banks in 1901 averaged £4,929,042, and the assets, £5,944,769; the note circulation was £378,372; the deposits bearing interest, £1,456,373, and those not bearing interest, £2,980,390; making the total deposits £4,436,763. The gold and silver held by the banks, including bullion, was £2,378,055. The savings banks are directly controlled by the Government, and are attached to the post offices; in 1901 there were 39,339 depositors in these banks, with £1,618,359 to their credit. In 1891 there were only 3564 depositors, and £46,181 at credit.

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(T. A. C.)

II. RECENT HISTORY.

The progressive history of West Australia may be said to commence in 1870, when its energetic and capable governor, the late Sir Frederick Weld, began to inaugurate public works on a large scale. It was still the day of small things, for the colony, though of the enormous extent of a million square miles, was practically unknown, its resources were restricted, and its population scanty. However, a beginning was then made, and the first Loan Bill to raise money for pushing on telegraphs, for surveying lines of projected railways, and above all for starting exploring expeditions, passed the Legislative Council. The colony was fortunate in possessing two brothers of the best practical type of explorer, John and Alexander Forrest. The object of their earliest expeditions was to find more land available for pastoral or agricultural settlement. Vast distances in various directions were covered, and severe hardships, chiefly from want of water, undergone by these intrepid pioneers. Perhaps the most famous of these journeys was that accomplished by Mr (afterwards Sir) John Forrest between Eucla and Adelaide in 1870. Other dauntless explorers—notably Mr Ernest Giles, the Gregorys, and Mr Austin—had also contributed to the growing knowledge of the resources of the vast territory, and the state owes and gratefully acknowledges its debt to these stalwart and splendid pioneers. Although, in consequence of the vast amount of gold which had been found in the eastern colonies, principally in Victoria, all these explorers had carefully examined any likely country for traces of gold, it was not until 1882 that the Government geologist reported indications of auriferous country in the Kimberley district, and the first payable gold-field was shortly afterwards "proclaimed" there. Exploring expeditions in every direction were then started both privately and publicly, and prosecuted with great vigour. Within five years gold-fields were proclaimed at Yilgarn, about 200 miles to the east of Perth, and the discovery of patches of rich alluvial gold in the Pilbarra district quickly followed, but the rush for the Coolgardie and Kalgoorlie gold-fields did not begin until 1893.

The year 1889 found the colony on the eve of responsible government. Two years before, a practically unanimous vote of the Legislature had affirmed the principle of autonomy, and the general election in the following year showed still more plainly the desire of the people of West Australia for the self-government which had enabled the eastern colonies to control their own affairs successfully for thirty years. The new Legislative Council of 1889 therefore drafted a Constitution Bill, which after some discussion was forwarded to Lord Knutsford, the Secretary of State for the Colonies. This Bill was duly laid before the Imperial Parliament; but the measure was then rejected by that assembly, chiefly owing to the misunderstanding of vital questions, such as the control of Crown lands, the scantiness of the scattered population, and other less important details. However, the governor of that day, the late Sir Frederick Napier Broome, K.C.M.G., having satisfied himself that the constitutional change was necessary not only for the immediate needs of the rapidly growing colony, but in view of the larger question of Imperial Federation, supported the demands of the Legislature in every possible way. A clear and able statement of the colonists' case, which appeared above his signature in *The Times* in the summer of that year, helped to bring about a better understanding of the subject; and a slightly modified Constitution Bill having been passed by the new Legislative Council, the governor and two members of the Legislature (Sir T. C. Campbell and Mr S. H. Parker, Q.C.) were selected to proceed to England as delegates to explain and urge the wishes of the colonists upon the Imperial Parliament. A select committee, with Baron de Worms as chairman, was appointed, and the matter was carefully considered; with the satisfactory result that the Bill enabling the Queen to grant a constitution to West Australia passed its third reading in the House of Commons on 4th July, and received the royal assent on 15th August 1890. Since then the colony has made great progress. Sir John Forrest, who was for ten years its Premier, brought to his arduous task not only administrative ability of a very high order, but a thorough and intimate knowledge of the needs and resources of the vast colony over so much of which he had travelled. The scanty and scattered population of 45,000 persons to whom the Imperial Parliament hesitated in 1890 to confide the guidance of their own affairs increased to 200,000, and the average annual revenue (1880–90) is now exceeded by the Treasurer's monthly returns. The geographical position of West Australia is much in its favour, offering, as it does in Fremantle, the first port of call for ocean steamers.

For a long time the advantages of Federation were not so apparent to the people of West Australia as to those of the eastern colonies, and although Sir John Forrest consistently and patiently laboured at every opportunity to explain the principles of the Bill framed by the Federal Convention which had held its sittings since 1886 in Adelaide, Sydney, and Melbourne, the desire to federate was of slow growth. Among the objections was the feeling that so far as West Australia was concerned the step was premature, and that the colony had more to lose than gain by Federation. This applied chiefly to the questions of tariff and free trade, and to the loss of the individual control of such sources of revenue as customs, postal and telegraph services. On the subject of defence there could be but one opinion, in favour of Federation, but that was hardly enough to counterbalance the fears of the local producer, who had become accustomed to a protective tariff. Then the gold-fields expressed a desire to be made into a separate colony, and although a numerously-signed petition to that effect was forwarded to the Queen, it was regarded in the light of a party move, and did not prove successful. Still there was great hesitation on the part of many of the colonists of West Australia to join the Commonwealth without receiving a pledge for the retention of their own customs dues for five years, and early in 1900 Sir John Forrest made a personal attempt to obtain this concession from the sister Governments. He was, however, unsuccessful, as was Mr S. H. Parker, Q.C., who in the same year accompanied the delegates from the eastern colonies to London, and endeavoured to obtain the insertion in the Enabling Bill of certain recommendations of the select committee in Perth. Yet as a whole the people of West Australia were loyal to the Federal cause, and therefore it was considered best to submit the Bill to a referendum of the electors, when a majority of over 25,000 votes decided in favour of Federation, as the Constitution Act provided that this state should have the right to enact her own tariff as against the sister states for the desired five years, decreasing annually at the rate of one-fifth of the amount of the original duty until the whole disappeared. (M. A. B.)

West Bay City, a city of Bay county, Michigan, U.S.A. It is on the river Saginaw, near its mouth and at the head of navigation, and on the Grand Trunk and Michigan Central railways, in the eastern part of the Lower Peninsula, at an altitude of 587 feet. Situated near the pineries of the Lower Peninsula, its industries are mainly connected with the manufacture and shipping of lumber. It has saw and planing mills, and other wood-working establishments. Population (1890), 12,981; (1900), 13,119, of whom 3754 were foreign-born.

Westboro, a town of Worcester county, Massachusetts, U.S.A., containing an area of 17 square miles of hilly country, situated in the central part of the state. The principal village bears the same name as the town, and has a level site, on which it is laid out irregularly. It is on the Boston and Albany Railroad, and is at an altitude of 300 feet. It contains a state insane asylum, and has manufactures of boots and shoes, hats, bicycles, &c. Population (1890), 5195; (1900), 5400, of whom 1127 were foreign-born.

West Bromwich, a municipal, county (1888), and parliamentary borough and market town of Staffordshire, England, on the Tame, 5 miles north-west of Birmingham by rail, and in water communication with all parts of England. The corporation has laid down electric lighting and power plant. The school board for the parish has spent about £47,000 on school buildings; and, in addition to board, there are numerous other schools, one of which maintains pauper children and teaches spade husbandry, baking, engineering, &c. The Institute (1886), providing instruction in science and art, was taken over by the corporation in 1894; law courts were erected in 1891; Oak House was opened as a museum and art gallery in 1898. Places of public recreation include Dartmouth Park, 65½ acres, Farley Park (1891), Kenrick Park (1895), and Hill Top Park (1897). Within the borough is Sandwell Park, lately the seat of the Earls of Dartmouth. In 1891 there were 6486 persons (males) engaged in the iron and steel manufacture, 726 in manufacture in mixed metals; 581 in the making of machines and tools; and 1395 in coal-mining. A thirty-feet coal-field of about 2000 acres in area has been discovered. Area of municipal and county and parliamentary boroughs, which are coextensive, 5860 acres. Population (1891), 59,538; (1901), 65,172.

Westbrook, a city of Cumberland county, Maine, U.S.A., on the river Presumpscot, and the Maine Central and the Portland and Rochester railways, in the south-western part of the state, adjoining Portland. The river furnishes water-power, which is utilized to a large extent in manufacture. There are factories for making paper, cotton and silk goods, and other articles. Population (1880), 3981; (1890), 6632; (1900), 7283, of whom 1673 were foreign-born.

Westbury, a parish and town in the Westbury or Western parliamentary division of Wiltshire, England, 26 miles north-west of Salisbury by rail. The town is of very ancient origin, and formerly sent two members to Parliament. Since 1885 its representation has been merged in that of the county. The church of All Saints' was restored in 1867 and the Laverton Institute opened in 1873. The chief trade is in fancy woollen coatings and meltons, but there are also brick and tile works and two blast-furnaces, employing a large number of hands. Population (1891), 4439; (1901), 3300.

West Chester, a borough of Pennsylvania, U.S.A., capital of Chester county, on the Pennsylvania Railroad, in the south-eastern part of the state, at an altitude of 406 feet. It is surrounded by market gardens, dairy farms, &c., and to some extent is a residential suburb of Philadelphia. Population (1890), 8028; (1900), 9524, of whom 566 were foreign-born and 1777 negroes.

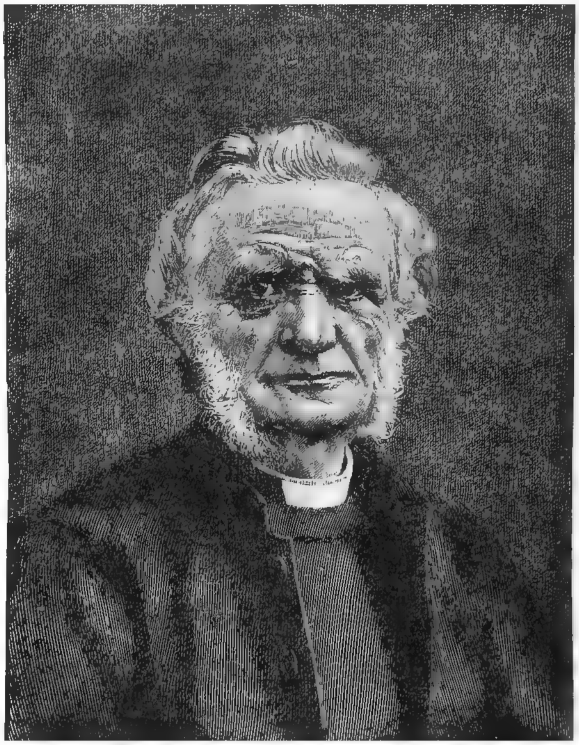
Westcott, Brooke Foss (1825–1901), English divine and Bishop of Durham, was born on the 12th of January 1825 in the neighbourhood of Birmingham. His father, Frederick Brooke Westcott, was a botanist of some distinction. Westcott was educated at King Edward VI. School at Birmingham. There he came under the influence of Dr Prince Lee, from whom he seems to have derived the ideal of exact scholarship and broad intellectual sympathy, of which he was himself the most conspicuous example among the many distinguished English Churchmen of the 19th century. To King Edward's School he was also indebted for his friendship with Joseph Barber Lightfoot. In 1844 Westcott obtained a scholarship at Trinity College, Cambridge. At the University he had a brilliantly distinguished career. He obtained Sir William Browne's medal for a Greek ode in 1846 and 1847, the Members' Prize for a Latin essay in 1847 as an undergraduate and in 1849 as a bachelor. He took his degree in January 1848, obtaining double-first honours. In mathematics he was twenty-fourth wrangler, Todhunter being senior, Bishop Barry and Lord Alwyne Compton (Bishop of Ely) being in the same class. In classics he was senior, being bracketed with Scott, afterwards headmaster of Westminster School. After obtaining his degree, Westcott remained for four years in residence at Trinity. In 1849 he obtained his fellowship; and in the same year he was ordained deacon and priest by his old headmaster, Prince Lee, who had become Bishop of Manchester. The time spent at Cambridge was devoted to most strenuous study. He took pupils; and among his pupils there were reading with him, almost at the same time, his school friend Lightfoot and two other men who became his attached and lifelong friends, Edward White Benson (afterwards Archbishop of Canterbury) and Fenton John Anthony Hort (afterwards Lady Margaret professor of divinity at Cambridge). The inspiring influence of Westcott's intense enthusiasm left its mark upon these three distinguished men. It is not too much to say that they regarded Westcott not only as their friend and counsellor, but as in an especial degree their teacher and oracle. The precocity of Westcott's attainments and learning was early recognized. But the publication of his Norrisian prize essay in 1851, with the title *Elements of Gospel Harmony*, first proclaimed to the reading world the promise of a great theologian. He devoted much attention to philosophical, patristic, and historical studies, but it soon became evident that he would throw his strength into New Testament work.

In 1852 he became an assistant master at Harrow. Shortly afterwards he was married to Miss Whithard, daughter of Mr Thomas Middlemore Whithard of Kingsdown, Bristol. He prosecuted his school work with characteristic vigour, and succeeded in combining with his school duties an enormous amount both of theological research and of literary activity. He worked at Harrow for nearly twenty years under Dr Vaughan and Dr Montagu Butler. He was felt in the school to be a unique personality, of whom the school was proud, but whom neither the boys, nor even the masters probably, pretended altogether to comprehend. Perhaps it is true that he never really understood the limitations of boy nature. At any rate, while he was always conspicuously successful in inspiring a few senior boys with something of his own intellectual and moral enthusiasm, he was never in the same measure capable of maintaining discipline among large numbers. The writings which he produced at this period created a new epoch in the history of modern English theological scholarship. In 1855 he published the first edition of his *History of the New Testament Canon*, which, frequently revised and expanded, became the standard English work upon the subject. In 1859 there appeared his *Characteristics of the Gospel Miracles*. In 1860 he expanded his Norrisian essay into an *Introduction to the Study of the Gospels*, a work remarkable for insight and minuteness of study, as well as for reverential treatment combined with considerable freedom from traditional lines. Westcott's work for Smith's *Dictionary of the Bible*, notably his articles on "Canon," "Maccabees," "Vulgate," entailed most careful and thorough preparation, and led to the composition of his subsequent valuable popular books, *The Bible in the Church* (1864) and a *History of the English Bible* (1869). To the same period belongs *The Gospel of the Resurrection* (1866). As a piece of consecutive reasoning upon a fundamental Christian doctrine it deservedly attracted great attention. Its width of view and its recognition of the claims of historical science and pure reason were thoroughly characteristic of Westcott's mode of discussing a theological question. At the time when the book appeared his method of apologetic showed both courage and originality, but it must be owned that the excellence of the work is somewhat impaired by the difficulty of the style.

In 1865 he took his B.D., and in 1870 his D.D. He received in later years the honorary degrees of D.C.L. from Oxford (1881), and of D.D. from Edinburgh (1883). In 1868 Westcott was appointed examining chaplain by Bishop Magee (of Peterborough); and in the following year he accepted a canonry at Peterborough, which necessitated his leaving Harrow. For a time he contemplated with eagerness the idea of a renovated cathedral life, devoted to the pursuit of learning and to the development of opportunities for the religious and intellectual benefit of the diocese. But the regius professorship of divinity at Cambridge fell vacant, and Lightfoot, who was then Hulsean professor, declining to become a candidate himself, insisted upon Westcott's standing for the post. It was due to Lightfoot's support almost as much as to his own great merits that Westcott was elected to the regius professorship on 1st November 1870. This was the turning-point of his life. He now occupied a great position for which he was supremely fitted, and at a juncture in the reform of university studies when a theologian of liberal views, but universally respected for his massive learning and his devout and single-minded character, would enjoy a unique opportunity for usefulness. Supported by his friends Lightfoot and Hort, he threw himself into the new work with extraordinary energy. His whole life was devoted to the promotion of the theological studies in which his own interests were absolutely centred. He deliberately sacrificed many of the social privileges of a university career in order that his studies might be more continuous and that he might see more of the younger men. His lectures were generally on Biblical subjects. His *Commentaries* on St John's Gospel (1881), on the Epistle to the Hebrews (1889), and the Epistles of St John (1883) resulted from his public lectures. One of his most valuable works, *The Gospel of Life* (1892), a study of Christian doctrine, incorporated the materials upon which he was engaged in a series of more private and esoteric lectures delivered on week-day evenings. The work of lecturing was an intense strain to him, but its influence was immense: to attend one of Westcott's lectures—even to watch him lecturing—was an experience which lifted and solemnized many a man to whom the references to Origen or Rupert of Deutz were almost ludicrously unintelligible. Between the years 1870 and 1881 Westcott was also continually engaged in work for the revision of the New Testament, in which he took a conspicuous part, and, simultaneously, in the preparation of a new text in conjunction with Hort. The years in which Westcott, Lightfoot, and Hort could thus meet frequently and naturally for the discussion of the work in which they were all three so deeply engrossed formed a happy and privileged period in their lives. Westcott's residence at Cambridge during the tenure of his professorship was 6 Scroope Terrace. In the year 1881 there appeared the famous Westcott and Hort text of the New Testament, upon which had been expended nearly thirty years of incessant labour. The reforms in the regulations for degrees in divinity, the formation and first revision of the new theological tripos, the inauguration of the Cambridge mission to Delhi, the institution of the Church Society (for the discussion of theological and ecclesiastical questions by the younger men), the meetings for the divinity faculty, the organization of the new Divinity School and Library, and, later, the institution of the Cambridge Clergy Training School, were all, in a very real degree, the result of Westcott's energy and influence as regius professor. To this list should also be added the Oxford and Cambridge preliminary examination for candidates for holy orders, with which he was from the first most closely identified. The success of this very useful scheme was due chiefly to his sedulous interest and help.

The departure of Lightfoot to the see of Durham in 1879 was a great blow to Westcott. Nevertheless it resulted in bringing him into still greater prominence. He was compelled to take the lead in matters where Lightfoot's more practical nature had previously been predominant. In 1883 Westcott was elected to a professorial fellowship at King's. Shortly afterwards, having previously resigned his canonry at Peterborough, he was appointed by the Crown to a canonry at Westminster, and accepted the position of examining chaplain to Archbishop Benson. His little edition of the *Paragraph Psalter* (1879), arranged for the use of choirs, and his admirable lectures on the Apostles' Creed, entitled *Historic Faith* (1883), are reminiscences of his vacations spent at Peterborough. He held his canonry at Westminster in conjunction with the regius professorship. The strain of the joint work was very heavy, and the constant attendance at meetings and committees both in Cambridge and in London told upon him severely. The intensity of the interest and study which he brought to bear upon his share in the labours of the Ecclesiastical Courts Commission, of which he had been appointed a member, added to his burden.

Preaching at the Abbey gave him an opportunity, which he valued immensely, of dealing with social questions. His sermons were generally portions of a series; and to this period belong the volumes *Christus Consummator* (1886) and *Social Aspects of Christianity* (1887).



Bishop Westcott.
(*From a photograph by the London Stereoscopic and Photographic Co., Ltd.*)

In March 1890 he was nominated to the see of Durham, there to follow in the steps of his beloved friend Lightfoot, who had passed away in December 1889. He was consecrated on the 1st of May at Westminster Abbey by Archbishop Thompson (of York): Hort was the preacher upon the occasion. Benson (Archbishop of Canterbury) also was present, but did not take part in the service, Durham being in the Northern Province. Westcott was enthroned at Durham Cathedral on the 15th of May. The change of work and surroundings could hardly have been greater. But the sudden immersion in the practical administration of a northern diocese gave him new strength. He surprised the world, which had supposed him to be a recluse and a mystic, by the practical interest he took in the mining population of Durham and in the great shipping and artisan industries of Sunderland and Gateshead. Upon one famous occasion in 1892 he succeeded in bringing to a peaceful solution a long and bitter strike which had divided the masters and men in the Durham collieries; and his success was due to the confidence which he inspired by the extraordinary moral energy of his strangely "prophetic" personality, at once thoughtful, vehement, and affectionate. His constant endeavour to call the attention of the Church to the religious aspect of social questions was a special note in his public utterances. He was a staunch supporter of the co-operative movement. He was practically the founder of the Christian Social Union. He continually insisted upon the necessity of promoting the cause of foreign missions, and he gladly gave four of his sons for the work of the Church in India. His energy was remarkable to the very end. But during the last two or three years of his life he had become suddenly older: the deaths of Hort and Benson had left him with a sense of loneliness; he was much troubled, too, with deafness, and complained of shortness of breath. In his visits to Cambridge in 1900 to lay the foundation stone of the Clergy School (which will always be associated with his memory), and again in December to preach the Commemoration Sermon at Trinity College, he displayed all the old vigour; but it was a farewell to his beloved university. His wife—who had been for some years an invalid—died rather suddenly on the 28th of May 1901. He placed a stone to her memory; the inscription on it was to wait until his own time came. It was not for long. He dedicated to her memory his last book, *Lessons from Work* (1901). He attended meetings in London in the early part of July. He preached a farewell sermon to the miners in Durham Cathedral at their annual festival, on the 20th of July. Then came a short, sudden illness, and he fell asleep on the 27th of July. He was buried in Auckland Castle chapel, in the same grave with his wife, and close to the grave of Bishop Lightfoot.

In appearance Westcott was short and spare; his face was one of striking power and beauty. The intensity of his look has been well caught by Sir William Richmond, whose picture of him hangs in the Fitzwilliam Museum at Cambridge. He was quick and active in movement; was always a vigorous walker; was wiry and tough in physique, and enjoyed good health. He was no narrow specialist. He had the keenest love of poetry, music, and art. He was himself no mean draughtsman, and used often to say that if he had not taken orders he would have become an architect. His literary sympathies were wide. He would never tire of praising Euripides, while few men had given such minute study to the writings of Robert Browning. He followed with delight the development of natural science studies at Cambridge. He spared no pains to be accurate, or to widen the basis of his thought. Thus he devoted one summer vacation to the careful analysis of Comte's *Politique Positive.* He studied assiduously *The Sacred Books of the East*, and earnestly contended that no systematic view of Christianity could afford to ignore the philosophy of other religions. The outside world was wont to regard him as a mystic; and the mystical, or sacramental, view of life enters, it is true, very largely into his teaching. He had in this respect many points of similarity with the Cambridge Platonists of the 17th century, and with F. D. Maurice, for whom he had profound regard. But in other respects he was very practical; and his strength of will, his learning, and his force of character made him really masterful in influence wherever the subject under discussion was of serious moment. He was a strong supporter of Church reform, especially in the direction of obtaining larger powers for the laity. He was always an energetic advocate of international arbitration as the means of settling national disputes. But in the Boer war he was convinced of the righteousness of the British contention. Preaching on 7th January 1900 he used these words, "It is not only our paramount authority in South Africa which is at stake, but, as involved in that, our dominion in India, and our fitness to inspire and guide the life of Great Britain."

He kept himself aloof from all party strife. He describes himself when he says, "The student of Christian doctrine, because he strives after exactness of phrase, because he is conscious of the inadequacy of any one human formula to exhaust the truth, will be filled with sympathy for every genuine endeavour towards the embodiment of right opinion. Partial views attract and exist in virtue of the fragment of truth—be it great or small—which they include; and it is the work of the theologian to seize this no less than to detect the first spring of error. It is easier and, in one sense, it is more impressive to make a peremptory and exclusive statement, and to refuse to allow any place beside it to divergent expositions; but this show of clearness and power is dearly purchased at the cost of the ennobling conviction that the whole truth is far greater than our individual minds. He who believes that every judgment on the highest matters different from his own is simply a heresy must have a mean idea of the faith; and while the qualifications, the reserve, the lingering sympathies of the real student make him in many cases a poor controversialist, it may be said that a mere controversialist cannot be a real theologian" (*Lessons from Work*, pp. 84–85). His theological work was always distinguished by the place which he assigned to Divine Revelation in Holy Scripture and in the teaching of history. His own studies have largely contributed in England to the better understanding of the doctrines of the Resurrection and the Incarnation. His work in conjunction with Hort upon the Greek text of the New Testament will endure as one of the greatest achievements of English Biblical criticism. The principles which are explained in Hort's introduction to the text had been arrived at after years of elaborate investigation and continual correspondence and discussion between the two friends. The place which it almost at once took among scientific scholars in Great Britain and on the Continent was a recognition of the great advance which it represented in the use and classification of ancient authorities. As a commentator his annotations upon St John's Gospel and Epistles and upon the Epistle to the Hebrews rank with Lightfoot's commentaries as the best type of Biblical exegesis produced by the English Church in the 19th century. As a preacher and speaker his reputation is due almost entirely to the last twenty years of his life. The late development of his power and effectiveness in this respect was very remarkable. He had a strong voice and a retentive memory; he spoke with great energy and conviction. At times, as, for instance, on the occasion of the famous demonstration in the Albert Hall, London, against the disestablishment of the Church in Wales, and, again, on the occasion of Mr Arthur Balfour's visit to Cambridge for the inauguration of Cambridge House in South London, a cherished hope of Westcott's, his speeches were pieces of oratory.

The following is a bibliography of Westcott's more important writings, giving the date of the first editions:—*Elements of the Gospel Harmony* (1851); *History of the Canon of First Four Centuries* (1853); *Characteristics of Gospel Miracles* (1859); *Introduction to the Study of the Gospels* (1860); *The Bible in the Church* (1864); *The Gospel of the Resurrection* (1866); *Christian Life Manifold and One* (1869); *Some Points in the Religious Life of the Universities* (1873); *Paragraph Psalter for the Use of Choirs* (1879); *Commentary on the Gospel of St John* (1881); *Commentary on the Epistles of St John* (1883); *Revelation of the Risen Lord* (1882); *Revelation of the Father* (1884); *Some Thoughts from the Ordinal* (1884); *Christus Consummator* (1886); *Social Aspects of Christianity* (1887); *The Victory of the Cross; Sermons in Holy Week* (1888); *Commentary on the Epistle to the Hebrews* (1889); *From Strength to Strength* (1890); *Gospel of Life* (1892); *The Incarnation and Common Life* (1893); *Some Lessons of the Revised Version of the New Testament* (1897); *Christian Aspects of Life* (1897); *Lessons from Work* (1901). (H. E. E.)

Westerås, or VESTERÅS, a town and bishop's see of Sweden, capital of the county of Vestmanland, on a northern bay of Lake Mälar, 60 miles north-west by west of Stockholm. Its Gothic cathedral, consecrated in 1271, was restored in 1850–60, and again in 1896–98. The episcopal library contains the valuable collection of books which Oxenstierna, the chancellor of Gustavus Adolphus, brought away from Mainz near the end of the Thirty Years' War. There is a 16th-century castle, built by Gustavus Vasa. Several national diets were held in this town, the most notable being those of 1527, when Gustavus Vasa formally introduced the Reformation into Sweden, and 1544, when he had the Swedish throne declared hereditary in his family. Population (1880), 6201; (1890), 8122; (1900), 11,999.

Westerly, a town of Washington county, Rhode Island, U.S.A., containing an area of 31 square miles of undulating country with marshes and ponds, in the south-western corner of the state. The principal village, also known as Westerly, lies on Pawcatuck river, and on the New York, New Haven, and Hartford Railroad. It is irregular in plan, and its principal industry is the manufacture of cotton and woollen goods, while granite is quarried in the town. Other villages are White Rock, Potter Hill, Avondale, Watch Hill, and Noyes Beach, the two last being seaside resorts. The town was incorporated in 1669. Population of the town (1880), 6104; (1890), 6813; (1900), 7541, of whom 1788 were foreign-born and 185 negroes.

Westfield, a town of Hampden county, Massachusetts, U.S.A., containing an area of 41 square miles of fairly level surface, situated in the south-western part of the state. The principal village, also known as Westfield, is beautifully situated in a valley, is irregularly laid out, but has broad streets, excellent water-supply and sewerage systems, and extensive manufactures of a great variety of articles. It is on the Boston and Albany and the New York, New Haven, and Hartford railways. Population of the town (1880), 7587; (1890), 9805; (1900), 12,310, of whom 2441 were foreign-born and 81 negroes.

West Ham, a parliamentary and county borough and suburb of London, in the county of Essex, England. The parish stretches north and south from Wanstead and Leyton to the Thames, and east and west from East Ham to the river Lea. It is divided into four wards—Church Street, Stratford-Langthorne, Plaistow, and Upton. The manor of West Ham was settled upon Stratford-Langthorne Abbey, founded by William de Montfichet in 1135 for monks of the Cistercian order. The abbey stood in the marshes, on a branch of the Lea known as the Abbey Creek, about half-a-mile south of Stratford Broadway. West Ham Church, dedicated to All Saints, is a large building, which contains some interesting features and a good Perpendicular west tower. In the restoration of 1866 a Transition Norman clerestory was discovered. West Ham Park (80 acres) occupies the site of Ham House and park, for many years the residence of Samuel Gurney, the banker and philanthropist. The place was purchased for £25,000, and vested in the Corporation of London for the use of the public. Of this amount the Gurney family contributed £10,000 and the Corporation the same sum, the remaining £5000 being collected from the inhabitants of West Ham. The house was taken down, and the park was formally opened for public use by the Lord Mayor on the 20th July 1874. Mrs Elizabeth Fry lived in a house in Upton Lane, on the confines of her brother's park. In 1762 the number of houses in West Ham parish was stated to be 700, of which "455 are mansions and 245 cottages." Now few large houses remain, but the smaller houses have greatly increased. West Ham has become the home of chemical and other manufactures which have been driven away from London itself; and its large population, which has increased by leaps and bounds, can be also traced to the foundation of the Victoria and Albert docks at Plaistow. Population (1871), 99,142; (1881), 200,958; (1891), 204,903; (1901), 267,308.

West Haven, a borough of New Haven county, Connecticut, U.S.A., on New Haven harbour, adjoining the city of New Haven, of which it is a suburb. Population (1900), 5247, of whom 893 were foreign-born.

West Hoboken, a town of Hudson county, New Jersey, U.S.A., on the Hudson river cliffs, north of Jersey city, and opposite New York. It is largely engaged in silk manufacture, for which there are several factories. Population (1880), 5441; (1890), 11,665; (1900), 23,094, of whom 9119 were foreign-born.

West Indies, The, sometimes called the Antilles (a name more properly applied to the West India Islands, excluding the Bahamas), an archipelago stretching in the shape of a rude arc or parabola from Florida and Yucatan in North America to Venezuela in South America, and enclosing the Caribbean Sea (615,000 square miles) and the Gulf of Mexico (750,000 square miles in area). The land area of all the islands is nearly 100,000 square miles, with an estimated population of about 6½ millions; that of the British islands about 12,000 square miles. The islands differ widely one from another in area, population, geographical position, and physical characteristics. They are divided into the Bahamas, the Greater Antilles (Cuba, Jamaica, Hayti, and Porto Rico), and the Lesser Antilles (comprising the remainder). The Lesser Antilles are again divided into the Windward Islands and Leeward Islands. Geographically, the Leeward Islands are those to the north of St Lucia, and the Windward, St Lucia and those to the south of it; but for administrative purposes the British islands in the Lesser Antilles are grouped as is shown in the table given later.

The population of the West Indies represents many original stocks, the descendants of which have developed variations of habits and customs in their New World environment. They may be divided into six main classes: (1) Europeans — immigrants (English, French, Spanish, and in a lesser degree Dutch, Danish, and German) and West Indian born; (2) African negroes—immigrants (a fast vanishing quantity) and West Indian born; (3) a mixture of Europeans and Africans; (4) coolies from India—imported and West Indian born; (5) Chinese; (6) aboriginal Indians of more or less pure descent. Of these, the people of pure African blood are in a large majority, the "coloured" race of mixed European and African blood being next in numerical importance. Under English influence the negroes of the West Indies have become English in thought and habit; and it would seem that the stimulating influence of European direction and encouragement is absolutely necessary for the future development and progress of these islands. Owing to recent occupation by the United States, Cuba and Porto Rico are in a state of transition. In the republics of San Domingo and Hayti the negroes are left to drift along, while the French and Danish islands show no great sign of progress.

Area and Population.—The following list of the West India islands gives their area and population (in the case of British islands, that of 1881 compared with that of 1897), British Guiana and British Honduras—which for the purposes of colonial administration are classed with the West India islands—being omitted. Notwithstanding the operations of educational institutions and of large numbers of missionaries of various religious denominations, the percentage of illegitimate births amongst the population of the British West Indian islands still remains very high—in Barbados, 53·9; in Jamaica, 63·4; in Trinidad, 59·2 per cent. of the general births; and 79·2 per cent. of the East Indian.

Nationality Name.	Area.		Population.			
	Square Miles.		1881 (Census).		1897 (estimated).	
British Colonies—						
BAHAMAS		4,466		43,521		52,000
JAMAICA	4200	4,369	584,170	588,902	706,394	711,749
TURKS ISLAND	169		4,732		5,355	
LEEWARD ISLANDS:						
Virgin Islands	57	665	5,287	119,546		129,751
St Kitts	115		41,001			
Nevis						
Antigua	170		34,964			
Montserrat	32		10,083			
Dominica	291		28,211			
BARBADOS		166		171,860		190,000
WINDWARD ISLANDS:						
St Lucia	233	498	38,551	121,502	47,332	154,743
St Vincent	132		40,548		46,112	
Grenada	133		42,403		61,299	
TRINIDAD		1,868		171,179		275,363
TOBAGO						
French Colonies—						
Guadeloupe and dependencies	722	1,143		..	170,000	360,692
Martinique	400				187,692	
St Martin (part)	21				3,000	
Dutch Colonies—						
St Martin (part)	17	404		..	4,023	48,175
Curaçao	210				28,187	
Buen Ayre	95				4,399	
Aruba	69				7,888	
St Eustatius	8				1,613	
Saba	5				2,065	
Danish Colonies—						
St Thomas	23	118		..	32,786	52,166
St John	21				950	
St Croix	74				18,430	
United States Territory—						
Porto Rico		3,550		..		806,708
Republics—						
San Domingo	20,588	29,830		..	500,000	1,744,650
Hayti	9,242				1,244,650	
Cuba		45,000				1,631,687
Grand total		92,077		1,216,510		6,157,684

The total value of the imports into the British West Indies in 1898 was £6,323,413, and exports £5,657,391, there being but little change for twenty years.

Government.—The British West India colonies are either Crown colonies—that is to say, their government is absolutely under the control of the British Colonial Office, the official members of their councils predominating, and the unofficial members being nominated by the Crown, as in the Windward and Leeward Islands—or they have a measure of representative government, as in the Bahamas, Barbados, British Guiana, Trinidad, and Jamaica, in which all or part of the legislatures are elected and are more or less independent of Crown control. The laws of the various colonies are English, with local statutes to meet local needs. The governors and high officials are appointed by the Crown; other officials are appointed by the governor. Each governor acts under the advice of a privy council.

Religion.—In all the British colonies there is full religious toleration. The Church of England Province of the West Indies is divided into the following bishoprics:—Jamaica, Nassau (*i.e.*, Bahamas), Trinidad, (British) Honduras, Antigua (*i.e.*, Leeward Islands), Barbados, Windward Islands, (British) Guiana. With the exception of Barbados and British Guiana, the Church of England is disestablished, disendowment taking place gradually, the churches thus becoming self-supporting. In Barbados the Church is both established and endowed. In the Bahamas and Jamaica disendowment is gradually taking place; in Trinidad and British Guiana the Church of England receives endowment concurrently with other religious bodies. The Windward Islands, Leeward Islands, and British Honduras are totally disendowed. In all the islands, except Trinidad, St Lucia, Grenada, and Dominica, the Church of England, though in all cases in a minority when compared with the aggregate of other bodies, is the most numerous of any denomination. There are Roman Catholic bishops at Port-of-Spain (Trinidad), Roseau (Dominica—for the Leeward Islands), Jamaica, British Guiana and Barbados (resident at Georgetown), British Honduras, Guadeloupe, Martinique, Hayti (archbishop and four bishops), San Domingo (archbishop), Cuba (archbishop and bishop), Porto Rico, and Curaçao. Other religious denominations working actively in the West Indies are the Baptists, Wesleyans, Presbyterians, Congregationalists, and Moravians.

Defence.—The only fortified places in the British West Indies are Jamaica, Barbados, and St Lucia—all of importance as coaling stations. In many of the islands there are local volunteer forces.

The police forces of the colonies are in the main modelled on the Irish constabulary, supplemented by rural constabulary. The force is usually officered by Europeans. The only naval dockyard is at Port Royal, Jamaica.

Production.—The great change of the last quarter of the 19th century has been the further decline of sugar cultivation and the development of that of bananas and other fruits, and in Trinidad and Grenada, of cacao. Of the islands, Barbados, Antigua, St Kitts, and Nevis are extremely well fitted for the cultivation of sugar, and hardly for that of any other product valuable for exportation. In 1902 Martinique and St Vincent suffered severely from volcanic eruptions. With a view to the improvement of agriculture in Barbados and the Windward and Leeward Islands in particular—and throughout the British West Indies generally—a Commissioner of Agriculture for the West Indies has been appointed at the expense of the British Exchequer, having his headquarters at Barbados. The general movement of trade is towards the United States (where most of the British West Indies find the best markets for their produce) at the expense of Great Britain. In order to foster trade with the mother country, a direct line of subsidized steamers was started to Jamaica in 1901.

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(F. CU.)

Westmeath, an inland county of Ireland, province of Leinster, bounded on the N. by Longford and Meath, on the E. by Meath, on the W. by Roscommon, and on the S. by King's County.

Population.—The area of the administrative county in 1900 was 434,626 acres, of which 78,489 were tillage, 86,542 pasture, 194 fallow, 7915 plantation, 35,127 turf bog, 5219 marsh, 880 barren mountain, and 20,260 water, roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, includes the portion of the town of Athlone formerly situated in Roscommon. The population in 1881 was 71,798; in 1891, 65,109; and in 1901, 61,629, of whom 31,880 were males and 29,749 females, divided as follows among the different religions: Roman Catholics, 56,673; Protestant Episcopalians, 4271; Presbyterians, 319; Methodists, 251; and other denominations, 115. The decrease of population between 1881 and 1891 was 9·32 per cent., and between 1891 and 1901, 10·18 per cent. The average number of persons to an acre in 1891 was ·16, and of the total population 56,546 persons inhabited the rural districts, being an average of 100 to each square mile under crops and pasture The following table gives the degree of education in 1891:—

	Males.	Females.	Total.	Percentage			
				R. C.	Prot. Epis.	Pres.	Meth.
Read and write	22,253	19,948	42,201	69·5	93·9	90·6	93·0
Read only .	3,476	3,656	7,132	12·8	3·2	6·5	2·7
Illiterate . .	5,154	4,646	9,800	17·7	2·9	2·9	4·3

The percentage of illiterates among Roman Catholics in 1881 was 25·0. In 1891 there were 5 superior schools with 345 pupils (Roman Catholics, 186, and Protestants, 159), and 154 primary schools with 9200 pupils (Roman Catholics 8609, and Protestants 591). The number of pupils on the rolls of the National schools on 31st December 1900 was 10,419, of whom 9805 were Roman Catholics and 614 Protestants. The following table gives the number of births, deaths, and marriages in the years specified:—

Year.	Births.	Deaths.	Marriages.
1881	1018	812	139
1891	1334	1076	238
1900	1140	1197	219

In 1900 the birth-rate per 1000 was 8·0, and the death-rate 9·5; the rate of illegitimacy was 1·9 per cent. of the total births. The total number of emigrants who left the county between 1st May 1851 and 31st December 1900 was 50,283, of whom 26,738 were males and 23,545 females. The chief towns in the county, with their populations in 1901, are: Athlone, 6617; Mullingar, 4500.

Administration.—The county is divided into two parliamentary divisions, North and South, the number of registered electors in 1901 being respectively 6208 and 6570. The rateable value in 1900 was £323,523. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the grand jury were transferred to a county council, urban and rural district councils were established, and under that Act the county now comprises one urban and six rural sanitary districts.

Agriculture.—The following tables show the acreage under crops, including meadow and clover, and the amount of live stock in 1881, 1891, 1895, and 1901. The figures for 1901 are for the new administrative county.

Year.	Wheat.	Oats.	Barley, Rye, &c.	Potatoes.	Turnips.	Other Green Crops.	Meadow and Clover.	Total.
1881	147	22,837	494	11,771	5319	2717	54,560	97,845
1891	91	16,757	751	10,251	4692	2678	48,384	83,604
1895	45	15,540	468	9,096	4364	3013	49,345	81,866
1901	120	13,272	545	8,293	3798	3283	48,516	77,827

In 1900 it was estimated that the total value of the cereal and other crops was £492,185. The number of acres under pasture in 1881 was 269,379; in 1891, 278,438; and in 1900, 286,542.

Year.	Horses & Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	12,268	4323	100,150	128,751	16,722	6108	275,246
1891	13,870	4740	108,134	157,488	19,487	7717	294,250
1895	14,529	4870	109,731	127,133	18,614	7125	305,467
1901*	12,104	5482	116,997	131,276	14,916	6909	324,575

* The figures for 1901 have not been revised.

The number of milch cows in 1891 was 14,794, and in 1901, 15,330. It is estimated that the total value of cattle, sheep, and pigs for 1901 was £1,761,938. In 1900 the number of holdings not exceeding 1 acre was 2217; between 1 and 5, 1728; between 5 and 15, 2367; between 15 and 30, 2134; between 30 and 50, 1372; between 50 and 100, 1058; between 100 and 200, 540; between 200 and 500, 289; and above 500, 47; total, 11,752. The number of loans issued (the number of loans being the same as the number of tenants) under the Land Purchase Acts, 1885, 1891, and 1896, up to 31st March 1901, was 726, amounting to £313,873. The number of loans for agricultural improvements sanctioned under sect. 31 of the Land Act, 1881, was 344, and the amount issued £30,276. The total amount issued on loan for all classes of works under the Land Improvement Acts from the commencement of operations in 1847 to 31st March 1901 was £106,465.

Westminster, largely synonymous with what is known as the "West End" of London, was formed into a borough by the London Government Act of 1899, and created a city by royal charter of the 29th of October 1900. It is governed by a mayor, ten aldermen, sixty councillors, and has as a municipality superseded the ten previously existing vestries and the district board of works. It comprises the three parliamentary boroughs of the Strand, Westminster, and St George's Hanover Square—each returning one member to the House of Commons—and three poor-law unions, which have the same names as, but yet are not conterminous with, the parliamentary boroughs. Westminster is bounded on the E. by the City of London and Clerkenwell, on the N. by Oxford Street, on the W. by South Kensington and Chelsea, and on the S. by the Thames. Its rateable value in 1901 was roughly 5½ millions sterling, and the population 183,000. It has five public libraries, five public baths, and a cemetery at Hanwell.

In Westminster centres the official and to a great extent the social and fashionable life of the metropolis, and within the past few years public and private enterprise have laboured together to embellish it in a manner befitting its dignity. A large number of imposing buildings have been erected, new thoroughfares laid, and old thoroughfares widened.

Proceeding westwards from Temple Bar, the work of reconstruction is immediately visible; the removal of Holywell Street has permitted at that point the widening of the Strand, which is to be continued throughout its whole length to Charing Cross. Opposite Somerset House a new street is planned to connect the Strand with Holborn. But it is in and around Charing Cross that the greatest changes have been effected. Old Northumberland House has given way to an avenue flanked by huge hotels and clubs; the National Gallery has received an addition in the New Portrait Gallery, in Italian palatial style, adjoining it on the north side. From this point the new Charing Cross Road, which has swept away many of the purlieus of Soho, proceeds to Tottenham Court Road, being joined at Cambridge Circus by another new artery, Shaftesbury Avenue. In Whitehall, the Admiralty has been enlarged by a wing abutting on St James's Park; a new War Office is in process of erection on a site between the Horse Guards Avenue and Whitehall Place; the banqueting hall of the former Whitehall Palace has been converted into the United Service Institution; and a magnificent pile of new Ministerial offices, to house the Local Government Board, Board of Education, and Board of Trade, is being built immediately south of the Home Office. The Victoria Embankment has been further embellished, and is now flanked by new municipal and other buildings, such as School Board Offices, Medical Examination Hall, some large hotels, Whitehall Court, the National Liberal Club, and New Scotland Yard, and may be described as one of the most magnificent thoroughfares in the world.

Although the project of continuing the Embankment to Chelsea has not yet been realized, the way has been prepared by the rebuilding of Vauxhall Bridge and the erection, on the site of the Millbank Penitentiary, of the Tate Gallery of British Art, opened in 1897 and enlarged in 1899. The Victoria station of the London, Brighton, and South Coast Railway is being rebuilt, with a frontage to Buckingham Palace Road, at an estimated cost of two millions sterling. In and around the Green Park other great changes have been made—Constitution Hill has been thrown open to vehicular traffic, Piccadilly has been widened at Hyde Park Corner. To the north of this thoroughfare the district about Grosvenor Square has been rebuilt on an extensive scale, whilst on the extreme west the Imperial Institute, erected in 1887–93, is now the seat of London University.

Ecclesiastical buildings.

In the Abbey itself, among the illustrious dead who have been laid there come the names of Darwin, Tennyson, Browning, Gladstone. The Church House, adjoining Dean's Yard—a memorial of Queen Victoria's Jubilee, 1887—consists at present of a spacious hall in brick and stone, with offices for many Church societies. The Roman Catholic Cathedral in Ashley Gardens is the most notable church built of recent years. The edifice is of brick and stone, in Early Byzantine style, and of grand proportions; its length being 360 feet, breadth 156 feet, height to cupola of nave 117 feet, while its campanile tower, since the destruction of that in Venice the highest in the world, soars to a height of 283 feet. The foundation stone was laid in 1896, and it was proposed to consecrate and open the building for divine service in 1903.

Westmorland, a north-western county of England, bounded on the S. and S.W. by Lancashire, on the N.W. and N. by Cumberland, on the N.E. by Durham, and on the E. and S.E. by Yorkshire.

Area and Population.—The area of the ancient and administrative county, as given in the census returns, is 500,906 acres or 783 square miles, with a population in 1881 of 64,191; in 1891 of 66,098, of whom 32,326 were males and 33,772 females; and in 1901 of 64,305, the number of persons per square mile being 82, and of acres to a person 7·8. The area of the registration county is 503,073 acres, with a population in 1891 of 66,215, of whom 24,949 were urban and 41,266 rural; and in 1901 of 64,411, of whom 30,551 were males and 33,860 were females. Within this area there was between 1881 and 1891 an increase of 2·96 per cent., but between 1891 and 1901 a decrease of 2·7 per cent. The excess of births over deaths between 1881 and 1891 was 8553, and the actual increase of population was 1907. The following table gives the numbers of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1898:—

Year.	Marriages.	Births.	Deaths.	Illegitimate Births.	
				Males.	Females.
1880	412	1995	1177	66	76
1890	423	1711	1020	68	58
1898	423	1541	906	47	49

The number of marriages in 1899 was 460, of births 1534, and of deaths 874. The following table gives the marriage-, birth-, and death-rates per thousand of the population, with the percentage of illegitimate births, for a series of years:—

	1870–79.	1880.	1880–89.	1890.	1888–97.	1898.
Marriage-rate . .	14·4	12·8	12·7	12·8	12·8	12·6
Birth-rate . .	31·0	30·9	29·1	26·0	25·7	22·9
Death-rate . .	17·7	18·2	15·8	15·4	15·1	13·4
Percentage of illegitimacy . .	7·7	7·1	7·0	7·3	6·4	6·2

The marriage-, birth-, and death-rates are below the average, but the percentage of illegitimacy is high. In 1891 there were in the county 1114 natives of Scotland, 625 natives of Ireland, and 84 foreigners.

Constitution and Government.—The county contains two municipal boroughs: Appleby (1764) and Kendal (14,183). The following are urban districts: Ambleside (2536), Bowness-on-Windermere (2682), Grasmere (781), Kirkby Lonsdale (1638), and Windermere (2379). The ancient county, which is entirely in the diocese of Carlisle, contains 81 entire ecclesiastical parishes or districts, and parts of 3 others.

Education.—The total number of elementary schools on 31st August 1899 was 116, of which 20 were board and 96 voluntary schools, the latter including 81 National Church of England schools, 1 Roman Catholic, and 14 "British and other." The average attendance at board schools was 1159, and at voluntary schools 8805. The total school board receipts for the year ended 29th September 1898 were over £5591. The income under the Agricultural Rates Act was over £459.

Agriculture.—Only about one-half of the total area of the county is under cultivation, and of this acreage about five-sixths is in permanent pasture, both cattle and sheep being largely kept. There are also about 208,000 acres in hill pasture, and over 17,000 acres are under woods. Orchards occupy over 400 acres, and small fruit on an average only about 100 acres. About sixteen-seventeenths of the acreage under corn crops is occupied by oats, and of the remaining 1000 acres the larger half is occupied by barley, and usually only about 200 acres by wheat, both these latter acreages having greatly diminished. About three-fourths of the acreage under green crops is occupied by turnips, potatoes occupying usually less than one-seventh. The following table gives the acreages of the larger main divisions of the cultivated area at intervals from 1885:—

Year.	Total Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885	250,465	18,947	9,848	15,798	205,608	263
1890	251,575	19,010	10,047	16,049	206,175	255
1895	250,972	17,910	9,958	16,909	205,942	120
1900	248,279	16,064	8,828	16,899	206,360	62

The following table gives particulars regarding the principal live stock for the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or in Calf.	Sheep.	Pigs.
1885	8620	65,586	24,434	332,923	4617
1890	8850	65,194	25,136	359,787	5979
1895	9614	64,107	23,644	359,978	4755
1900	8942	67,608	24,096	374,453	4274

Industries and Trade.—According to the report for 1898 of the chief inspector of factories (1900), the total number of persons employed in factories and workshops in 1897 was 4401, as compared with 4187 in 1896. In non-textile factories 3085 persons were employed. Explosives are manufactured. In 1899, 71,492 tons of limestone were raised, 66,000 tons of granite, 2953 tons of slate, and 810 tons of coal. The production of lead was 1198 tons (below the average) valued at £11,976; of gypsum, 6009 tons valued at £1352, as compared with 2100 tons in 1890.

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Weston-super-Mare, an urban district and watering-place, in the Wells parliamentary division of Somersetshire, England, 20 miles south-west of Bristol by rail; on a recess in the Bristol Channel. A north aisle was added to the parish church of St John the Baptist in 1891. A new wing was added to the town hall in 1897. In 1896 the urban district council purchased an extensive bathing establishment. Grove Park, once the manor house, is now the property of the council, and is used as a free library, its grounds being laid out as a public park. The free library and museum, on the Boulevard, erected to commemorate Queen Victoria's Diamond Jubilee, was opened in 1900. Population (1891), 15,860; (1901), 19,047.

West Orange, a town of Essex county, New Jersey, U.S.A., in the north-eastern part of the state, on a branch of the Delaware, Lackawanna, and Western Railroad. Population (1890), 4358; (1900), 6889, of whom 1772 were foreign-born.

Westphalia, a western province of Prussia, with an area of 7803 square miles, and population (1895) of 2,701,420; (1900), 3,187,977. This province contains the principal coal-fields of Germany, the chief centre being Dortmund and the vicinity. The output has increased very greatly since 1870, when 11,570,600 tons were produced; in 1880 the output was 22,495,200 tons; in 1890, 35,469,300 tons; and in 1900, 42,557,150 tons, valued at £17,958,000. In 1900 the number of workmen employed was 167,839. The other chief mining statistics for 1900 are as follows:—1,215,000 tons of iron ore, valued at £639,550; 19,997 tons of zinc, valued at £78,800; 10,730 tons of lead, valued at £106,700; copper, 44,985 tons, valued at £18,400; and 145,130 tons of pyrites, valued at £49,100: aggregate value of all minerals mined in the province in 1900, £18,850,000. Of Glauber salts, 4640 tons, valued at £6000, and 26,800 tons of common salt, valued at £37,150, were also produced in the same year. The smelting furnaces produced 1,684,965 tons of iron, valued at £5,743,500; 14,920 tons of zinc, valued at £307,800; and 64,960 tons of sulphuric acid, valued at £74,950: total value of metals, £6,126,250. The iron foundries, forges, &c., yielded 387,957 tons of ingots, bars, pig-iron, rails, &c., valued at £3,177,650. Of the area of this province 42·5 per cent. is arable and garden ground, 25 per cent. meadow and pasture, and 28 per cent. forest. Dairying and gardening are thriving industries. There are a dairy school (at Dortmund) and two agricultural colleges, a dozen agricultural schools, and an agricultural experimental station (at Münster); there is also a State stud (horses) at Warendorf. In 1900 the live stock embraced 883,476 pigs, 660,452 cattle, 223,609 sheep, and 155,427 horses. In 1900 the sugar factories produced 17,620 tons of sugar; the breweries, 85,061,200 gallons of beer; and the distilleries, 2,873,000 gallons of pure alcohol.

West Pittston, a borough of Lackawanna county, Pennsylvania, U.S.A., in the valley of the North Branch of the Susquehanna river, in the anthracite coal region, in the north-eastern part of the state. Population (1900), 5846, of whom 1192 were foreign-born.

West Point, a military post, and the seat of the United States Military Academy. It is on the west bank of the Hudson river in Orange county, New York, and on the West Shore Railroad, in the south-eastern part of the state. The site of the academy is on high ground, 180 feet above the river. This academy is the training school for army officers. The students, known as cadets, commonly number about 300. Each Congressional district and each Territory is entitled to have one cadet in the Academy, who is appointed by the Secretary of War at the request of the representative or delegate in Congress from the district or Territory in which the person so appointed is a resident. The course of instruction is an arduous one, requiring four years of study and drill. The instructors are officers of the regular army.

West Springfield, a town of Hampden county, Massachusetts, U.S.A., containing 18 square miles of broken country, west of the Connecticut river, in the southern part of the state. It contains a few small villages, but most of the population is rural. Population (1880), 4149; (1890), 5077; (1900), 7105, of whom 1501 were foreign-born.

West Troy. See WATERVLIET.

West Virginia, one of the eastern states of the American Union. The population of the state in 1900 was 958,800, as compared with 762,794 in 1890 and 618,457 in 1880. The percentage of increase from 1890 to 1900 was 25·7, as against 23·3 for the decade just preceding. Of the population in 1900, 499,242 were males and 459,558 were females; 936,349 were native-born, and only 22,451 (2·3 per cent.) were foreign-born. The negroes and persons of negro descent numbered 43,499, or about 4·5 per cent. of the total population. The white population born of native parents was 88 per cent. of the total, and of this white population probably 90 per cent. are descended from Revolutionary stock. The urban population in 1900 (classing as such all persons in cities of more than 4000 inhabitants) was 11·6 per cent. of the total, as compared with 8·8 per cent. in 1890. Out of 240,970 adult males in 1900, 32,066 were illiterate (unable to write), of whom 5584 were negroes and 2904 were foreign-born. The total land surface of West Virginia is approximately 24,645 square miles, the average number of persons to the square mile being 31 in 1890 and 38·9 in 1900. There were (1900) 140 incorporated cities, towns, and villages, of which twenty-two had a population of more than 2000 inhabitants; of these, eight had more than 5000, namely, Wheeling with 38,878, Huntington with 11,923, Parkersburg with 11,703, Charleston with 11,099, Martinsburg with 7564, Fairmont with 5655, Grafton with 5650, and Moundsville with 5362 inhabitants. Although destined to become one of the first coal-mining and oil-producing states of the Union, West Virginia is yet chiefly agricultural and grazing, and the population is composed chiefly of independent persons living upon their own land.

Education, Charity, &c.—The number of free public schools in the state in 1900 was 5691, with 7179 teachers and an attendance of 151,254 pupils. These were supported by local taxes to the amount of $1,669,201 and state funds to the amount of $349,964. There were six normal schools supported by legislative grants from the state treasury, with 48 teachers and an attendance of 1557 students. The state also possesses what is known as the state school fund, into which certain state revenues annually pass, and which, 1st July 1900, amounted to $1,040,968; the interest from the investment of this fund is a perpetual income for the support of the schools of the state, in supplement to the additional moneys raised by direct local taxation. The University of West Virginia, which is supported by state grants, is situated at Morgantown, and had, in 1900, 65 instructors and 800 students. The state also supports the preparatory branch of the University at Montgomery, with 4 teachers and 64 students; the West Virginia Coloured Institute, in Kanawha county, 11 teachers, 168 students; the Bluefield Coloured Institute at Bluefield, 5 teachers, 70 students; two hospitals for the insane—one at Weston, the other at Spencer—with a total of 1629 inmates; an asylum for the blind, at Romney, with 19 instructors and 209 inmates; a reform school for boys, at Pruntytown, with 288 inmates; an industrial school for girls, at Salem, with 50 inmates. The penitentiary, at Moundsville (508 inmates), is entirely supported by the profits derived from the labour of the convicts. There are miners' hospitals at Fairmont, McKendree, and Welch, and also an asylum for incurables at Huntington. The leading religious denominations in the order of their size (1900) are the Methodist, the Baptist, the Roman Catholic, the United Brethren, and the Presbyterian.

Banks.—There were in the state (30th June 1900) 34 national banks, with a paid-up capital of $3,551,000, surplus and undivided profits of $1,238,070, and deposits of $11,919,158; 89 state banks, with capital of $3,449,000 and deposits of $19,362,000; 6 savings banks or banks of deposit with savings departments, with $1,461,000 savings deposits. The legal rate of interest is 6 per cent.

Coal and Coke.—In 1899 the coal-mines of West Virginia produced 18,201,189 long tons (2240 ℔) of bituminous coal; 1,950,179 tons (of 2000 ℔) of coke were manufactured; 8591 coke ovens were in blast; and 24,726 men were employed at 3000 collieries, working an average of 240 days in the year. West Virginia is now the third state in the Union in the production of coal, and second in that of coke. Of the fifty-five counties, fifty are more or less underlain by coal. The state contains over 22,000 square miles of coal area, the most extensive in the United States. The building of the Chesapeake and Ohio Railway in 1872 from tidal water at Newport News, and its completion to Cincinnati, Ohio, in 1888, opened up the extensive deposits of bituminous coal in the counties of Raleigh, Fayette, and Kanawha, along the New and Great Kanawha rivers. In the New River coal-field the coals are known as the No. 12 (after Rogers) measures or conglomerate (or Pottsville Conglomerate of Pennsylvania geology). In these measures some sixty mines and collieries ship coal east and west, and 3000 ovens are manufacturing coke. The fixed carbon in the coals averages as high as 70 to 72 per cent., and in the coke as high as 94 to 96 per cent. Along the Kanawha valley great development in the coal measures known as No. 13 (Rogers), or Freeport and Kittanning measures of the Pennsylvania geologists, have taken place. From the lower seams of the series (Kittanning seams) a superior coke is manufactured in Fayette county; and from the upper seams (Freeport) great quantities of coal locally known as "hard splint" or "block" coal, famous for its ability to stand transportation, is shipped east and west by rail, and west and south by water, on the Kanawha and Ohio rivers. The extensive system of locks and dams, completed by the United States Government in 1899, renders the shipment of coal from the mines by the Great Kanawha possible at all seasons of the year. The building of the Norfolk and Western Railway in 1884, from Norfolk, Virginia, on Chesapeake Bay, westward to and along the southern border of the state, has developed the now celebrated "Pocahontas" or "Flat Top" coal-field, where the No. 12 (Rogers) measures greatly thicken. These coals, like those of the New River and Kanawha basins, are worked by horizontal drifts, and have become renowned for their steam-producing qualities, being said to excel the famous Cardiff coals of Wales. Some fifty collieries are now shipping their coals eastwards to Norfolk and westwards to the Great Lakes and Chicago. The analyses of these coals are similar to the New River region, to which geologically they belong. In the northern district of the state extensive mines in the famous Pittsburg seam, along the upper waters of the Monongahela River, are shipping coal and coke by both Pennsylvania and Baltimore and Ohio railways' connexions. In the north-eastern "pan-handle" of the state, along the West Virginia Central and Pittsburg Railway, extensive mines are now working in the No. 13 measures (Rogers). Coal and coke are hauled directly to Baltimore and Philadelphia, and are thence shipped by rail and water.

Oil and Gas.—West Virginia has become one of the leading oil-producing states in the Union. The petroleum, known as white sand paraffin oil, is of the highest quality, and similar to that of the Pennsylvania pools. In 1899 there were 2412 new wells drilled, the total number of oil-producing wells was 10,200, and the total production was 13,910,620 barrels, with a value of $18,014,766. The oil is mainly pumped through pipe lines to Baltimore and Philadelphia, a distance of three or four hundred miles. The entire western district lies within probable oil-producing limits, and every month an increasing number of producing wells are opened. With the production of oil natural gas of great power has been developed. Most of the cities of the northern and western districts are now heated and lighted by gas which is piped directly from the wells, and the Pittsburg manufacturing region is also largely supplied. The production and transportation are regulated by stringent laws for the prevention of waste, and it is probable that West Virginia will be an unfailing source of natural gas supply for many years. In 1899 the number of new gas wells drilled was 78; the total number was 338, with a value for the gas produced of $3,036,623.

Manufactures.—The following table shows the condition of the manufacturing industries in 1890 and 1900:—

	1890.	1900.	Percentage of Increase.
Number of establishments	2376	4415	85·8
Capital	$28,118,030	$55,719,938	98·2
Wage - earners, average number . . .	19,340	33,085	71·1
Total wages . . .	$6,911,779	$12,876,902	86·3
Value of products . .	$38,702,125	$74,177,681	91·7

The leading industries were iron and steel, lumber and timber products, flouring and grist mill products, coke, and leather.

Political History.—The original situation of the state capitol at Wheeling in the northern "pan-handle," at the extreme north-western border, was necessarily inconvenient to the people at large. So early was this recognized, that in the session of the legislature of 1869 a resolution was passed to remove the capitol to a more central situation, and Charleston, in Kanawha county, was chosen. In May 1870 the archives of the state were moved to Charleston and lodged in a building erected for the purpose, presented by the citizens of the Great Kanawha valley. The accommodation for the state's needs was still too contracted however, and on 20th September 1875 the capitol was transferred back to Wheeling, and there remained for a period of ten years. Meanwhile the question of the permanent situation was submitted to a vote of the people in August 1877, and Charleston, receiving a majority of the votes, was selected as the seat of the state government. A new and commodious capitol building was then erected, and upon its completion in the spring of 1885, the archives were removed from Wheeling. In 1894 the Republican party carried the state for the first time since the Civil War, and in 1896 it elected a full state ticket and all four Congressmen; West Virginia was thus the first Southern state to leave the Democrat ranks and become entirely Republican. In 1900 McKinley received a still larger majority over Bryan than in 1896. This great political change was due partly to extensive emigration from Ohio and Pennsylvania, and partly to general economic conditions and manufacturing interests. (W. S. E.)

Westward Ho, a seaside resort of England, on the east side of Barnstaple Bay, Devonshire, and 2½ miles north-west of Bideford. It is of modern growth (since about 1867), and takes its name from Charles Kingsley's well-known novel. It is a favourite place of residence with Anglo-Indians and others, and has a college and first-rate golf links. It forms part of the parish of Northam, which had a population in 1901 of 5322.

Wetter (Swedish, *Vetter* or *Vätter*), a lake of Sweden, 733 square miles in area, with a drainage basin of 2528 square miles; length, 80 miles; breadth, 18 miles; maximum depth, 391 feet; altitude above sea-level, 289 feet. Its shores are picturesque, on the east side steep, and its waters of remarkable transparency and blueness. The lake is subject to sudden storms. Near the south end is the picturesque island of Visingsö (8 miles long by 2 broad), with a ruined palace of the Brahe family (1662). On the shores of the lake stand the towns of Jönköping and Vadstena. By the western branch of the Göta canal it has navigable communication with Lake Vener, and so with the Cattegat, and by the eastern branch of the same canal with the Baltic. Its only outflow is by the Motala river, on the east side. The mean depth on the sill of the sluice (made 1810) of the Motala is 10 feet; volume of discharge, 1118 cubic feet per second.

Wetteren, a town of Belgium, in the province of East Flanders, 9 miles south-east of Ghent by rail, on the right bank of the Scheldt. Its numerous manufactures include cotton and linen goods, lace and gunpowder. Population (1890), 11,923; (1900), 14,441.

Wetzlar, a town of Prussia, Rhine province, on the Lahn, 64 miles by rail east by north of Coblenz. It was formerly a free imperial town and the seat (1689–1806) of the Supreme Court of the empire, the archives of which are still preserved in the town. The most conspicuous building is the cathedral, dating in part from the 11th, in part from the 14th–16th centuries. The town preserves associations of Goethe, who lived here as an official of the Supreme Court, and of Charlotte Buff (cf. *Werthers Leiden:* Lotte). Overlooking the town are the ruins of the mediæval castle of Kalsmunt. There are iron mines, glove, optical instrument, and chemical factories. Population (1885), 7844; (1900), 9043.

Wexford, a maritime county of Ireland, province of Leinster, bounded on the N. by Wicklow, on the E. by St George's Channel, on the W. by Waterford, Kilkenny, and Carlow, and on the S. by the Atlantic Ocean.

Population.—The area of the administrative county in 1900 was 578,718 acres, of which 193,160 were tillage, 321,393 pasture, 204 fallow, 10,206 plantation, 794 turf bog, 7694 marsh, 17,090 barren mountain, and 28,177 water, roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, includes the portion of the town of New Ross, formerly situated in Kilkenny. The population in 1881 was 123,854; in 1891, 111,778; and in 1901, 103,860, of whom 51,614 were males and 52,246 females, divided as follows among the different religions: Roman Catholics, 95,284; Protestant Episcopalians, 7805; Presbyterians, 272; Methodists, 332; and other denominations, 167. The decrease of population between 1881 and 1891 was 9·75 per cent., and between 1891 and 1901, 7·3 per cent. The average number of persons to an acre was ·19, and of the total population, 86,810 persons inhabited the rural districts, being an average of 110 to each square mile under crops and pasture. The following table gives the degree of education in 1891:—

	Males.	Females.	Total.	Percentage.			
				R. C.	Pr. Ep.	Presb.	Meth.
Read and write	33,876	34,988	68,864	65·7	89·7	95·8	94·4
Read only .	5,750	7,081	12,831	13·4	4·9	1·4	1·8
Illiterate . .	10,234	9,654	19,888	20·9	5·4	2·8	3·8

The percentage of illiterates among Roman Catholics in 1881 was 27·4. In 1891 there were twelve superior schools with 589 pupils (Roman Catholics 537, and Protestants 52), and 200 primary schools with 15,070 pupils (Roman Catholics 13,894, and Protestants 1176). The number of pupils on the rolls of the National schools on 31st December 1900 was 14,312, of whom 13,177 were Roman Catholics, and 1135 Protestants. The following table gives the number of births, deaths, and marriages in the years specified:—

Year.	Births.	Deaths.	Marriages.
1881	3084	2551	554
1891	2314	2003	445
1900	2157	2050	479

In 1900 the birth-rate per 1000 was 20·8, and the death-rate 19·7; the rate of illegitimacy was 3·5 per cent. of the total births. The total number of emigrants who left the county between 1st May 1851 and 31st December 1900 was 72,109, of whom 37,953 were males and 34,156 females. The chief towns in the county are Wexford, New Ross, Enniscorthy, and Gorey.

Administration.—The county is divided into two parliamentary divisions, North and South, the number of registered electors in 1901 being respectively 9158 and 8800. The rateable value in 1900 was £384,456. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the grand jury were transferred to a county council, urban and rural district councils were established, and under that Act the county now comprises three urban and four rural sanitary districts.

Agriculture.—The following tables show the acreage under crops, including meadow and clover, and the amount of live stock in 1881, 1891, 1895, and 1901. The figures for 1901 are for the new administrative county.

Year.	Wheat.	Oats.	Barley, Rye, &c.	Potatoes.	Turnips.	Other Green Crops.	Meadow and Clover.	Total.
1881	7933	45,766	50,700	22,451	17,818	5623	59,695	209,986
1891	5984	50,717	34,036	23,057	18,942	6363	58,471	197,570
1895	3388	53,954	29,233	21,359	20,091	6327	63 635	107,987
1901	4664	44,718	31,978	18,868	20,245	8599	58,978	188,050

Wexford produces more barley than any other county in Ireland. In 1900 the total value of the cereal and other crops was estimated at £1,295,280, the largest amount of any county in Leinster. The number of acres under pasture in 1881 was 297,153, in 1891, 308,385, and in 1900, 321,393.

Year.	Horses and Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	28,300	8116	118,483	114,516	61,215	6023	557,517
1891	32,047	8341	126,011	203,250	80,459	8324	599,958
1895	35,055	8911	124,208	175,273	76,064	8279	671,780
1901*	31,048	9154	134,936	213,706	66,153	7384	735,039

* The figures for 1901 have not been revised.

The number of milch cows in 1891 was 35,824, and in 1901, 36,097. It is estimated that the total value of cattle, sheep, and pigs for 1901 was £2,254,200. In 1900 the number of holdings not exceeding 1 acre was 2578; between 1 and 5, 2165; between 5 and 15, 3070; between 15 and 30, 3031; between 30 and 50, 2625; between 50 and 100, 2447; between 100 and 200, 871; between 200 and 500, 189; and above 500, 18; total, 16,994. The number of loans issued (the number of loans being the same as the number of tenants) under the Land Purchase Acts, 1885, 1891, and 1896 up to 31st March 1901, was 1976, amounting to £993,925. The number of loans for agricultural improvements sanctioned under sect. 31 of the Land Act, 1881, between 1882 and 1901, was 224; and the amount issued, £17,608. The total amount issued on loan for all classes of works under the Land Improvement Acts from the commencement of operations in 1847 to 31st March 1901 was £137,890.

Fisheries.—In 1900 the number of vessels registered in the deep-sea and coast fishing district of Wexford was 92, employing 326 hands. In the same year the number of persons employed in the salmon fishing district of Wexford was 517. (W. H. Po.)

Wexford, a maritime town, capital of the above county, inland, on the river Slaney, 82 miles south of Dublin by rail. Under the Local Government (Ireland) Act, 1898, it retains its mayor and corporation, which, however, has now practically the status of an urban district council. In 1900, 567 vessels of 73,418 tons entered and 251 of 49,052 tons cleared. The number of vessels registered in the fishery district in 1900 was 92, employing 326 men and boys. Population (1891), 11,545; (1901), 11,154.

Wexiö, or Vexiö, a town and bishop's see of Sweden, county of Kronoberg, 124 miles north-east of Malmö by rail. It has been rebuilt since a fire in 1843. The cathedral dates from about 1300, but has been restored, the last time in 1898. The town has the Småland Museum, with antiquarian and numismatic collections, a library, and a bust of Linnæus; also a deaf and dumb school, an asylum for the insane, with iron foundries, a match factory, &c. On the shore of Lake Helga, 5 miles north from the town, is the royal palace of Kronoberg, and on an island in the lake the ruins of a former castle of the same name. Population (1890), 6606; (1900), 7365.

Weyler y Nicolau, Valeriano, Don (1839– ——), Spanish general, senator, and Marquis of Tenerife, was born on 17th September 1839 at Palma de Majorca. His family were originally Prussians, and served in the Spanish army for several generations. He entered at sixteen the military college of infantry at Toledo, and, when he attained the rank of lieutenant, passed into the staff college, from which he came out number one in his class. Two years afterwards he became captain, and was sent to Cuba at his own request. He distinguished himself in the expedition to Santo Domingo in many fights, and especially in a daring reconnaissance with few men into the heart of the enemy's lines, for which he got the cross with laurels of San Fernando. From 1868 to 1872 he served also brilliantly against the Cuban rebels, and commanded a corps of volunteers specially raised for him in Havana. He returned to Spain in 1873 as brigadier-general, and took an active part against the Carlists in the eastern provinces of the Peninsula in 1875 and 1876, for which he was raised to the rank of general of division. Then he was elected senator and given the title of Marquis of Tenerife. He held the post of captain-general in the Canary Isles from 1878 to 1883, and in the Balearic Isles afterwards. In 1888 he was sent out as captain-general to the Philippines, where he dealt very sternly with the native rebels of the Carolines, of Mindanao, and other provinces. On his return to Spain in 1892 he was appointed to the command first of the 6th Army Corps in the Basque Provinces and Navarre, where he soon quelled agitations, and then as captain-general at Barcelona, where he remained until January 1896. In Catalonia, with a state of siege, he made himself the terror of the Anarchists and Socialists. After Marshal Campos had failed to pacify Cuba, the Conservative Government of Canovas del Castillo sent out Weyler, and this selection met the approval of most Spaniards, who thought him the proper man to crush the rebellion. Weyler attempted to do this by a policy of inexorable repression against the non-combatant population that sympathized with the insurgents, literally leaving them no alternative but that of joining the enemy in the forests and bush or submitting to concentration within the Spanish lines, there to live on the barest means of existence doled out by the authorities. This stern policy, and vigorous military operations by which he drove the rebels out of four provinces to two in the eastern mountainous and forest-clad provinces, made Weyler famous, but precipitated the intervention of American diplomacy in the person of General Woodford, who insisted upon his recall. This recall was granted by the Liberal Government of Sagasta, but Weyler afterwards asserted that, had he been left alone, he would have stamped out the rebellion in six months. On his return to Spain he coquetted in succession with all the parties—Carlists, Republicans, Conservatives—and finally endeavoured to become the ally of the Liberals, with a view to getting some day into the War Office under Sagasta. He became in the meanwhile the most popular leader of the military malcontents of all ranks from the old colonial armies, and was looked upon as the likely dictator of the future and the man who would revive the influences of militarism in Spain. He kept quiet until he saw one of the Cuban generals, Linares, the defender of Santiago against the Americans, become War Minister. His appointment as captain-general in Madrid by Linares caused a ministerial crisis, involving the dismissal of two Conservative ministers—Dato and Gasset—who would not assent to the idea of placing at the head of the garrison of the capital such an ambitious officer. Silvela resigned the post of premier on seeing the impression caused by the appointment of Weyler, but he advised the Queen to send for General Azcarraga to form another Conservative administration that did not dare to dispense with the services of Linares as War Minister and of Weyler.

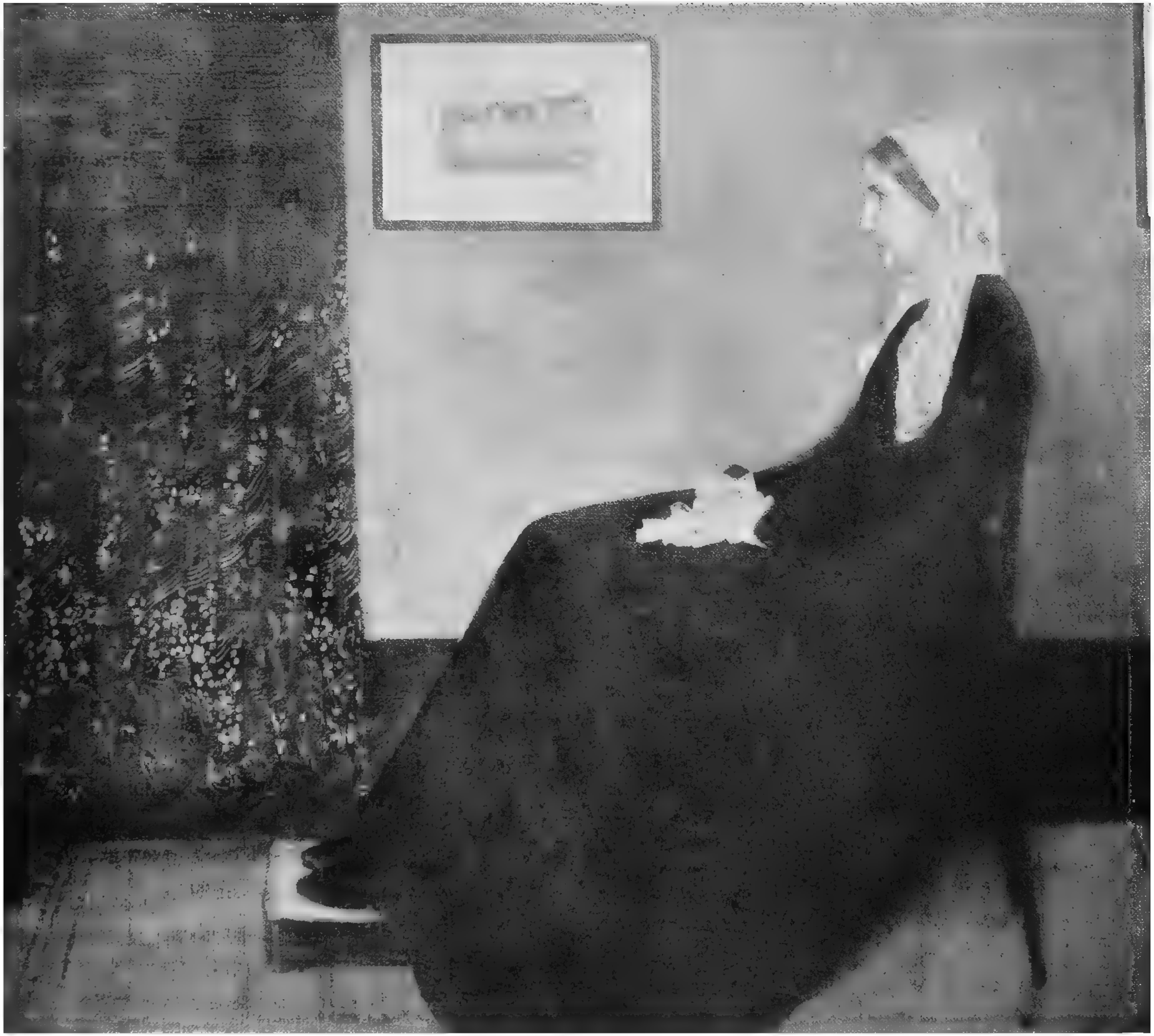
Weymouth and Melcombe Regis, a municipal borough (extended 1895), seaport, and market town in the southern parliamentary division of Dorsetshire, England, at the mouth of the Wey, 142 miles south-west by west of London by rail. The Royal Eye Infirmary has been enlarged, and cottage homes have been erected. Weymouth is the Great Western Railway packet station for the Channel Islands. In 1888 the registered shipping totalled 29 vessels of 2264 tons; in 1900, 22 vessels of 1241 tons. In 1888, 970 vessels of 108,778 tons entered, and 957 of 107,746 tons cleared; in 1900, 1032 vessels of 198,792 tons entered, and 1032 vessels of 197,689 tons cleared; these numbers include repeated voyages. The imports were in 1900 valued at £517,520 and the exports at £328,335. Population (1891), 16,100; (1901), 19,831.

Weymouth, a town of Norfolk county, Massachusetts, U.S.A., containing an area of 18 square miles of undulating country, in the eastern part of the state. It contains several villages, among which are Weymouth, East Weymouth, South Weymouth, and Weymouth Landing, most of the population of the town being rural. In the villages the principal industry is the manufacture of boots and shoes. Population (1880), 10,570; (1890), 10,866; (1900), 11,324, of whom 1845 were foreign-born.

Wheat. See Agriculture.

Wheeler, William Almon (1819–1887), Vice-President of the United States from 1877 to 1881, was born at Malone, New York, on the 30th of June 1819. After studying at the University of Vermont, he was admitted to the bar in 1845. As a Whig and then a Republican he played a substantial part in state politics, and represented his district in Congress from 1869 to 1877. His most notable achievement during this time was the pacification of parties disputing for the government of Louisiana through the so-called "Wheeler compromise" of 1875. Nominated for Vice-President by the Republicans in 1876 to serve with President Hayes, he was installed in office through the decisions of the electoral commission, and at the end of his term he retired from public life. He died at Malone on the 4th of June 1887.

Wheeling, a city of West Virginia, U.S.A., capital of Ohio county, and the largest and most important city in the state. It is situated in 40° 05′ N. and 80° 43′ W., in the "pan-handle," on the east bank of the river Ohio, and on an island in the river, at an altitude of 645 feet. It is regularly laid out, mainly in the level bottom lands, the residential portion spreading up on the cliffs. It is divided into eight wards, has a good water-supply by pumping, is sewered and well paved. It is an important railway centre, since the lines of seven companies enter the city. These are the Baltimore and Ohio; the Cleveland, Lorain, and Wheeling; the Ohio River; the Pittsburg, Cincinnati, Chicago, and St Louis; the Wheeling and Elm Grove; the Wheeling and Lake Erie, and the Wheeling Bridge and Terminal



Portrait of the Painter's Mother. By J. M'N. Whistler.

(From a Photograph by W. A. Mansell and Co.)

railways. These, with the boats on the river, which is navigable at all times of the year, afford ample facilities for commerce. It is primarily, however, a manufacturing city; in 1900 it contained 406 manufacturing establishments, with a total capital of $13,224,577. They employed 7219 hands, and the products had a value of $16,747,544. The item first in value was iron and steel, $5,833,950. In 1900 the assessed valuation of real and personal property was $23,683,532, the net debt of the city was $640,414, and the rate of taxation per $1000 was $18.90. Population (1890), 34,522; (1900), 38,878, of whom 5461 were foreign-born and 1066 negroes.

Whidah. See DAHOMEY.

Whippingham, a parish, Hampshire, England, in the Isle of Wight, 3½ miles north by east of Newport by rail, is beautifully situated above the estuary of the Medway. The chancel of the church of St Mildred was built at the sole cost of Queen Victoria. Osborne House, situated in this parish, was given to the British people in 1902 by King Edward VII. as a thank-offering for his coronation.

Whistler, James Abbott McNeill (1834——), American artist, was born, it is believed, in Lowell, Mass., about 1834. His father was Major G. W. Whistler, and his mother one of the Baltimore family of Winans. He was first heard of in Europe in 1857, when he had already been an art student, in Paris, in the studio of Gleyre. His first etchings, those known as "The French Set," were the means of bringing him under the notice of certain people interested in art, but the circulation of these first, like that of his later etchings, has always, of necessity, been more limited than their fame. The impressions from each plate are generally few. It was still in etching that Whistler continued his labours, and, coming to London in 1859, it appears, he almost at once addressed himself to the chronicle of the quaint riverside buildings and the craft of the great stream—the Thames "below Bridge." The "French Set" had included De Hooch-like or Nicholas Maes-like genre pieces, such as "La Vieille aux Loques," the "Marchande de Moutarde," and "The Kitchen," this last incomparably improved and perfected by the retouching that was accomplished a quarter of a century after the first performance. The Thames series of sixteen etchings, wrought chiefly in 1859, disclosed a new vision of the river, in which there was expressed, with perfect draughtsmanship, with a hitherto unparalleled command of vivacious line, the form of barge and clipper, of warehouse, wharf, and waterside tavern. "The Pool," "Thames Police," and "Black Lion Wharf" are perhaps the finest of this series. Before it was begun, Whistler, ere he left Paris, had proceeded far with a plate, existing only in the state of trial proof, and, in that, of extreme rarity. It is called "Paris, Île de la Cité," and has distinct and curious manifestations of a style to be more generally adopted at a later period. For several years after the completion of the "Sixteen Etchings," Whistler etched comparatively little; but about 1870 we find him entering what has been described as his "Leyland period," on account of his connexion with the wealthy shipowner and art patron, Mr Leyland, of Prince's Gate, whose house became famous for Whistler's Peacock Room,[1] painted in 1877. In that period he worked greatly in dry-point. The "Model Resting," one of the most graceful of his figure pieces, and "Fanny Leyland"—an exquisite instance of girl portraiture—are notable performances of this time. To it also belong the largely conceived dry-points, so economical of means and endowed with so singular a unity of effect, the "London Bridge," and "Price's Candle-works." A little later came the splendid visions of the then disappearing wooden bridges of Battersea and Putney, and the plate "The Adam and Eve," which records the river-front of old Chelsea. This, however, is only seen in perfection in the most rare proofs taken before the publication by the firm of Hogarth. From these plates we pass almost imperceptibly to the period of the Venetian etchings, for in 1879, at the instance of the Fine Art Society, Whistler made a sojourn in Venice, and here he wrought, or to speak accurately, commenced, not only the set of prints known as the "Venice Set," but also the "Twenty-six Etchings"—likewise chiefly, though not wholly, of Venice—issued later by the firm of Dowdeswell. One or two of the minor English subjects of the "Twenty-six Etchings"—those done after the artist's return from Venice—give indications of the phase reached more clearly in certain little prints executed a few years later, and, with perhaps one exception, never formally published. "Fruit Shop," "Old Clothes Shop," and "Fish Shop, busy Chelsea," belong to this time. Later, and bent upon doing justice to quite different themes, which demand different methods, the ever flexible artist again changes his way, and—not to speak of the dainty little records of the places about the Loire, which in method have affinity with the pieces last named—we have "Steps, Amsterdam," "Nocturne, Dance House," with its magical suggestion of movement and light, and the admirable landscape "Zaandam." With the mention of these things may fitly close a sketch of Whistler's periods in etching; but before proceeding to other branches of his work, the main characteristics of the whole series of etchings (of which, in Wedmore's *Whistler's Etchings*, nearly 300 examples are described) should be briefly indicated. These main characteristics are precision and vivacity; freedom, flexibility, infinite technical resource, at the service always of the most alert and comprehensive observation; an eye that no picturesqueness of light and shade, no interesting grouping of line, can ever escape—an eye, that is, that is emancipated from conventionality, and sees these things therefore with equal willingness in a cathedral and a mass of scaffolding, in a Chelsea shop and in a suave nude figure, in the façade of a Flemish palace and in a "great wheel" at West Kensington. Mr Whistler's pictures have as a chief source of their attractiveness those mental qualities of alertness and emancipation. Charm of colour and of handling enhance the hold which they obtain upon such people of taste as may be ready to receive them. There are but very few of them, however, at least very few oil pictures, when one considers the number of years since the artist began to labour; and one notable fact must be at once understood—the admitted masterpieces in painting belong almost entirely to the earlier time. "Sarasate" is an exception, and "Lady Archibald Campbell," and in its smaller, but still charming, way "The Little Rose of Lyme Regis"; but even these—save the "Little Rose"—are of 1885 or thereabouts. A few years earlier than they are the "Connie Gilchrist," the "Miss Alexander," and the "Rosa Corder," and the Thames "Nocturnes"; but we go farther back to reach the "Portrait of the Painter's Mother," which is now in the Luxembourg (see Plate), the "Portrait of Carlyle," now at Glasgow, the "Cremorne Gardens," the "Nocturne, Valparaiso Harbour," the "Music Room," with little Miss Annie Haden standing by the piano while her mother plays, and the "White Girl," or "Little White Girl," in which Whistler shows the influence, but never the domination, of the Japanese. Of the slight but always exquisitely harmonious studies in water colour, undertaken by Whistler in his middle period, none calls for special notice. To the middle time, too, belong, not perhaps all of his slight but delicately modelled pastels of the figure, but at least his more universally accepted pastels of Venetian scenes, in which he caught the sleepy beauty of the Venetian byeway. In pastel, as in painting, in water colour and in etching, Whistler has never been unmindful of the particular qualities of the medium in which he has worked, nor of the applicability of a given medium to a given subject. The result, accordingly, is not now a victory and now a failure, now a "hit" and now a "miss," but rather a succession of triumphs great and small. One other medium taken up by Whistler must now be mentioned. His lithographs—his drawings on the stone in many instances, and in others his drawings on that "lithographic paper" which with some people is the easy substitute for the stone today—are perhaps half as numerous as his etchings. Mr T. R. Way has catalogued about a hundred. Some of the lithographs are of figures slightly draped; two or three of the very finest are of Thames subjects—including a "nocturne" at Limehouse, of unimaginable and poetic mystery; others are bright and dainty indications of quaint prettiness in the old Faubourg St Germain, and of the sober lines of certain Georgian churches in Soho and Bloomsbury. An initiator, in his own generation, and ever tastefully experimental, Whistler no doubt has found enjoyment in the variety of the mediums he has worked in, and in the variety of subjects he has brilliantly tackled. The absence of concentration in the Whistlerian temperament, the lack of great continuity of effort, may probably prove a drawback to his taking exactly the place as a painter of oil pictures which, in other circumstances, his genius and his taste would most certainly have secured for him. In the future Whistler must be accounted, in oil painting, a master exquisite but rare. But the number and the range of his etched subjects and the extraordinary variety of perception and of skill which he has brought to bear upon the execution of his nearly three hundred coppers, ensure, and have indeed already compassed, the acceptance of him as a master among masters in that art of etching. Rembrandt's, Van Dyck's, Méryon's, Claude's, are, in fact, the only names which there is full warranty for pronouncing beside his own.

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[1] Whistler quarrelled with Leyland, and eventually painted his life-size portrait as a devil with horns and hoofs.

No account of Whistler's career would be complete without a reference to his supremely controversial personality. In 1878 he brought a libel action against Ruskin for his criticisms in *Fors Clavigera* (1877). Ruskin had denounced one of his nocturnes at the Grosvenor Gallery as "a pot of paint flung in the public face." After a long trial, Whistler was awarded a farthing damages. His examination caused much interest, especially in artistic circles, on account of his attitude in vindication of the purely artistic side of art; and it was in the course of it that he answered the question as to how long a certain "impression" had taken him to execute by saying, "All my life." His eccentricity of pose and dress, combined with his artistic arrogance, sharp tongue, and bitter humour, made him one of the most talked-about men in London, and his *mots* were quoted everywhere. He followed up his quarrel with Ruskin by publishing a satirical pamphlet, *Whistler* v. *Ruskin: Art* v. *Art Critics.* In 1885 he gave his *Ten o'Clock Lecture* in London, afterwards embodied in *The Gentle Art of Making Enemies* (1890). The substance of this flippantly-written and amusing outburst was an insistence on the liberty of the artist to do what was right in his artistic eyes, and the inability of the public or the critics to have any ideas about art worth considering at all. In 1895 another quarrel, with Sir William Eden, whose wife's portrait Whistler had painted, but refused to hand over, came into the courts in Paris; and Whistler, though allowed to keep his picture, was condemned in damages.

Whitby, a watering-place, urban district (1894), and market town, Yorkshire, England, in the Whitby parliamentary division of the North Riding, 56 miles north-east of York by rail, on both banks of the Esk, where it enters the sea. Brunswick Wesleyan church was erected in 1891, and a new lifeboat station was opened in 1895. Iron ships are now built here. In 1901, 482 vessels of 79,699 tons entered, 475 vessels of 79,312 tons cleared. Population (1891), 13,075; (1901), 11,748.

White, Andrew Dickson (1832– ——), American author and diplomatist, was born at Homer, New York, 7th November 1832. He graduated at Yale College in 1853, studied history in Paris and Berlin, was an attaché of the United States legation at St Petersburg, and became professor of history in the University of Michigan in 1857. Returning to his native state in 1864, he was elected to its senate, and was influential in shaping the legislation whereby Cornell University, at Ithaca, was opened on the basis of the governmental land grant for state agricultural colleges and of a large gift by Ezra Cornell. Dr White became its first president in 1867, and developed its educational and material resources as a scientific and literary institution primarily designed for students of slender financial means; he also gave it his valuable historical library of 30,000 volumes and 10,000 manuscripts, and other considerable donations. Resigning the presidency in 1885, he devoted himself to literary and diplomatic pursuits. In 1871, while retaining his position at Cornell, he had been United States Commissioner to the republic of San Domingo, and from 1879 to 1881 minister to Germany, by appointment of President Hayes. Between 1892 and 1894 he was minister to Russia under President Harrison; was a member of the commission concerning the Venezuela boundary—in discussion between Great Britain, Venezuela, and the United States—in 1896–97; and in 1897 was appointed ambassador to Germany by President McKinley (a post from which he retired in 1902), also serving as a member of the Peace Conference at The Hague in 1899, and being chairman of the American delegation. As a diplomatist his long experience enabled him to combine graciousness with decision in an unusual degree. Of his published writings, which are not numerous, but cover various topics in history, finance, and governmental politics, the chief is a history of *The Warfare of Science with Theology* (1st edition 1876, afterwards revised and enlarged), which was reissued in London with a preface by John Tyndall.

White, Maria. See Lowell, James Russell.

White, Richard Grant (1821–1885), American author, was born in New York City, 22nd May 1821, graduated at the University of New York in 1839, and became a lawyer, but soon devoted the greater part of his time to the writing of dramatic, musical, and art criticisms for the daily press, also being editor-in-chief of the *Courier and Enquirer*, 1854–59. From 1853 until his death he was constantly engaged in the study of Shakespearean and related textual and critical problems, and between 1857 and 1865 produced, in twelve volumes, the first thorough American edition of the poet, with useful collateral essays on his life and on the history of the

English drama. This edition was reissued in 1883, and in 1885 appeared a readable collection of *Studies in Shakespeare*, pleading for a rational treatment of the plays, without over-annotation, textual or æsthetic. He also wrote *Words and their Uses, Past and Present* (1870), and *Everyday English* (1880), which, without linguistic thoroughness or scholarly value, stimulated interest in the general subject of good use in language. His other work included fiction and sketches of travel in England, but more important was the series of letters to the London *Spectator* during the Civil War, which aided in developing English sympathy with the Union cause. From 1861 to 1878 he was employed in the United States Revenue Marine Bureau in New York, where he died, 8th April 1885.

White, Sir William Arthur (1824–1891), British diplomatist, was born at Pulawy, in Poland, on 13th February 1824. He was descended on his father's side from an Irish Roman Catholic family. His mother's family, though not of Polish extraction, owned considerable estates in Poland, where White, though educated at King William's College, Isle of Man, and Trinity College, Cambridge, spent a great part of his early days, and thus gained an intimate knowledge of the Slavonic tongues. From 1843 to 1857 he lived in Poland as a country gentleman, but in the latter year he accepted a post in the British consulate at Warsaw, and had almost at once to perform the duties of acting consul-general. The insurrection of 1863 gave him an opportunity of showing his immense knowledge of Eastern politics and his combination of diplomatic tact with resolute determination. He was promoted in 1864 to the post of consul at Danzig. The Eastern Question was, however, the great passion of his life, and in 1875 he succeeded in getting transferred to Belgrade as consul-general for Servia. In 1878 he was made British Agent at Bucharest. In 1884 he was offered by Lord Granville the choice of the legation at Rio or Buenos Aires, and in 1885 Lord Salisbury, who was then at the Foreign Office, urged him to go to Peking, pointing out the increasing importance of that post. White's devoted friend, Sir Robert Morier, wrote in the same sense. But White, who was already acting as ambassador *ad interim* at Constantinople, decided to wait; and during this year he rendered one of his most conspicuous services. It was largely owing to his efforts that the war between Servia and Bulgaria was prevented from spreading into a universal conflagration, and that the union of Bulgaria and eastern Rumelia was accepted by the Powers. In the following year he was rewarded with the embassy at Constantinople. He was the first Roman Catholic appointed to a British embassy since the Reformation. At Constantinople he was by general consent the most influential and most successful British representative since the days of Lord Stratford de Redcliffe. He pursued consistently the policy of counteracting Russian influence in the Balkans by erecting a barrier of independent states animated with a healthy spirit of national life, and by supporting Austrian interests in the East. To the furtherance of this policy he brought an unrivalled knowledge of all the under-currents of Oriental intrigue, which his mastery of languages enabled him to derive not only from the newspapers, of which he was an assiduous reader, but from the obscurest sources. His bluff and straightforward manner, and the knowledge that with him the deed was ready to follow the word, enabled him at once to inspire confidence and to overawe less masterful rivals. The official honours bestowed on him culminated in 1888 with the G.C.B. and a seat on the Privy Council. He was still ambassador at Constantinople when he was attacked by influenza during a visit to Berlin, where he died on 28th December 1891.

(H. SY.)

White, Sir William Henry (1845–——), English naval architect, was born at Devonport on 2nd February 1845, and at the age of fourteen became an apprentice in the dockyard there. In 1864 he took the first place in the scholarship competition at the Royal School of Naval Architecture, which had then just been established by the Admiralty at South Kensington, and in 1867 he gained his diploma as fellow of the school with first-class honours. At once joining the constructive staff of the Admiralty, he acted as confidential assistant to the chief constructor, Sir Edward Reed, until the latter's retirement in 1870. The loss of the *Captain* in that year was followed by an inquiry into designs for ships of war, and in connexion with this White, together with his old fellow-student, William John, worked out a long series of calculations as to the stability and strength of vessels, the results of which were published in an important paper read in 1871 before the Institution of Naval Architects. In 1872 White was appointed secretary to the Council of Construction at the Admiralty, in 1875 assistant constructor, and in 1881 chief constructor. In April 1883 he left the service of the Admiralty, at the invitation of Lord (then Sir W. G.) Armstrong, in order to undertake the difficult task of organizing a department for the construction of warships of the largest size at the Elswick works; but he only remained there for two and a half years, for in October 1885 he returned to the Admiralty in succession to Sir Nathaniel Barnaby as director of naval construction, retaining that post until the beginning of 1902, when ill-health obliged him to relinquish the arduous labours it entailed. During that period, which in Great Britain was one of unprecedented activity in naval shipbuilding as a result of the awakening of public opinion to the vital importance of sea-power, more than 200 vessels of various types were added to the British navy, at a total cost of something like 100 millions sterling, and for the design of all of these, as well as for the work of their construction, Sir William White was ultimately responsible. In addition, he has done much to further the knowledge of scientific shipbuilding. He was professor of naval architecture at the Royal School from 1870 to 1873, and when in the latter year it was moved to Greenwich to be merged in the Royal Naval College, he reorganized the course of instruction and acted as professor for eight years more. The lectures he gave in that capacity were the foundation of his *Manual of Naval Architecture*, which has been translated into several foreign languages and is recognized as a standard text-book all over the world. Sir William White, who was chosen a fellow of the Royal Society in 1888, is also the author of many professional papers read before various learned and engineering societies. He was created K.C.B. in 1895.

Whitehaven, municipal (since 1894) and parliamentary borough, railway station, seaport, and parish, in the Egremont or Western parliamentary division of Cumberland, England, 41 miles south of Carlisle. There is a tidal harbour and dock. In 1888, 2554 vessels of 299,091 tons entered and 2542 of 291,960 tons cleared; in 1901, 1186 vessels of 185,424 tons entered and 1187 of 186,146 tons cleared. Since 1892 the port has been subordinate to that of Maryport. Smelting and finished-iron works are increasing in number in the neighbourhood of the iron-ore mines. In 1893 the electric lighting of the town was inaugurated. Population (1891), 19,370; (1901), 19,325.

White Mountains, a name loosely applied to a portion of the Appalachian system in New Hampshire, U.S.A., but more properly perhaps to a group comprising the highest of these mountains, among which is Mount Washington, situated in the northern part of the state. These mountains, like the Adirondacks of New York, are composed of somewhat homogeneous granite rocks, and represent the remnants of long-continued erosion of a region formerly greatly elevated. In this group rise the Androscoggin and Merrimac rivers and branches of the Connecticut. Among the summits are Mount Washington, 6293 feet; Mount Adams, 5805 feet; Mount Clay, 5540 feet; Mount Jefferson, 5725 feet; Mount Madison, 5380 feet; and Mount Monroe, 5390 feet. The summit of Mount Washington, on which is an excellent hotel, is reached by a cog-wheel railway. This region has long been known as a popular summer resort, is traversed by railways, and contains numerous villages and fine hotels.

White Plains, a village of New York, U.S.A., capital of Westchester county, in the south-eastern part of the state, on the Harlem branch of the New York Central and Hudson River Railroad, 22 miles north-east of New York, at an altitude of 201 feet. It is a residence suburb of New York, and is the seat of the Bloomingdale insane asylum. At this place, 28th October 1776, the American army was defeated by the British forces under General Howe. Population (1880), 2381; (1890), 4042; (1900), 7899, of whom 1679 were foreign-born and 369 negroes.

Walt Whitman.
(*From a photograph by Bartlett F. Kenney, Boston.*)

Whitman, Walt (1819–1892), American poet, was born at West Hills, on Long Island, New York, 31st May 1819. His ancestry was mingled English and Holland Dutch, and had flourished upon Long Island more than 150 years—long enough to have taken deep root in the soil and to have developed, in its farmers and seafaring men, many strong family traits. His father, Walter Whitman, was a farmer and carpenter; his mother, Louisa Van Velsor, was the granddaughter of a sea captain. There do not appear to be any men in his line of descent given to scholarly or intellectual pursuits till we get back to the 17th century, when we come to Abijah Whitman, a clergyman, settled in Connecticut. Later this Abijah moved to Long Island, and from him all the Whitmans on the island descended. Walt was the second of a family of nine children. The parents early moved to Brooklyn, where Whitman spent his youth. His career was a chequered one, like that of so many other self-made American men. First he was an errand boy in a lawyer's office; then he was employed in a printing office; next he became a country school teacher; then he edited the *Long Islander* at Huntington (1838), and later a daily paper in Brooklyn (the *Eagle*, 1846–47); then he was found in New Orleans, on the editorial staff of the *Crescent* (1848–49); afterwards he passed his time carpentering, building, and selling small houses in Brooklyn (1851–54), in the meanwhile writing for the magazines and reviews and turning out several novels, and finally revolving in his mind the scheme of his *Leaves of Grass.* This scheme was probably gestating in his mind during the years 1853, 1854, and 1855. He frequently stopped his carpentering to work at his poems. He left voluminous manuscript notes, showing the preparatory studies and reflections that preceded the *Leaves;* many of them, under the title of *Notes and Fragments,* were privately printed by his literary executor, Dr Richard Maurice Bucke, in 1899. Finally, in the summer of 1855 the first edition of *Leaves of Grass* appeared—a small quarto of ninety-four pages. The book did not attract the attention of the critics and the reading public till a letter from Emerson to the poet, in which the volume was characterized as "the most extraordinary piece of wit and wisdom that America has yet contributed," was published in the New York *Tribune.* This created a demand for the book, and started it upon a career that has probably had more vicissitudes and called forth more adverse as well as more eulogistic criticism than any other contemporary literary work. In 1856 a second and much enlarged edition of *Leaves of Grass* appeared. In 1860 a third edition, with much new matter, was published in Boston. In 1862 Whitman went to Washington to look after his brother, Lieutenant-Colonel George W. Whitman, who was wounded at the battle of Fredericksburg. Henceforth, for more than ten years he remained in and about Washington, acting as a volunteer nurse in the army hospitals as long as the war lasted, and longer, and then finding employment as a clerk in the Government departments, in the meantime adding to and revising his *Leaves* and publishing two or three editions of them, himself his own publisher and bookseller. Out of his war experiences came in 1866 his *Drum Taps,* subsequently incorporated into the main volume. Early in 1873 he suffered a paralytic stroke which partially disabled him. He then went to Camden, New Jersey, to live, and continued to reside in that city till his death on 27th March 1892. In 1871 appeared his prose volume called *Democratic Vistas.* In 1876 he published a thin volume, called *Two Rivulets,* made up of prose and verse. *Specimen Days and Collect,* also prose, appeared in 1882. New editions of his *Leaves* continued to appear at intervals as long as he lived. A final and complete edition of his works, including both prose and verse, was published in Philadelphia in 1889.

Whitman never married, never left America, never laid up, or aimed to lay up, riches: he gave his time and his substance freely to others, belonged to no club nor coterie, associated habitually with the common people—mechanics, coach-drivers, working men of all kinds—was always cheerful and optimistic. He was large and picturesque of figure, slow of movement, tolerant, receptive, democratic, and full of charity and goodwill towards all. His life was a poet's life from first to last—free, unworldly, unhurried, unconventional, unselfish, and was contentedly and joyously lived. He left many notes that throw light upon his aims and methods in composing *Leaves of Grass.* "Make no quotations," he charged himself, "and no reference to any other writers. Lumber the writing with nothing—let it go as lightly as the bird flies in the air or a fish swims in the sea. Avoid all poetical similes; be faithful to the perfect likelihoods of nature—healthy, exact, simple, disdaining ornaments. Do not go into criticisms or arguments at all; make full-blooded, rich, flush, natural works. Insert natural things, indestructibles, idioms, characteristics, rivers, states, persons, &c. Be full of *strong sensual germs.* . . . Poet! beware lest your poems are made in the spirit that comes from the study of pictures of things—and not from the spirit that comes from the contact with real things themselves." The mother-idea of his poems, he says, is democracy, and democracy "carried far beyond politics into the region of taste, the standards of manners and beauty, and even into philosophy and theology." His *Leaves* certainly radiates democracy as no other modern literary work does, and brings the reader into intimate and enlarged relations with fundamental human qualities—with sex, manly love, charity, faith, self-esteem, candour, purity of body, sanity of mind. He was democratic because he was not in any way separated nor detached from the common people by his quality, his culture, or his aspirations. He was bone of their bone and flesh of their flesh. Tried by current standards his poems lack form and structure, but they undoubtedly have in full measure the qualities and merits that the poet sought to give them. (J. BU.)

Whitney, Josiah Dwight (1819–1896), American geologist, was born at Northampton, Massachusetts, 23rd November 1819. He graduated at Yale in 1839, and after two years' work as assistant in the geological survey of New Hampshire, spent some time in Europe in the study of geology. Returning to the United States in 1847, he laboured successively in the copper and iron lands of the Lake Superior region, in Iowa, in the lead region of the upper Missouri river, in Wisconsin, and in Illinois, publishing many reports, singly or in collaboration with others. From 1860 to 1874 he was state geologist of California, and superintended a comprehensive and thorough series of reports on its topography, geology, and botany. In 1869, with William H. Brewer, he accurately determined the heights of the principal Rocky Mountain summits; and in recognition of his labours Mount Whitney (14,900, in Inyo county, California, the highest peak in the United States) received its name from him. From 1865 until his death he was professor of geology and director of the school of mining and practical geology at Harvard University, residing in Cambridge save when absent on expeditions of research. The records of his investigations are somewhat dispersed; the most homogeneous of his writings are *The Metallic Wealth of the United States, described and compared with that of other Countries* (1854), a work of importance at the time of its issue, and *Contributions to American Geology* (vol. i. only, 1880). He died at Lake Sunapee, New Hampshire, 18th August 1896.

Whitney, William Dwight (1827–1894), American philologist, was born at Northampton, Massachusetts, 9th February 1827. He was the fourth child and the second surviving son of Josiah Dwight Whitney, a banker, and Sarah Williston, daughter of the Rev. Payson Williston of Easthampton, Massachusetts. Through both parents he was descended from New England stock remarkable alike for physical and mental vigour; and he inherited all the social and intellectual advantages that were afforded by a community noted, in the history of New England, for the large number of distinguished men whom it has produced. At the age of fifteen (1842) he entered the sophomore class of Williams College (at Williamstown, Massachusetts), where he graduated three years later with the highest honours. His attention was at first directed to natural science, and his interest in it always remained keen, while his knowledge of its principles and methods exerted a noticeable influence upon his philological work. In 1849 he had charge of the botany, the barometrical observations, and the accounts of the United States survey of the Lake Superior region conducted by his brother, Josiah D. Whitney, and in 1873 assisted in the geographical work of the Hayden expedition in Colorado. His interest in the study of Sanskrit was first awakened in 1848, and he at once devoted himself with enthusiasm to this at that time little explored field of philological labour. After a brief course at Yale with Professor Salisbury, then the only trained Orientalist in the United States, Whitney went to Germany (1850) and studied for three years at Berlin, under Weber, Bopp, and Lepsius, and at Tübingen (two summer semesters) under Roth, returning to the United States in 1853. In the following year he was appointed professor of Sanskrit in Yale, and in 1869, also of comparative philology. He also gave instruction in French and German in the college until 1867, and in the Sheffield Scientific School until 1886. An urgent call to a professorship at Harvard was declined in 1869. The importance of his contributions to science was early and widely recognized. He was elected to membership of numerous learned societies in all parts of the world, and received many honorary degrees, the most notable testimonial to his fame being his election, 31st May 1881, as Foreign Knight of the Prussian order *pour le mérite* for science and arts to fill the vacancy caused by the death of Carlyle. In 1870 he received from the Berlin Academy of Sciences the first Bopp prize for the most important contribution to Sanskrit philology during the preceding three years—his edition of the *Tāittirīya-Prātiçākhya* (*Journal* of the American Oriental Society, vol. ix.). His death occurred at New Haven, Connecticut, 7th June 1894.

As a philologist Whitney is noted especially for his work in Sanskrit, which placed him among the first scholars of his time. He edited (1855–56) with Professor Roth the *Atharva-Veda-Sanhitā*, published (1862) with a translation and notes; the *Atharva-Veda-Prātiçākhya;* made important contributions to the great Petersburg lexicon; issued an index verborum to the published text of the *Atharva-Veda* (*Journal* of the American Oriental Society, 1881); projected a second volume of the Roth–Whitney edition of the *Atharva-Veda*, which he did not live to complete; and published a large number of special articles upon various points of Sanskrit philology. His most notable achievement in this field, however, is his *Sanskrit Grammar* (1879), a work which, as Professor Delbrück has said, not only is "the best text-book of Sanskrit which we possess," but also places its author, as a scientific grammarian, on the same level with such writers as Madvig and Krüger. To the general public Whitney is best known through his popular works on the science of language and his labours as a lexicographer. The former are perhaps the most widely read of all English books on the subject, and have merited their popularity through the soundness of the views which they present and the lucidity of their style. His most important service to lexicography was his guidance, as editor-in-chief, of the work on *The Century Dictionary* (1888–91). Apart from the permanent value of his contributions to philology, Whitney is notable for the great and stimulating influence which he exerted throughout his life upon the development of American scholarship. No man has done more, by precept and example, to establish it upon a solid and enduring foundation.

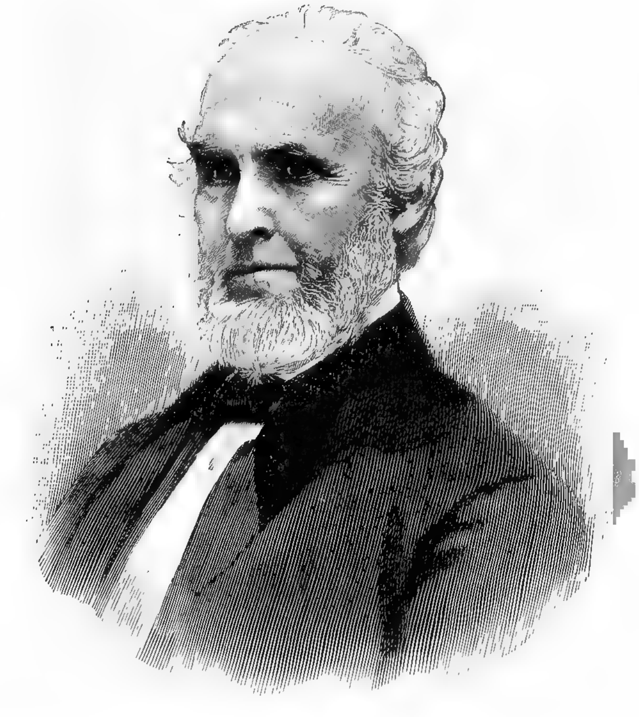
The chronological bibliography of Whitney's writings appended to the nineteenth volume (first half) of the *Journal* of the American Oriental Society, issued in May 1897, contains 360 numbers. Of these the most important, in addition to those mentioned above, are: *Translation of the Sūrya-Siddhānta, a Text-book of Hindu Astronomy*, *Jour.* Am. Oriental Soc., vol. vi. (1860); *Language and the Study of Language*, 1867; *A Compendious German Grammar*, 1869; *Oriental and Linguistic Studies*, 1873, second series 1874; *The Life and Growth of Language*, 1875; *Essentials of English Grammar*, 1877; *A Compendious German and English Dictionary*, 1877; *A Practical French Grammar*, 1886; *Max Müller and the Science of Language*, 1892. (B. E. S.)

Whitstable, urban district (1894), watering-place, and seaport, in the Eastern, or St Augustine's, parliamentary division of Kent, England, on the south side of the Thames estuary, 5½ miles north-north-west of Canterbury. In 1896 a special Act of Parliament transferred the management of the celebrated oyster fishery from the Incorporated Company of Dredgers to the Whitstable Oyster Fishery Company. The harbour has berths along its quay to accommodate vessels of 350 to 400 tons. The urban district consists of parts of the old parishes of Whitstable and Seasalter. Population (1891), 5669; (1901), 7086.

Whittier, John Greenleaf (1807–1892), America's "Quaker poet" of freedom, faith, and the sentiment of the common people, was born in a Merrimack Valley farmhouse, Haverhill, Mass., 17th December 1807. The dwelling was built in the 17th century by his ancestor, the sturdy immigrant, Thomas Whittier, notable through his efforts to secure toleration for the disciples of George Fox in New England. Thomas's son Joseph joined the Society of Friends and bore his share of obloquy. Successive generations obeyed the monitions of the Inner Light. The poet was born in the faith, and adhered to its liberalized tenets, its garb and speech, throughout his lifetime. His father, John, was a farmer of limited means but independent spirit. His mother, Abigail Hussey, whom the poet strongly resembled, was of good stock. The Rev. Stephen Bachiler, an Oxford man and a Churchman, who became a Nonconformist and emigrated to Boston in 1632, was one of her forebears and also an ancestor of Daniel Webster. The poet and the statesman showed their kinship by the "dark, deep-set, and lustrous eyes" that impressed one who met either of these uncommon men. The former's name of Greenleaf is thought to be derived from the French Feuillevert, and to be of Huguenot origin; and there was Huguenot blood as well in Thomas Whittier, the settler. The poet thus fairly inherited his conscience, religious exaltation, and spirit of protest. All the Whittiers were men of stature and bodily strength, John Greenleaf being almost the first exception, a lad of delicate mould, scarcely adapted for the labour required of a Yankee farmer and his household. He bore a fair proportion of it, but throughout his life was frequently brought to a halt by pain and physical debility. In youth he was described as "a handsome young man, tall, slight, and very erect, bashful but never awkward." His shyness was extreme, though covered by a grave and quiet exterior, which could not hide his love of fun and sense of the ludicrous. In age he retained most of these characteristics, refined by a serene expression of peace after contest. His eyes never lost their glow, and were said by a woman to be those of one "who had kept innocency all his days."

Whittier's early education was restricted to what he could gain from the primitive "district school" of the neighbourhood. His call as a poet came when a teacher lent to him the poems of Burns. He was then about fifteen, and his taste for writing, bred thus far upon the quaint *Journals of Friends*, the Bible, and *The Pilgrim's Progress*, was at once stimulated. There was little art or inspiration in his boyish verse, but in his nineteenth year an older sister thought a specimen of it good enough for submission to *The Free Press*, a weekly paper which William Lloyd Garrison, the future emancipationist, had started in the town of Newburyport. This initiated Whittier's literary career. The poem was printed with a eulogy, and the editor sought out his young contributor: their alliance began, and continued until the triumph of the anti-slavery cause thirty-seven years later. Garrison overcame the elder Whittier's desire for the full services of his son, and gained permission for the latter to attend the Haverhill academy. To meet expenses the youth worked in various ways, even making slippers by hand in after-hours; but when he came of age his text-book days were ended. Meanwhile he had written creditable student verse, and contributed both prose and rhyme to newspapers, thus gaining friends and obtaining a decided if provincial reputation. He soon essayed journalism, first spending a year and a half in the service of a publisher of two Boston newspapers, *The Manufacturer*, an organ of the Clay protectionists, and *The Philanthropist*, devoted to humane reform. Whittier edited the former, having a bent for politics, but wrote for the latter also. His father's last illness recalled him to the homestead, where both farm and family became his pious charge. Money had to be earned, and he now secured an editorial post at Hartford, Conn., which he sustained until forced by ill-health, early in his twenty-fifth year, to re-seek the Haverhill farm. There he remained from 1832 to 1836, when the property was sold, and the Whittiers removed to Amesbury in order to be near their meeting-house and to enable the poet to be in touch with affairs. The new home became, as it proved, that of his whole after-life; a dwelling then bought and in time remodelled was the poet's residence for fifty-six years, and from it, after his death on 7th September 1892, his remains were borne to the Amesbury graveyard.

While in Hartford, Whittier issued in prose and verse his first book, *Legends of New England* (1831), and edited the writings of the poet Brainard. Thenceforward he was constantly printing verse, but of the hundred or more pieces composed before his settlement at Amesbury, less than fifty are retained in his final collection. Of these none has more significance than the poem to Garrison, which appeared in 1831, and was read (December 1833) at the Philadelphia Convention that formed the Anti-Slavery Society. To that convention, with one-third of its membership composed of Friends, Whittier was a delegate, and was appointed one of the committee that drafted the famous Declaration of Sentiments. Although a Quaker, he had a polemical spirit; men seeing Whittier only in his saintly age knew little of the fire wherewith, setting aside ambition and even love, he maintained his warfare against the "national crime," employing action, argument, and lyric scorn. A future was open for him among the Protectionists, who formed the Whig party, and doubtless soon would have carried him to the United States Congress. As it was, he got no farther than the legislature of his own state (1835–36), elected by his neighbours in an anti-slavery town. But if Garrison, Phillips, and Sumner and Mrs Stowe were to be the rhapsodists of the long emancipation struggle, Whittier was its foreordained poet-seer. In 1833 he had issued at his own cost a pamphlet, *Justice and Expediency*, that provoked vehement discussion North and South. Later, he shared with the agitators their experience of lawlessness, mob-violence, and political odium. His sister Elizabeth, who became his life companion, and whose verse is preserved with his own, was president of the Woman's Anti-Slavery Society in Amesbury. It is to be noted that the first collection of Whittier's lyrics was the *Poems written during the Progress of the Abolition Question in the United States*, issued by a friend in 1837. But *Mogg Megone* (1836) was his first book, a crude attempt to apply the manner of Scott's romantic cantos to a native theme. Among his other lyrical volumes, of dates earlier than the Civil War, were *Lays of my Home* (1843), *Voices of Freedom* (1846), *Songs of Labor* (1850), *The Chapel of the Hermits* (1853), *The Panorama* (1856), *Home Ballads* (1860). The titles of *In War Time* (1863) and *National Lyrics* (1865) rightly designate the patriotic rather than Tyrtæan contents of these books. The poet was closely affiliated with the *The Atlantic Monthly* from the foundation of that classic magazine in 1857. His repute became national with the welcome awarded to *Snow-Bound* in 1866, and brought a corresponding material reward. Of his later books of verse may be mentioned *The Tent on the Beach* (1867), *The Pennsylvania Pilgrim* (1872), *The Vision of Echard* (1878), *The King's Missive* (1881), *At Sundown*, his last poems (1890). As early as 1849 an illustrated collection of his poems appeared, and his *Poetical Works* was issued in London in 1850. During the ensuing forty years no less than ten successive collections of his poems appeared. Meanwhile he did much editing and compiling, and produced, among other works in prose, *The Stranger in Lowell* (1845), *Supernaturalism in New England* (1847), *Leaves from Margaret Smith's Journal* (1849), a pleasing treatment in old-style English of an early Colonial theme. When he died, in 1892, in New Hampshire, among the hills he loved and sang so well, he had been an active writer for over sixty years, leaving more than that number of publications that bore his name as author or editor. His body was brought to Amesbury for interment; the funeral services were held in the open air, and conducted after the simple rites of the Friends, in the presence of a large concourse, certain of whom "spake as they were moved" in tribute to the bard. The Amesbury house has been acquired by the "Whittier Home Association," so that the building and grounds are guarded as he left them, and form a shrine to which there is a constant pilgrimage. The Haverhill homestead, memorized in *Snow-Bound*, is also held by trustees "to preserve the natural features of the landscape," and to keep the buildings and furniture somewhat as they were in their minstrel's boyhood.



John Greenleaf Whittier.
(From a photograph by Conly, Boston.)

It would be unjust to consider Whittier's genius from an academic point of view. British lovers of poetry—except John Bright and others of like faith or spirit—have been slow to comprehend his distinctive rank. As a poet he was essentially a balladist, with the faults of his qualities; and his ballads, in their freedom, naïveté, even in their undue length, are among the few modern examples of unsophisticated verse. He returned again and again to their production, seldom labouring on sonnets and lyrics of the Victorian mould. His ear for melody was inferior to his sense of time, but that his over-facility and structural defects were due less to lack of taste than to early habit, Georgian models, disassociation from the schools, is indicated by his work as a writer of prose. In *Margaret Smith's Journal* an artistic, though suppositive, Colonial style is well maintained. Whittier became very sensible of his shortcomings; and when at leisure to devote himself to his art he greatly bettered it, giving much of his later verse all the polish that it required. In extended composition, as when he followed Longfellow's *Tales of a Wayside Inn* with his own *Tent on the Beach*, he often failed to rival his graceful brother poet. In American balladry he was pre-eminent; such pieces as "The Swan Song of Parson Avery," "Marguerite," "Barclay of Ury," "Skipper Ireson's Ride," "In the 'Old South,'" hold their place in literature. It is necessary above all to consider the relation of a people's years of growth and ferment to the song which represents them; for in the strains of Whittier, more than in those of any other 19th-century lyrist, the saying of Fletcher of Saltoun as to the ballads and laws of a nation finds a historic illustration. He was the national bard of justice, humanity, and reform, whose voice went up as a trumpet until the victory was won. Its lapses resembled those of Mrs Browning, who was of his own breed in her fervour and exaltation. To the last it was uncertain whether a poem by Whittier would "turn out a sang," or "perhaps turn out a sermon"; if the latter, it had deep sincerity and was as close to his soul as the other. He began as a liberator, but various causes employed his pen; his heart was with the people, and he was understanded of them; he loved a worker, and the *Songs of Labor* convey the zest of the artisan and pioneer. From 1832 to 1863 no occasion escaped him for inspiring the assailants of slavery, or chanting pæans of their martyrdom or triumph. No crusade ever had a truer laureate than the author of "The Virginia Slave Mother," "The Pastoral Letter"—one of his stinging ballads against a time-serving Church—"A Sabbath Scene," and "The Slaves of Martinique." "Randolph of Roanoke" is one of the most pathetic and most elevated of memorial tributes. "Ichabod" and "The Lost Occasion," both evoked by the attitude of Webster, are Roman in their condemnation and "wild with all regret."

The green rusticity of Whittier's farm and village life imparted a bucolic charm to such lyrics as "In School Days," "The Barefoot Boy," "Telling the Bees," "Maud Muller," and "My Schoolmate." His idyllic masterpiece is the sustained transcript of winter scenery and home-life, *Snow-Bound*, which has had no equal except Longfellow's "Evangeline" in American favour, but, in fact, nothing of its class since "The Cottar's Saturday Night" can justly be compared with it. Along with the Quaker poet's homing sense and passion for liberty of body and soul, religion and patriotism are the dominant notes of his song. His conception of a citizen's prerogative and duty, as set forth in "The Eve of Election," certainly is not that of one whose legend is "our country, right or wrong." Faith, hope, and boundless charity pervade the "Questions of Life," "Invocation," and "The Two Angels," and are exquisitely blended in "The Eternal Goodness," perhaps the most enduring of his lyrical poems. "We can do without a Church," he wrote in a letter; "we cannot do without God, and of Him we are sure." The inward voice was his inspiration, and of all American poets he was the one whose song was most like a prayer. A knightly celibate, his stainless life, his ardour, caused him to be termed a Yankee Galahad; a pure and simple heart was laid bare to those who loved him in "My Psalm," "My Triumph," and "An Autograph." The spiritual habit abated no whit of his inborn sagacity, and it is said that in his later years political leaders found no shrewder sage with whom to take counsel. When the question of primacy among American poets was canvassed by a group of the public men of Lincoln's time, the vote was for Whittier; he was at least one whom they understood, and who expressed their feeling and convictions. Parkman called him "the poet of New England," but as the North and West then were charged with the spirit of the New England states, the two verdicts were much the same. The fact remains that no other poet has sounded more native notes, or covered so much of the American legendary, and that Whittier's name, among the patriotic, clean and true, was one with which to conjure. He was revered by the people cleaving to their altars and their fires, and his birthdays were calendared as festivals, on which greetings were sent to him by young and old.

In his age the poet revised his works, classifying them for a definitive edition, in seven volumes, published at Boston, 1888. Their metrical portion, annotated by Horace E. Scudder, can be found in the one-volume "Cambridge Edition," Boston, 1894. Whittier's *Life and Letters*, prepared by his kinsman and literary executor, Samuel T. Pickard, also appeared in 1894.

(E. C. S.)

Whitworth, Sir Joseph, Bart. (1803–1887), English engineer, was born at Stockport, near Manchester, on the 21st of December 1803. On leaving school at the age of fourteen, he was placed with an uncle who was a cotton-spinner, with the view of becoming a partner in the business; but his mechanical tastes were not satisfied with this occupation, and in about four years he gave it up. He then spent some time with various machine manufacturers in the neighbourhood of Manchester, and in 1825 moved to London, where he gained more experience in machine shops, including those of Maudslay and Holtzapffel. In 1833 he returned to Manchester and started in business as a tool-maker. In 1840 he attended the meeting of the British Association at Glasgow, and read a paper on the preparation and value of true planes, describing the method which he had successfully used for making them when at Maudslay's, and which depended on the principle that if any two of three surfaces exactly fit each other, all three must be true planes. The accuracy of workmanship thus indicated was far ahead of what was contemplated at the time as possible in mechanical engineering, but Whitworth not only proved that it could be attained in practice, but also showed how it could be measured. He found that if two true planes were arranged parallel to each other, an exceedingly small motion towards or from each other was sufficient to determine whether an object placed between them was held firmly or allowed to drop, and by mounting one of the planes on a screwed shaft provided with a comparatively large wheel bearing a scale on its periphery, he was able to obtain a very exact measurement of the amount, however minute, by which the distance between the planes was altered, by observing through what angular distance the wheel had been turned. In 1841, in a paper read before the Institution of Civil Engineers, he urged the necessity for the adoption of a uniform system of screw threads in place of the various heterogeneous pitches then employed, and he had the satisfaction of seeing the uniformity he desired become universal in less than twenty years. His system of standard gauges was also widely adopted. The principles of exact measurement and workmanship which he advocated were strictly observed in his own manufactory, with the result that in the Exhibition of 1851 he had a show of machine tools which were far ahead of those of any competitor. It was doubtless this superiority in machine construction that caused the Government three years later to request him to design, and estimate for making, the machinery for producing rifled muskets at the new factory at Enfield. He did not see his way to agree to the proposition in this form, but it was ultimately settled that he should undertake the machinery for the barrels only. Finding that there was no established practice to guide him, he began a series of experiments to determine the best principles for the manufacture of rifle barrels and projectiles. He ultimately arrived at a weapon in which the necessary rotation of the projectile was obtained, not by means of grooving, but by making the barrel polygonal in form, with gently rounded angles, the bullets also being polygonal and thus travelling on broad bearing-surfaces along the rotating polygon. The projectile he favoured was 3 to 3½ calibres in length, and the bore he fixed on was 0·45 inch, which was at first looked upon as too small. It is reported that at the trial in 1857 weapons made according to these principles excelled the Enfield weapons in accuracy of fire, penetration, and range to a degree "which hardly leaves room for comparison." He also constructed heavy guns on the same lines; these were tried in competition with Armstrong's ordnance in 1864 and 1865, and in their inventor's opinion gave the better results, but they were not adopted by the Government. In constructing them Whitworth experienced difficulty in getting large steel castings of suitable soundness and ductility, and thus was led to devise his compressed steel process, in which the metal is subjected to high pressure while still in the fluid state, and is afterwards forged in hydraulic presses, not by hammers. In 1868 he founded the Whitworth scholarships, setting aside an annual sum of £3000 to be given for "intelligence and proficiency in the theory and practice of mechanics and its cognate sciences," and in the following year he was created a baronet. He died at Monte Carlo, whither he had gone for the sake of his health, on the 22nd of January 1887. In addition to handing over £100,000 to the Science and Art Department for the permanent endowment of the thirty Whitworth scholarships, his residuary legatees, in pursuance of what they knew to be his intentions, expended over half a million on charitable and educational objects, mainly in Manchester and the neighbourhood.

(H. M. R.)

Whymper, Edward (1840– ——), British artist, explorer, and mountaineer, was born in London on 27th April 1840. The son of an artist, he was himself at an early age trained to the profession of a wood-engraver. In 1860 he was commissioned to make a series of sketches of Alpine scenery, and undertook an extensive journey in the Central and Western Alps. Finding, on his first expeditions, that he possessed the steady head and sure foot of the mountaineer, he planned for the following year an ambitious programme. Among the objects of his tour in 1860 had been the illustration of an attempt, which proved unsuccessful, made by Professor Bonney's party, to ascend Mont Pelvoux, at that time believed to be the highest peak of the Dauphiné Alps. He successfully accomplished the ascent in 1861—the first of a series of expeditions that threw much light on the topography of a district at that time very imperfectly mapped. From the summit of Mont Pelvoux he made the important discovery that it was overtopped by a neighbouring peak, subsequently named the Pointe des Écrins, which, before the annexation of Savoy added Mont Blanc to the possessions of France, was the highest point in the French Alps. Its ascent by Mr Whymper's party in 1864 was perhaps the most remarkable feat of mountaineering up to that date. The years 1861 to 1865 are filled with a number of new expeditions in the Mont Blanc group and the Pennine Alps, among them the ascent of the Aiguille Verte and the crossing of the Moming Pass. But the peak which from the first exercised its fascination upon him, and with which his name remains inseparably associated, is the Matterhorn. Professor Tyndall and Mr Whymper emulated each other in fruitless attempts to reach the summit by the south-western or Italian ridge. Mr Whymper, six times repulsed, determined to try the eastern face, convinced that its precipitous appearance when viewed from Zermatt was an optical illusion, and that the dip of the strata, which on the Italian side formed a continuous series of overhangs, should make the opposite side a natural staircase. No more brilliant example can be named of the application of scientific reasoning to the conquest of natural obstacles. His attempt by what is now the usual route was crowned with success (14th July 1865); but on the descent four of the party slipped and were killed, and only the breaking of the rope saved Mr Whymper and the two remaining guides from the same fate. The account of his attempts on the Matterhorn occupies the greater part of his *Scrambles among the Alps* (1871)—one of the classics of Alpine literature. In one respect it stands unique, the illustrations being engraved by the author himself. No engraving could surpass the reproduction of rock-texture in "Matterhorn from the Riffelberg," or of the characteristic appearance of freshly-fallen snow on a lofty peak in "Matterhorn from the summit of the Théodule Pass." His campaign of 1865 had been planned to exercise his judgment in the choice of routes as a preparation for an expedition to Greenland. Entirely an individual effort, save for small grants from the British Association and the Royal Geographical Society, the expedition resulted in an important collection of fossil plants, which were described by Professor Heer and deposited in the British Museum. Mr Whymper's report was published in the *Report* of the British Association for the year 1869. Though hampered by want of means and by the prevalence of an epidemic among the natives, he proved that the interior could be explored by the use of suitably-constructed sledges, and thus contributed an important advance to Arctic exploration. Another expedition followed in 1872, and was devoted to a survey of the coast-line. He next organized an expedition to Ecuador, designed primarily to collect data for the study of mountain-sickness and of the effect of diminished pressure on the human frame. He took as his chief guide Jean Antoine Carrel, whose subsequent death from exhaustion on the Matterhorn after bringing his employers into safety through a snow-storm forms one of the noblest pages in the history of mountaineering. During 1880 Mr Whymper on two separate occasions ascended Chimborazo, whose summit, 20,500 feet above sea-level, had never before been reached; spent a night on the summit of Cotopaxi, separated from its fires by so thin a crust that the temperature of the ground in his tent rose to 110°, and obtained a photograph of the crater; and made first ascents of half-a-dozen other great peaks. In 1892 he published the results of his journey in a volume, entitled *Travels amongst the Great Andes of the Equator*. His observations on mountain-sickness led him to conclude that it was caused by "diminution in atmospheric pressure, which operates in at least two ways—namely, (*a*) by lessening the value of the air that can be inspired in any given time, and (*b*) by causing the air or gas within the body to expand, and to press upon the internal organs"; and that "the effects produced by (*b*) may be temporary and pass away when equilibrium has been restored between the internal and external pressure." The publication of his work was recognized on the part of the Royal Geographical Society by the award of the Patron's medal. His experiences in South America having convinced him of certain serious errors in the readings of aneroid barometers at high altitudes, he published a work, entitled *How to Use the Aneroid Barometer*, and succeeded in introducing important improvements in their construction. He afterwards published two excellent guide-books to Zermatt and Chamonix. In 1901 he undertook an important expedition in an unexplored region of the Canadian Rockies.

Wichita, a city of Kansas, U.S.A., capital of Sedgwick county. It is situated in 37° 40′ N. and 97° 20′ W. in the broad bottom lands of the river Arkansas, in the southern part of the state, at an altitude of 1300 feet. The site of the city is level, its plan regular; it is divided into six wards, and it has water-supply and sewer systems. Four great railway systems enter the city—the Atchison, Topeka, and Santa Fé; the Chicago, Rock Island, and Pacific; the Missouri Pacific, and the St Louis and San Francisco—and make of it an important transportation centre for the rich agricultural region surrounding it. In 1900 the city contained 328 manufacturing establishments, with a total capital of $2,108,524. They employed 1505 hands, and the product was valued at $4,724,068. The city contains also stock-yards and meat-packing establishments. Like other cities of central and western Kansas, Wichita suffered from the "boom" which occurred between 1880 and 1890. In 1880 it had a population of but 4911; in 1890 the number had leaped to 23,853. This was followed by a great falling-off, and it is only in recent years that the city has recommenced to gain. In 1900 the population was 24,671, of whom 1447 were foreign-born and 1389 negroes.

Wick, a royal and parliamentary burgh (Wick group), seaport, and county town of Caithness, Scotland, on the German Ocean, 161 miles north-north-east of Inverness by rail. The town hall and county buildings have been enlarged; there are two free libraries. A harbour extension, begun in 1884, cost £100,000, and a further extension is in progress. In 1888, 1169 vessels of 142,280 tons entered; in 1898, 1057 of 113,262 tons. Exports (mainly fish) were valued at £111,428 in 1888, and £108,282 in 1898. 152 boats employing 636 men belonged to Wick and Pulteneytown in 1899, and the value of the fish landed was £75,669. A new industry is the manufacture of fish guano and fish food products. Population (1891), 8464; (1901), 7881.

Wicklow, a maritime county of Ireland, province of Leinster, bounded on the N. by Dublin, on the E. by St George's Channel, on the W. by Carlow and Kildare, and on the S. by Wexford.

Population.—The area of the administrative county in 1900 was 499,957 acres, of which 89,532 were tillage, 238,481 pasture, 308 fallow, 17,957 plantation, 4446 turf bog, 11,937 marsh, 119,444 barren mountain, and 17,852 water, roads, fences, &c. The new administrative county under the Local Government (Ireland) Act, 1898, includes the portion of the township of Bray formerly situated in Dublin. The population in 1881 was 70,386, in 1891, 62,136, and in 1901, 60,679, of whom 30,500 were males and 30,179 females, divided as follows among the different religions: Roman Catholics, 48,001; Protestant Episcopalians, 11,323; Presbyterians, 495; Methodists, 606; and other denominations, 254. The decrease of population between 1881 and 1891 was 11·72 per cent., and between 1891 and 1901 5·9 per cent. The average number of persons to an acre in 1891 was ·12, the smallest average of any county in Ireland, and of the total population 50,159 persons inhabited the rural districts, being an average of 100 to each square mile under crops and pasture. The following table shows the degree of education in 1891:—

	Males.	Females.	Total.	Percentage.			
				R. C.	Pr. Ep.	Presb.	Meth.
Read and write	20,300	21,159	41,459	69·6	89·9	94·9	95·3
Read only . .	2,636	2,637	5,273	10·7	4·5	2·4	2·1
Illiterate . .	5,056	4,312	9,368	19·7	5·6	2·7	2·6

The percentage of illiterates among Roman Catholics in 1881 was 25·2. In 1891 there were nine superior schools with 261 pupils (Roman Catholics, 142, and Protestants, 119), and 154 primary schools with 9094 pupils (Roman Catholics, 7245, and Protestants, 1849). The number of pupils on the rolls of the National schools on 31st December 1900 was 9636, of whom 7834 were Roman Catholics and 1802 Protestants. The following table gives the number of births, deaths, and marriages in the years specified:—

Year.	Births.	Deaths.	Marriages.
1881	1462	1188	281
1891	1249	1037	297
1900	1286	1199	287

In 1900 the birth-rate per 1000 was 21·2, and the death-rate 19·8; the rate of illegitimacy was 2·6 per cent. of the total births. The total number of emigrants who left the county between 1st May 1851 and 31st December 1900 was 29,072, of whom 16,217 were males and 12,855 females. The chief towns in the county are Bray, Arklow, and Wicklow.

Administration.—The county is divided into two parliamentary divisions, East and West, the number of registered electors in 1901 being respectively 5069 and 4668. The rateable value in 1900 was £285,501. By the Local Government (Ireland) Act, 1898, the fiscal and administrative duties of the grand jury were transferred to a county council, urban and rural district councils were established, and under that Act the county comprises two urban and five rural sanitary districts.

Agriculture.—The following tables show the acreage under crops, including meadow and clover, and the amount of live-stock in 1881, 1891, 1895, and 1901. The figures for 1901 are for the new administrative county.

Year.	Wheat.	Oats.	Barley, Rye, &c.	Potatoes.	Turnips.	Other Green Crops.	Meadow and Clover.	Total.
1881	3397	25,209	1199	11,374	5237	1849	59,168	107,433
1891	954	23,480	551	10,264	5414	2469	55,106	98,238
1895	295	23,847	614	9,067	6241	2116	57,807	99,987
1901	267	21,568	508	7,719	5691	2583	51,872	90,208

In 1900 the total value of the cereal and other crops was estimated at £546,507. The number of acres under pasture in 1881 was 225,919, in 1891, 226,229, and in 1900, 238,481.

Year.	Horses and Mules.	Asses.	Cattle.	Sheep.	Pigs.	Goats.	Poultry.
1881	12,309	3585	76,654	183,222	19,204	7016	214,509
1891	12,366	3607	81,809	215,321	23,465	6769	226,873
1895	13,194	3615	74,847	202,686	22,542	5883	229,767
1901*	12,224	3611	78,770	219,391	19,020	5384	247,446

* The figures for 1901 have not been revised.

The number of milch cows in 1891 was 24,032, and in 1901 21,845. It was estimated that the total value of cattle, sheep, and pigs in 1901 was £1,494,549. In 1900 the number of holdings not exceeding 1 acre was 1388; between 1 and 5, 834; between 5 and 15, 1301; between 15 and 30, 1260; between 30 and 50, 1175; between 50 and 100, 1348; between 100 and 200, 730; between 200 and 500, 282; and above 500, 65; total, 8383. The number of loans issued (the number of loans being the same as the number of tenants) under the Land Purchase Acts, 1885, 1891, and 1896, up to 31st March 1901, was 319, amounting to £289,538. The number of loans for agricultural improvements, sanctioned under sect. 31 of the Land Act, 1881, was 192, and the amount issued, £17,002. The total amount issued in loan for all classes of works under the Land Improvement Acts, from the commencement of operations in 1847 to 31st March 1901, was £128,070.

Fisheries.—In 1900 160 vessels, employing 838 hands, were registered in the deep-sea and coast fishery district of Wicklow.

(W. H. Po.)

Widdin, or VIDDIN, a fortified town and seaport, and the capital of a department of the same name, in the principality of Bulgaria, situated on the right bank of the Danube, 151 miles north-north-west of Sofia. It consists of three divisions—the modern suburbs extending along the banks of the Danube, the old town surrounded by walls, and the citadel. The old town contains the ruined mosque of Mustafa Pasha, the ruined palace of the pashas, and the clock tower. The chief trade is in cereals, dried fruit, and jewellery, and there is also a large distillery. The exports in 1899 amounted to 33,914 tons, valued at £123,856, and the imports to 39,052 tons, valued at £70,824. Population, 14,772.

Widnes, a municipal borough (since 1892) and manufacturing town, in the Widnes parliamentary division of Lancashire, England, on the river Mersey, 13 miles south-east of Liverpool by rail. A technical school and free library were opened in 1896. The fever hospital was enlarged in 1900, at a cost of £10,000, and in the same year the Victoria Park (34 acres) and the Victoria Promenade, bordering the river, were opened. A cemetery of 15 acres, with three mortuary chapels, was laid out in 1898. Population (1891), 30,011; (1901), 28,580.

Widor, Charles Marie (1845-——), French composer and organist, was born at Lyons, 22nd February 1845. He studied first at Lyons, then at Brussels under Lemmens for the organ and Fétis for composition. In 1870 he became organist of the church of Saint Sulpice in Paris. He succeeded César Franck as professor of the organ at the Paris Conservatoire, where he was also appointed professor of composition, counterpoint, and fugue in 1896. M. Widor is a very prolific composer, and has displayed his creative ability in a variety of different styles. His works include an opera, *Maître Ambros* (Opéra Comique, 1896), *La Korrigane* (ballet, given at the Opéra, 1880), incidental music to *Conte d'Avril* (1885), *Les Jacobites* (1885), and *Jeanne d'Arc* (a pantomime play, 1890), two symphonies, *The Walpurgis Night*, and other works for orchestra, a quintet for strings and piano, trio for piano and strings, a mass, psalm, and other sacred compositions, symphonies for organ, a large number of piano pieces, and many songs.

Wiedemann, Gustav Heinrich (1826–1899), German physicist, was born at Berlin on the 2nd of October 1826. After attending the Cologne gymnasium, he entered the University of Berlin in 1844, and took his doctor's degree there three years later. His thesis on that occasion was devoted to a question in organic chemistry, for he held the opinion that the study of chemistry is an indispensable preliminary to the pursuit of physics, which was his ultimate aim. In Berlin he made the acquaintance of Helmholtz at the house of Magnus, and was one of the founders of the Berlin Physical Society. In 1854 he left Berlin to become professor of physics in Basel University, removing nine years afterwards to Brunswick Polytechnic, and in 1866 to Carlsruhe Polytechnic. In 1871 he accepted the chair of physical chemistry at Leipzig. The attention he had paid to chemistry in the earlier part of his career enabled him to hold his own in this position, but he found his work more congenial when in 1887 he was transferred to the professorship of physics. He died at Leipzig on the 24th of March 1899. His name is probably most widely known for his literary work. In 1877 he undertook the editorship of the *Annalen der Physik und Chemie* in succession to Poggendorff, thus starting the series of that scientific periodical which is familiarly cited as *Wied. Ann.*

Another monumental work for which he was responsible was *Die Lehre von der Elektricität*, or, as it was called in the first instance, *Lehre von Galvanismus und Elektromagnetismus*, a book that is unsurpassed for accuracy and comprehensiveness. He produced the first edition in 1861, and a fourth, revised and enlarged, was only completed a short time before his death. But his original work was also important. His data for the thermal conductivity of various metals were for long the most trustworthy at the disposal of physicists, and his determination of the ohm in terms of the specific resistance of mercury showed remarkable skill in quantitative research. He carried out a number of magnetic investigations which resulted in the discovery of many interesting phenomena, some of which have been rediscovered by others; they related among other things to the effect of mechanical strain on the magnetic properties of the magnetic metals, to the relation between the chemical composition of compound bodies and their magnetic properties, and to a curious parallelism between the laws of torsion and of magnetism. He also investigated electrical endosmosis and the electrical resistance of electrolytes. His eldest son, EILHARD, born at Berlin on the 1st of August 1852, became professor of physics at Erlangen in 1886, and his younger son, ALFRED, born at Berlin on the 18th of July 1856, was appointed to the extraordinary professorship of Egyptology at Bonn in 1892.

Wieliczka, a mining town in Galicia, Austria, 9 miles from Cracow, built on the slopes of a hill which half encircles the place, and over the celebrated salt-mines of the same name. Two of the entrances to the mines are in the town. They suffered from inundations in 1868 and 1879, the former of which greatly damaged the subterranean chapels with their altars, statues, and ornaments in rock-salt. The worst effects of both inundations were averted, but the whole soil on which the town is built shows signs of subsidence. There are about 1000 hands employed in the mines, which in 1894 yielded 80,170 tons of salt, of a value of £291,600. They have been in the exclusive possession of the Austrian State since 1814. Population (1890), 6037; (1900), 6012.

Wiener-Neustadt, an important manufacturing town in Lower Austria, about 30 miles south of Vienna by rail. The town has a large ammunition factory in addition to its other industries, and an important pig fair. Population (1890), 25,040; (1900), 28,438, including a garrison of 1595 men.

Wieniawski, Henri (1835–1880), Polish violinist and composer, was born at Lublin, in Poland, 10th July 1835. He was a pupil of the Paris Conservatoire from 1843 to 1846, and again in 1849–50. Meanwhile he had given concerts in his native country and in Russia, and in 1850 entered upon the career of a travelling virtuoso, together with his brother Joseph, a distinguished pianist. He was appointed solo violinist to the Tsar in 1860, and taught in the Conservatoire of St Petersburg from 1862 to 1867. He went on tour again in 1872 with Rubinstein in America, and on his return in 1874 was appointed to succeed Vieuxtemps as professor in the Brussels Conservatoire; but like his predecessor, he was compelled through ill-health to give up the post after three years, returning to a public career in spite of his illness, until his death in Moscow, 31st March 1880. He was a wonderfully sympathetic player, who had conquered in early life all possible technical difficulties; he was a good if not a great quartet player, but his impulsive nature fitted him rather for the interpretation of works like his own, compositions which, with their strongly marked individuality, make a direct appeal to the average hearer, are eminently grateful to the player, and by no means unpleasing to musicians. His *Légende*, the fantasias on *Faust* and on Russian airs, his two concertos, and some other pieces, have retained their high place in the violin repertory.

Wiesbaden, a watering-place of Prussia, province of Hesse-Nassau, on the southern slope of the Taunus range, and 6 miles north of Mainz. The total number of persons who in the year visit its mineral baths and various health institutions is estimated at 120,000. A new drinking hall was built in 1888–90 to enclose the "Kochbrunnen." In 1884–87 a new town hall was constructed of sandstone in the German Renaissance style; it affords shelter to the Fischbach textile museum. The Protestant Ring-Kirche, a Transitional building (1892–94), forms a conspicuous object on the west side of the town. The Augusta Victoria bath-house, a fine Renaissance edifice, opened in 1895, is equipped interiorly like the Friedrich bath-house in Baden. There is a new (1893–95) Roman Catholic church, Mariahilfkirche. In 1892–94 the royal theatre was provided with a new rear façade (1892–94). The town is adorned with bronze statues of the Emperor Frederick III. (1897) and Bismarck (1898), and a marble statue by Schilling of the Emperor William I. (1894). A chemical laboratory, agricultural institute and experimental station, technical school, architects' school, musical conservatoriums, blind asylum, and several special medical institutions are the principal educational and health establishments. Population (1885), 55,454; (1895), 74,133; (1900), 86,086.

Wigan, a municipal, county (1888), and parliamentary borough and market town of Lancashire, England, 195 miles by rail north-west of London. In 1890 it was divided into 10 wards under a mayor, recorder, 10 aldermen, and 30 councillors. The convent of Notre Dame (1854), with a college for pupil teachers and a high school for girls, was rebuilt in 1894. There are four Roman Catholic churches and five Roman Catholic schools. In 1891 there were 5086 persons (4103 females) employed in the manufacture of cotton goods, 5937 in coal-mining, and 1180 in the iron and steel manufacture. Area of municipal and parliamentary borough, which are coextensive, 2188 acres. Population (1891), 55,013; (1901), 60,770.

Wight, Isle of, an island adjacent to the south coast of Hampshire, England, from which it is separated by the Solent and Spithead. It is much frequented by holiday visitors all the year round, and by invalids, especially those suffering from pulmonary complaints, in winter. Cowes (for yachting), Ryde, Shanklin, and Ventnor are the places chiefly visited; the last named is also the principal winter resort. But in addition to these, there are several smaller places rising more or less rapidly into note, in part for sea-bathing, as Bembridge, Seaview, near Ryde, and Sandown, on the east coast; and Freshwater Gate and Totland Bay, at the western extremity of the island. The south and west coasts offer stretches of picturesque scenery, the most famous being the Undercliff, Blackgang Chine, 400 feet in height, backed by St Catherine's Hill (830 feet), the highest point in the island. The stretch of cliff scenery between Freshwater Bay and Alum Bay reaches 400 to 500 feet and overlooks the Needles, three chalk pinnacles which rise 100 feet above the sea, the outermost bearing a lighthouse. In the vicinity of Freshwater Gate is Farringford, for some time the residence of Lord Tennyson, the poet, to whom a national monument, in the shape of a beacon on Freshwater Down, was erected in 1897. One of the loveliest spots in the island is the village of Bonchurch, immediately east of Ventnor. Yarmouth, near the west end of the island, has a good natural harbour, used by the steamboats which ply to Lymington, and is the headquarters of the Solent Yacht Club. The associations which knit the British royal family with the Isle of Wight centre chiefly in Osborne House, a villa in the Italian style, close to East Cowes and overlooking the channel of Spithead, where Queen Victoria used to spend some months every year, and where she died. Osborne House was presented to the nation in 1902 by King Edward VII. in commemoration of his coronation. Whippingham church, close by, was designed by the Prince Consort, and its font by Princess Christian and Princess Louise. It contains memorials of the Prince Consort and of Prince Henry of Battenberg. Princess Beatrice succeeded her husband as honorary governor of the Isle of Wight in 1896. Population (1891), 78,672; (1901), 82,387.

Wigtown, a royal burgh and county town of Wigtownshire, Scotland, on Wigtown Bay, and the Wigtownshire Railway, 129 miles south-south-west of Edinburgh by road. There are a town hall, two burgh crosses—the latter built to commemorate Waterloo—and a mechanics' institute. The harbour admits ships of 300 tons. At the end of 1898, 18 vessels of 709 tons were registered at the port; in 1888, 434 vessels of 30,947 tons entered and 433 of 30,755 tons cleared; in 1898, 246 vessels of 14,551 tons entered and 257 of 15,034 tons cleared. Two public schools had an average attendance of 217 in 1898–99, and a Roman Catholic school 36. Valuation in 1889–90, £5401; 1899–1900, £7011. Population (1881), 1780; (1891), 1509; (1901), 1386.

Wigtownshire, a maritime county in the south-west corner of Scotland, bounded on the N. by the Irish Channel and Ayrshire, on the E. by Kirkcudbright and Wigtown Bay, on the S. by the Irish Sea, and on the W. by the Irish Channel.

Area and Population.—The area of the county (foreshore excluded) is 314,405 acres, or about 491 square miles. The population was, in 1881, 38,611; in 1891, 36,062; in 1901, 32,683, of whom 15,269 were males and 17,414 females. Taking the land area only (310,747 acres, or 485·5 square miles), the number of persons to the square mile in 1901 was 67, and the number of acres to the person 9·6. In the registration county the population decreased between 1881 and 1891 by 6·7 per cent. Between 1881 and 1891 the excess of births over deaths was 4293, and the decrease of the resident population 2568. The following table shows the births, deaths, and marriages, with the percentage of illegitimacy:—

Year.	Deaths.	Marriages.	Births.	Percentage of Illegitimates.
1880	699	185	1169	16·9
1890	667	169	971	15·86
1899	600	174	775	14·1

The following table gives the birth-rate, death-rate, and marriage-rate per thousand of the population for a series of years:—

	1880.	1881–90.	1890.	1891–98.	1899.
Birth-rate . .	30·39	29·31	26·92	26·81	22·95
Death-rate . .	18·17	17·76	18·49	12·01	17·76
Marriage-rate .	4·81	5·23	4·68	5·54	5·15

In 1891 there were 68 Gaelic-speaking persons in the county and 14 foreigners. Valuation in 1889–90, £209,732; 1899–1900, £221,690.

Administration.—The county returns one member to Parliament. There are three royal burghs—Stranraer (6009), Whithorn (1186), and Wigtown (1386), the county town. There are 17 civil parishes, forming with Ballantrae in Ayrshire, the Wigtownshire combination. The number of paupers and dependents in September 1899 was 1116. Wigtownshire forms part of the sheriffdom of Dumfries and Galloway, and a sheriff-substitute sits at Wigtown and Stranraer.

Education.—Eighteen school boards manage 48 schools, which had an average attendance of 5088 in 1898–99, while 3 Roman Catholic schools had an average attendance of 133. There are 3 high schools, 1 in Stranraer and 2 in Newton-Stewart. Whithorn and Wigtown public schools have secondary departments, and 9 other public schools earned grants in 1898 for giving higher education. The county council expends the "residue" grant in providing bursaries for science pupils, and in subsidizing agricultural classes at Kilmarnock and Edinburgh University, cookery classes and the science departments of the high schools.

Agriculture.—The percentage of cultivated area was 48·8 in 1898, the county ranking tenth in Scotland in this respect. Oats are the predominant crop. Wheat, which covered 7343 acres in 1855, covered only 560 in 1898, and barley continues to decline. The greatest development has taken place in dairying, which is now carried on in large combinations and on scientific principles. Creameries have been established all over the dairy country, and in 1900 there were 7 of them in operation. The following table gives the principal acreages in 1885 and various subsequent years:—

Year.	Area under Crops.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885	147,214	37,502	18,580	69,364	21,371	397
1890	153,447	36,693	18,332	71,036	27,067	301
1895	152,963	36,059	18,367	65,393	32,910	221
1899	154,311	35,125	17,841	66,977	34,033	311

The following table gives particulars of the live-stock during the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or Calf.	Sheep.	Pigs.
1885	5879	44,347	21,090	116,352	9,011
1890	6029	46,968	22,088	128,198	11,093
1895	6501	48,323	24,077	117,974	11,236
1899	5966	59,778	23,743	127,032	12,020

Of the 1325 holdings in 1898 the average size was 115 acres. The percentage under 5 acres was 13·21; between 5 and 50 acres, 20·79, and over 50 acres, 66·00. Farms between 50 and 100 acres numbered 183, between 100 and 300, 442, between 300 and 500, 93, and over 500, 24, one being over 1000. In 1895, 7952 acres were under wood, 220 having been planted since 1881. At the census of 1891, 4685 men and 899 women were returned as being engaged in agriculture.

AUTHORITIES.—Sir HERBERT MAXWELL. *History of Dumfries and Galloway.* Edinburgh, 1896.—ÆNEAS B. HUTCHISON. *Memorials of Dundrennan Abbey.* Exeter, 1857.—Sir ANDREW AGNEW. *The Agnews of Lochnaw.* Edinburgh, 1893.—*The Galloway Herd-Book.* Dumfries, 1880.—THOMAS MACLELLAND. "The Agriculture of Wigtownshire" (*Trans. of H. and A. Soc.*). 1875.—*Proceedings of Soc. of Ant. of Scotland, passim.*—GORDON FRASER. *Wigtown and Whithorn.* Wigtown, 1877.—J. M'ANDREW. *List of Wigtownshire Plants.* 1894.—*Trans. of Dumfriesshire and Galloway Natural History Society.* Dumfries, 1862.

Wilde, Oscar O'Flahertie Wills (1856–1900), English author, son of Sir William Wilde, a famous Irish surgeon, was born in Dublin, 15th October 1856; his mother was well known in Dublin as a graceful writer of verse and prose, who adopted the pen-name of "Speranza." Having distinguished himself in classics at Trinity College, Dublin, Oscar Wilde went to Magdalen College, Oxford, in 1874, and won the Newdigate prize in 1878 with his poem "Ravenna," besides taking first-classes in classical Moderations and Greats. But his career at Oxford, brilliant intellectually as he showed himself to be, was chiefly signalized by the part he played in what came to be known as the Æsthetic Movement. He adopted what to undergraduates appeared the effeminate pose of casting scorn on manly sports, wearing his hair long, decorating his rooms with peacocks' feathers, lilies, sunflowers, blue china, and other *objets d'art*, which he declared his desire to "live up to" affecting a lackadaisical manner, and professing intense emotions on the subject of "art for art's sake"—then a new-fangled doctrine which Mr Whistler was bringing into prominence. Wilde made himself the apostle of this new cult, which—though at Oxford his behaviour procured him a ducking in the Cherwell, and a wrecking of his rooms—spread among certain sections of society to such an extent that languishing attitudes, "too-too" costumes, and "æstheticism" generally became a recognized pose, and culminated in the production of Gilbert and Sullivan's travesty *Patience* (1881), which practically killed by ridicule the absurdities to which it had grown. At the same time it cannot be denied that the movement was one side of something better, which, as represented by the school of Morris and Rossetti, had a permanent influence on English decorative art. As the leading "æsthete," Oscar Wilde became one of the most prominent personalities of the day; apart from the ridicule he encountered, his affected paradoxes and his witty sayings were quoted on all sides, and in 1882 he went on a lecturing tour in the United States. In 1884 he married Constance Lloyd. He had already published in 1881 a selection of his poems, which, however, only attracted admiration in a limited circle. In his writings there was to most people an undertone of rather nasty suggestion, and his novel *Dorian Gray* (1888), with all its sparkle and cleverness, impressed them more from this point of view than from its purely literary brilliance. Wilde contributed some characteristic articles to the reviews, all coloured by his peculiar attitude towards art and life, and in 1891 republished three of them as a book called *Intentions*. He also published some fairy tales; but his first real success was as a dramatist with *Lady Windermere's Fan* at the St James's Theatre in 1892, followed by *A Woman of No Importance* (1893), *The Ideal Husband* (1895), and *The Importance of Being Earnest* (1895). The dramatic and literary ability shown in his plays, all of which were published later in book form, was as undoubted as their diction and ideas were characteristically paradoxical. In 1893 the licenser of plays refused a licence to Wilde's *Salomé*, but it was produced in Paris. His success as a dramatist had by this time gone some way to disabuse hostile critics of the suspicions as regards his personal character which had been excited by the apparent looseness of morals which since his Oxford days it had always pleased him to affect; but to the consternation of his friends, who had never credited the existence of any real moral obliquity, in 1895 came fatal revelations as the result of his bringing a libel action against the Marquis of Queensberry; and at the Old Bailey, in May, Wilde was sentenced to two years' imprisonment with hard labour for offences under the Criminal Law Amendment Act. It was a melancholy end to what might have been a singularly brilliant career. Even after leaving prison he was necessarily an outcast from decent circles, and he lived mainly on the Continent, where he died on 30th November 1900. In 1898 he published his powerful *Ballad of Reading Gaol*. His *Collected Poems*, containing, it must be admitted, some beautiful verse, had been issued in 1892. The Old Bailey revelations removed all doubt as to the essential unhealthiness of Oscar Wilde's influence; but his literary gifts were none the less remarkable, and his plays were perhaps the most original contributions to English dramatic writing during the period.

Wilderness, a region in north-eastern Virginia, U.S.A., famous as the scene of some of the fiercest battles of the Civil War. In May 1864, General Grant began his determined movement upon Richmond, the Confederate capital. General Meade, who was in command of the army of the Potomac, was encamped between the Rappahannock and the Rapidan. With Meade's forces, Grant advanced upon Lee, who was encamped upon the south bank of the Rapidan, about sixty miles north of Richmond. The opposing armies met in a wild, swampy region called "The Wilderness," and on 5th May the fighting began. It lasted two days, resulting in severe losses on both sides, but in no decisive victory for either. The Union loss is estimated at 15,000 in killed, wounded, and prisoners; but the Confederates, who were familiar with the country, lost only about 10,000 in killed and wounded, and few prisoners. These battles were the beginning of the close of the war; they were followed by the bloody contests at Spottsylvania, North Anna, and Cold Harbor. It is said that at least 100,000 men on both sides were lost in little over a month in killed, wounded, and missing.

Wilhelmina (WILHELMINA HELENA PAULINE MARIA, QUEEN OF THE NETHERLANDS (1880- ——), Princess of Orange-Nassau, was born at The Hague on the 31st of August 1880. Her father, William III. (Willem Paul Alexander Frederik Lodewijk), had by his first wife, Sophia Frederika Mathilde of Würtemberg, three sons, all of whom predeceased him. Having been left a widower on 3rd June 1877, he married on the 7th of January 1879 Adelheid Emma Wilhelmina Theresia, second daughter of Prince George Victor of Waldeck-Pyrmont, born 2nd August 1858, and Wilhelmina was the only issue of that union. She succeeded to the throne on her father's death, which took place on the 23rd of November 1890, but until her eighteenth year, when she was "inaugurated" at Amsterdam on

QUEEN WILHELMINA.
(From a photograph by Wegner and Mottu, Amsterdam.)

the 6th of September 1898, the business of the State was carried on under the regency of the queen-mother, in accordance with a law made on the 2nd of August 1884. On the 7th of February 1901 Queen Wilhelmina married Henry Wladimir Albert Ernst, Duke of Mecklenburg-Schwerin (born on the 19th of April 1876), and the rejoicings on that occasion, though the celebration was somewhat damped by the death of Queen Victoria, were little less than those called forth by her formal installation. (See also under HOLLAND: *History.*)

Wilhelmshaven, the chief naval station and port of Prussia on the North Sea coast, on the western side of Jahde Bay, forming an exclave of the province of Hanover, in the heart of the duchy of Oldenburg, 60 miles by rail north-west of Bremen. The so-called new harbour (170 acres in area and 26¼ feet deep) is connected by means of a sluice (571 feet long) with the new harbour entrance, which was completed in 1886. On the north it is connected with the "equipment dock" (3832 feet long, 446 feet wide), which again is connected by a sluice (158 feet long) with the outer basin (617 feet long, 410 feet wide), and so with the old harbour entrance. On the west side of the "equipment dock" lies the shipbuilding basin (1237 feet long by 742 feet wide), with three dry docks (of which two are each 453 feet long, 85 feet wide, and more than 30 feet deep, whilst the third is 394 feet long), and also with two slips of the largest size. The special torpedo harbour is in the south-east of the new harbour. There are also an observatory (8° 8′ 48″ E. and 53° 31′ 57″ N.), a laboratory, infirmary, machine shops, steam hammers, iron foundries, boiler works, &c. The commercial harbour lies on the south side of the town; in 1899 it was cleared by 961 vessels of 55,186 tons engaged in foreign trade. Wilhelmshaven is visited for its sea-bathing. Population (1885), 13,972; (1895), 19,422; (1900), 22,571.

Wilkesbarre, a city of Pennsylvania, U.S.A., capital of Luzerne county. It is situated in 41° 14′ N. and 75° 56′ W., on the north branch of the river Susquehanna, in the north-eastern part of the state, at an altitude of 545 feet. The plan of the city is regular, it is divided into sixteen wards; its water-supply, owned by private parties, is in part obtained by gravity and in part by pumping; it is well sewered, and well paved in great part with asphalt. It is in the anthracite coal region, and its industries are in great part connected with mining and shipping coal. It has five railways—the Central of New Jersey; the Delaware and Hudson; the Lehigh Valley; the New York, Susquehanna, and Western; and the Pennsylvania, affording ample means of transportation. The city is an important manufacturing place. In 1900 it contained 438 manufacturing establishments, with a total capital of $10,501,537. They employed 5977 hands, and the product was valued at $10,758,348. In 1900 the assessed valuation of real and personal property was $18,155,939, the net debt of the city was $602,391, and the rate of taxation was $26·75 per $1000. Population (1890), 37,718; (1900), 51,721, of whom 12,188 were foreign-born and 680 negroes.

Wilkinsburg, a borough of Allegheny county, Pennsylvania, U.S.A., in the south-western part of the state, a few miles east of Pittsburg, of which it is a suburb. Population (1890), 4662; (1900), 11,886, of whom 1336 were foreign-born and 275 negroes.

Wilkinson, James John Garth (1812–1899), Swedenborgian writer, the son of James John Wilkinson (died 1845), a writer on mercantile law and judge of the County Palatine of Durham, was born in London on 3rd June 1812. He studied medicine, and set up as a homœopathic doctor in Wimpole Street in 1834. He was early attracted by the works of William Blake, whose *Songs of Experience* he endeavoured to interpret, and of Swedenborg, to the elucidation of whose writings he devoted the best energies of his life. Between 1840 and 1850 he edited Swedenborg's treatises on *The Doctrine of Charity*, *The Animal Kingdom*, *Outlines of a Philosophic Argument on the Infinite*, and *Hieroglyphic Key to Natural and Spiritual Mysteries.* Wilkinson's preliminary discourses to these translations and his criticisms of Coleridge's comments upon Swedenborg displayed a striking aptitude not only for mystical research, but also for original philosophic debate. The vigour of his thought won admiration from Henry James (father of the novelist) and from Emerson, through whom he became known to Carlyle and Froude; and his speculation further attracted Tennyson, the Oliphants, and Edward Maitland. He wrote an able sketch of Swedenborg for the *Penny Cyclopædia*, and a standard biography, *Emanuel Swedenborg* (published in 1849); but interest in this subject far from exhausted his intellectual energy, which was, indeed, multiform. He was a traveller, a linguist, well versed in Scandinavian literature and philology, the author of mystical poems entitled *Improvisations from the Spirit* (1857, 16mo), a social and medical reformer, and a convinced opponent of vivisection and also of vaccination. He died at Finchley Road, South Hampstead, where he had resided for nearly fifty years, on 18th October 1899. He is commemorated by a bust and portrait in the rooms of the Swedenborgian Society in Bloomsbury Street, London.

(T. SE.)

Willesden, a suburb of London and important railway junction in the Harrow parliamentary division of Middlesex, about 4 miles north-west of Hyde Park Corner. An isolation hospital, completed in 1894, cost £20,000. In the same year a recreation ground of about 26 acres was laid out. Population (1881), 27,453; (1891), 61,265; (1901), 114,815.

William II. (FRIEDRICH WILHELM VICTOR ALBERT), KING OF PRUSSIA AND GERMAN EMPEROR (1859– ——), was born 27th January 1859 at Berlin, being the eldest child of Prince Friedrich of Prussia, afterwards Crown Prince and second German Emperor. Like all princes of the House of Hohenzollern, he was on his tenth birthday introduced into the army, being appointed second lieutenant in the First Regiment of the Guards, but contrary to all precedent, at the special wish of his mother, he was with his younger brother Heinrich educated at a public school. From September 1874 to January 1877 he attended the lyceum at Cassel; afterwards for two years he was a student at the University of Bonn, where his father also had studied. On the conclusion of his general education he was for some years chiefly occupied with military affairs, in which he displayed great interest and ability. In 1885 he became colonel of the Hussars of the Guards, a position in which he showed, as throughout his career, that he was not content with holding the honorary titles which came to him in virtue of his birth, but carried out the duties of his office with the strictness and diligence which would be demanded from every other officer. It was natural that he was at this time much influenced by the military associations in which most of his life was spent, and in his opinions on political affairs he was more in sympathy with the strongly monarchical feelings of the Emperor William and Bismarck than with the more liberal views of his own parents. Until the illness of his father in 1887 he took no part in political or public life, and proposals that during the absence of the Crown Prince from Berlin authority should be given to Prince

William to sign State papers for his grandfather, whose health was failing, were not carried out owing to the fear that it would cause offence to the Crown Prince. The death of his grandfather was quickly followed by that of his father, and on 15th June he became ninth king of Prussia and third German Emperor. In accordance with Prussian tradition, there was no formal coronation. His accession was regarded with some apprehension, for it was feared that his military ardour might induce him to take Frederick the Great as his model, and that he might break the peace of Europe in order to win laurels for himself, while his strong monarchical feelings might lead him to unconstitutional acts. By attending a meeting at the house of Count Waldersee in aid of the Berlin City Mission he had also to some extent identified himself with the religious endeavours of the Conservative and Christian Socialist party. These fears were also increased by the determination with which he brought forward the military side of his position: his first act was an address to the army and navy, while that to his people followed after three days; and throughout his reign he has repeatedly stated that the army was the true basis of his throne: "The soldier and the army, not parliamentary majorities, have welded together the German Empire. My confidence is placed on the army."

William II., German Emperor.
(*From a photograph by Reichard and Lindner, Berlin.*)

For a history of the political events of his reign the reader is referred to the article on Germany. It is sufficient here to say that from the first day of his accession the new Emperor took the reins of government into his own hand. Full of self-confidence, and believing in a special Providence watching over the fortunes of his country and his House, he was not satisfied any longer to leave the real management of things to Bismarck. From the first he showed his intention to be his own Chancellor, and it was this which brought about the quarrel with Bismarck, who could not endure to be less than all-powerful. The decision with which the great statesman was dismissed, and the determination with which the founder of the Empire was placed in disgrace, first revealed the resolution of the new ruler; for it is to his personal wishes that we must attribute the steps by which the disgrace of Bismarck was officially proclaimed. Equally marked were the distinctions showered on him when the reconciliation took place—the almost royal honours with which he was received at his last visit to Berlin; the visit of the Emperor on the Prince's eightieth birthday; the telegram in which the Emperor expressed the indignation and disgust of the nation that a majority of the Reichstag refused on this occasion to vote an address of congratulation; and the offer on his death to give him a grave among the tombs of his own ancestors. In favour and disgrace alike we see the fixed will that the greatness of the statesman should appear to depend on, and be secondary to, that of the Hohenzollern. He even on one occasion, in words which referred to Bismarck, spoke of "the councillors who had the honour of carrying out the thoughts of the Emperor William I." as "tools of his exalted will, filled with the spirit of the exalted Emperor"—words which in Germany called forth many indignant protests. As regards foreign affairs, the apprehensions felt at his accession were not fulfilled. With all his enthusiasm for the army, he was as determined as every other responsible statesman to avoid the catastrophe of a European war. While he maintained and confirmed the alliance with Austria and Italy, in obedience to the last injunctions of his grandfather, he repeatedly attempted to establish more cordial relations with "the Eastern neighbour," Russia. By his frequent visits to the other courts of Europe he soon made himself the most conspicuous figure in Europe, and his individuality became one of the chief factors in the European system. Within little more than a month of his accession, attended by a powerful squadron of ships of war, he visited the three Baltic courts—St Petersburg, Stockholm, and Copenhagen—a strange and striking inauguration of his reign. His overtures to Russia were scarcely received with a cordiality equal to the *empressement* which he showed. The intimacy of Russia with

France increased, and more than a year passed before the Tsar appeared on a short visit to Berlin. In 1890 the Emperor again went to Russia, and the last meeting between him and Alexander III. took place at Kiel in the autumn of 1891, but it was marked by considerable coolness. By his visit to Copenhagen, as in his treatment of the Duke of Cumberland and in his frequent overtures to France, the Emperor William showed the strong desire, by the exercise of his own great personal charm and ability, to heal the wounds left by the events of a generation before, but the visit was not repeated. In the autumn of 1888 he visited not only the courts of the Confederate Princes, but those of Austria and Italy. While at Rome he went to the Vatican and had a private conversation with the Pope, and this visit was repeated in 1895. In 1889 the marriage of his sister, the Princess Sophie, to the Duke of Sparta, took him to Athens; and thence he sailed to Constantinople, where he was received by the Sultan with marked honour. It was the first time that one of the great rulers of Christendom had been the guest of the Padishah. A more active interest was now taken by Germany in the affairs of the Levant, and the Emperor showed that he would not be content to follow the secure and ascertained roads along which Bismarck had so long guided the country. It was not enough that Berlin had become the centre of the European system. The Emperor was the apostle of a new Germany, which claimed that her voice should be heard in all political affairs, in whatever quarter of the globe they might arise. Once again, in 1898, he went to Constantinople. It was the time when the memory of the Armenian massacres had made the name of Abdul Hamid notorious in Western Europe, and the very striking friendliness shown towards him scarcely seemed consistent with the frequent claims made by the Emperor to be the leader of Christendom; but any scruples on this point were doubtless outweighed by the great impulse he was able to give to German trade and German influence in the East. From Constantinople he passed on to Palestine. He was present at the consecration of the German Protestant Church of the Redeemer. By the favour of the Sultan he was able to present to the German Catholics a plot of ground, the Dormition de la Sainte Vierge, very near to the Holy Places.

The Emperor's constant travels soon gained for him the nickname of "Der Reise-Kaiser," his grandfather's having been "Der greise Kaiser," and his father's "Der weise Kaiser." It was unusual at the time of his accession for Germans to travel abroad as English people of the same class did, and his activity struck them as unnatural. As time went on, however, the Emperor's example began to be followed by his subjects, and at the end of the 19th century they were to be found as tourists in foreign countries to almost the same extent as Englishmen or Americans. With the exception of France and the Iberian Peninsula, there is not a country in Europe that he did not repeatedly visit. Not politics alone guided his movements, but a keen interest in men and things, the desire to know and see. His love of the sea was shown in an annual voyage to Norway, and in the visits to the Cowes regatta which he made each year from 1889 to 1895. An ardent sportsman, he hunted the wild reindeer beyond the North Cape, and whale in the Arctic Ocean, bears in Russia and the Carpathians, red deer on the Scottish moors, and grouse, as the guest of Lord Lonsdale, on the famous Wemmersgill moors. On each of his journeys not only was he occupied in spreading the name of his country, but he was always active to observe the institutions of the countries he visited, and to bring back inventions and suggestions for the government of his own.

The Emperor's relations with Great Britain are of special interest, for in them we can see the constant struggle between a genuine affection and admiration for a country to which he was attached by many close ties and the exigencies of the political situation. At the time of his accession there was a strong manifestation of anti-British feeling in Berlin, and there seemed reason to suppose that the party from which it proceeded had the patronage of the Emperor. Any temporary misunderstanding was removed by his visit to England in 1889. For the next six years he was every year the guest of Queen Victoria, and during the period that Caprivi held office the political relations between Germany and Great Britain were very close. While the Emperor's visits were largely prompted by personal desires and family ties, they were not without an important effect on the political situation; and in 1890, when he was entertained at the Mansion House in London and visited Lord Salisbury at Hatfield, the basis for an *entente cordiale* was discussed. After 1895 the growth of the colonial spirit in Germany and the strong spirit of rivalry with Great Britain, which became each year more manifest, made the conduct of the Emperor more difficult. His own ambitions and his conviction as to the necessity for a vigorous naval policy made him the leader of those who were always ready to appeal to the spirit of emulation against Great Britain, which in many degenerated into deliberate and bitter hatred. On the occasion of the Jameson Raid he despatched to the President of the Transvaal a telegram, in which he congratulated him that "without appealing to the help of friendly Powers," he had succeeded in restoring peace and preserving the independence of his country. It is impossible to regard this merely as unconsidered and generous sympathy with a weak state unjustly attacked. It was warmly approved in Germany, but the political results were unsatisfactory, for it caused a long alienation from Great Britain, and helped to bring about that concentration of British energy which it was in the interests of the German colonial parties to prevent. Moreover, it at once became clear that on colonial questions any misunderstanding with Great Britain would leave Germany in a dangerous isolation. The Emperor did not again visit England till, at the beginning of 1901, he hurried away from the celebration of the two hundredth anniversary of the foundation of the kingdom of Prussia to attend the deathbed and funeral of Queen Victoria. On this occasion he placed himself in strong opposition to the feelings of the large majority of his countrymen by conferring on Lord Roberts the Order of the Black Eagle, the most highly prized of Prussian decorations. He had already refused to receive the ex-President of the Transvaal on his visit to Europe.

The most important work to which the Emperor turned his attention was the increase of the German naval forces, and he will always be remembered as the real founder of the German fleet. As a young man he had no connexion with the navy; his occupation was in the army, while his brother Henry was attached to the fleet. From the moment of his accession he constantly showed the keenest interest in naval affairs, and set himself to create among the people an interest in the navy equal to that in the army. At his accession he made a proclamation to the navy as well as to the army, in which he expressed the "lively and warm interest which since his earliest years had united him to the navy." The numerous changes made in the organization during the next years were due to his personal initiative. It was from the beginning of 1895 that he publicly put himself at the head of the movement for making Germany a sea Power. In this he was doubtless much influenced by his close acquaintance with Great Britain and the British fleet, and also by the numerous works on naval policy which at that time appeared in England. In January 1895, at an evening reception to members of the Reichstag, he gave a lecture of nearly two hours' length on the necessity for increasing the navy; and some weeks later at the Berlin Military Academy lectured on the relations of the army and navy with special reference to the Chino-Japanese war. Next year, in the great speech at the anniversary of the foundation of the Empire, he declared that it was the duty to bind together the Germans beyond the seas, for the "German Empire has become a World Empire." In all the discussions on the naval Bills his influence was decisively used to overcome the resistance of the Reichstag. In an evening reception he overcame the reluctance of many of the Conservative and National Liberal members to the new naval policy; he sent to the Reichstag tabular representations of the comparative increase of the great fleets of the world during the last years, signed by himself. In speeches in all parts of the country he combated the indifference of the inland Germans to the sea, as when at Carlsruhe he declared that "the trident is now in our hands." "I will not rest," he telegraphed to his brother, "till I have brought my navy to the same height at which my army stands." "Vaterlandslose" he called those who had "succeeded in preventing the provision of the most necessary ships."

During his constant sea journeys he gained a really intimate acquaintance with the machinery of a modern warship, and he found time to occupy himself with sketches and designs of ships drawn by his own hand. As an amateur yachtsman he himself steered the *Meteor* when it won the Queen's Cup in the Cowes regatta in 1893. He did much to introduce into Germany yachting and other aquatic sports. He founded numerous prizes at different regattas, and there may be mentioned especially that for an annual race from Dover to Heligoland. Every year he sent a telegram to congratulate the winners of the Oxford and Cambridge boat-race. A pronounced lover of all open-air occupations, he attempted to popularize boat-racing in Germany as a means towards combating the too exclusively sedentary life followed by the younger men and boys. His personal vigour was illustrated by the fact that though his left arm was crippled owing to an accident at birth, he made himself an excellent rider and a successful sportsman.

The Emperor's speeches revealed considerable rhetorical power. Clear, concise, positive, in many passages they show deep feeling and a powerful imagination, but they are touched sometimes with the theatrical. Thus, in a characteristic utterance when he despatched his brother, Prince Henry, in command of a German squadron to China, he proclaimed that "the power of the Empire implies power by sea," and instructed his brother, "if any one attempts to injure us in our good right, then strike him with mailed fist." He has always been imbued with a belief in the special Providence which watches over the fortunes of his country and family, and a deep conviction of the necessity for Christianity as the foundation of the state. Thus, at Brandenburg, he declared his "conviction that our old ally of Rossbach and Dennewitz will not leave me in the lurch. He has given Himself such endless trouble with our old Mark and our House that we cannot assume that He has done this for nothing." He ever appealed to the traditions of his family as represented especially by his grandfather, who at Königsberg "had proclaimed the kingdom by the Grace of God," that the Hohenzollern "had received their kingdom from God alone." It was, indeed, with almost mystic reverence that he spoke of William I., for whom, with a curious misapplication of an epithet too often misused, he decreed the title of "The Great." "He came forth from Coblenz as a chosen instrument of the Lord"; "Providence chose him as a tool"; "Had he lived in the Middle Ages he would have been beatified; from every land would have come pilgrimages to offer their prayers at his relics. Thank God, now too that is so."

By temper and traditions an autocrat, and unchecked by any real organization of popular opinion in Germany, where, in the absence of a strong parliamentary system, the army is the dominating institution, the Emperor from time to time made his will felt in every department of social life. A patron of the stage, he required that the dramatists should adopt his canons of taste: "The royal theatre should be an instrument of the monarch," he said in 1898; "the artists must aid the Emperor to serve the causes of idealism with firm confidence in God, and to fight against materialism and un-German ways to which German playhouses have unfortunately descended." In the technical questions of schools he had strong, clear, and well thought out plans of reform. The excessive study of Latin and the abnormally long hours of study common in German schools were censured by him, and his speech at the Educational Congress which he summoned at Berlin in 1890 deserves the careful study even of professional teachers. He decorated Berlin with many monuments of his ancestors; and in the plastic arts he supported the older idealist school, and not the modern developments in which the younger artists were interested. At the beginning of his reign he took much interest in projects for social reform, and summoned to Berlin a general European Conference to discuss questions connected with the hours and conditions of labour. But soon he more than adopted Bismarck's policy of hostility to the Social Democrats. He publicly declared that every Social Democrat was an enemy to the Empire and his House. The Socialists are fond of referring with indignation to a speech which he is reported to have made to the recruits of the Guard, in which he said to them, "You have given yourselves to me body and soul. For you there is only one enemy, and that is my enemy. It may happen—I pray that God avert it—that I order you to shoot down your relations, your brothers, nay, your parents; but then without a murmur you must obey my commands."

The Emperor married on the 27th of February 1881 Princess Auguste Victoria, daughter of Frederick, Duke of Schleswig-Holstein-Sonderburg-Augustenburg, who in 1864 had come forward as claimant to the duchies of Schleswig-Holstein; the marriage had, therefore, some political importance, for it sealed the reconciliation of one of the dynasties that had suffered by the rise of Prussia. The Empress took no part in political affairs. There are six sons and one daughter sprung from the marriage, viz., Wilhelm, born 6th May 1882, Crown Prince, whose coming of age was celebrated with much ceremony on his eighteenth birthday; Eitel Friedrich, born 7th July 1883; Adalbert, born 14th July 1884; August Wilhelm, born 29th January 1887; Oskar, born 27th July 1888; Joachim, born 17th December 1890; and Victoria Louise, born 13th September 1892.

Williams, Sir William Fenwick, Bart. (1800–1883), British general, colonel-commandant Royal Artillery, second son of Commissary-General Thomas Williams, barrack-master at Halifax, Nova Scotia, was born at Annapolis, Nova Scotia, on 4th December 1800. He entered the Royal Artillery as second lieutenant in 1825. His services were lent to Turkey in 1841, and he was employed as a captain in the arsenal at Constantinople. He was British commissioner in the conferences preceding the treaty of Erzerúm in 1847, and again in the settlement of the Turko-Persian boundary in 1848 (brevet majority and lieutenant-colonelcy and C.B.). Promoted colonel, he was British commissioner with the Turkish army in Anatolia in the Russian war of 1854–56, and, having been made a *ferik* (Turkish lieutenant-general) and a pasha, he practically commanded the Turks during the heroic defence of Kars, repulsing several Russian attacks and severely defeating the Russian general Muravieff in the battle of Kars on 29th September 1855. Cold, cholera, famine, and hopelessness of succour from without, however, compelled Williams to make an honourable capitulation on 28th November following. A baronetcy with pension for life, K.C.B., the war medal with clasp, the grand cross of the Legion of Honour and of the Turkish Medjidie, the freedom of the City of London with a sword of honour, honorary degree of D.C.L. of Oxford University, were the distinctions conferred upon him for his valour. Promoted major-general in November 1855 on his return from captivity in Russia, he held the Woolwich command, and represented the borough of Calne in Parliament from 1856 to 1859. He became lieutenant-general and colonel-commandant Royal Artillery in 1864, general in 1868, commanded the forces in Canada from 1859 to 1865, held the governorship of Nova Scotia until 1870, and the governorship of Gibraltar until 1876. He was made G.C.B. in 1871, and Constable of the Tower of London in 1881. He died in London on 26th July 1883.

(R. H. V.)

Williamsburg, a city of Virginia, U.S.A., capital of James City county, on the Chesapeake and Ohio Railway, about 50 miles south-east of Richmond, between the James and York rivers. It is the oldest incorporated city in the state, and until 1779 was the state capital. On the 5th of May 1862 a battle was fought here between the Union forces under General Sumner and the Confederates under General Longstreet. It was a part of McClellan's peninsula campaign, and resulted in the voluntary abandonment of the city by the Confederates, who withdrew towards Richmond. It is the seat of William and Mary College. Population (1880), 1480; (1890), 1831; (1900), 2044.

Williamson, Alexander William (1824–——), English chemist, was born at Wandsworth, London, on 1st May 1824. After working under Gmelin at Heidelberg, and Liebig at Giessen, he spent three years in Paris studying the higher mathematics under Comte. In 1849 he was appointed professor of practical chemistry at University College, London, and from 1855 until his retirement in 1887 he also held the professorship of chemistry. He had the credit of being the first to explain the process of etherification and to elucidate the formation of ether by the interaction of sulphuric acid and alcohol. Ether and alcohol he regarded as substances analogous to and built up on the same type as water, and he further introduced the water-type as a widely applicable basis for the classification of chemical compounds. The method of stating the rational constitution of bodies by comparison with water he believed capable of wide extension, and that one type, he thought, would suffice for all inorganic compounds, as well as for the best-known organic ones, the formula of water being taken in certain cases as doubled or tripled. So far back as 1850 he also suggested a view which, in a modified form, is of fundamental importance in the modern theory of ionic dissociation, for, in a paper on the theory of the formation of ether, he urged that in an aggregate of molecules of any compound there is an exchange constantly going on between the elements which are contained in it; for instance, in hydrochloric acid each atom of hydrogen does not remain quietly in juxtaposition with the atom of chlorine with which it first united, but changes places with other atoms of hydrogen. A somewhat similar hypothesis was put forward by Clausius about the same time. For his work on etherification Williamson in 1862 received a Royal medal from the Royal Society, of which he became a fellow in 1855, and which he served as foreign secretary from 1873 to 1889.

Williamson, William Crawford (1816–1895), English naturalist, was born at Scarborough on 24th November 1816. His father, John Williamson, after beginning life as a gardener, became a well-known local naturalist, who, in conjunction with William Bean, first explored the rich fossiliferous beds of the Yorkshire coast. He was for many years curator of the Scarborough natural history museum, and the younger Williamson was thus from the first brought up among scientific surroundings and in association with scientific people. William Smith, the "father of English geology," lived for two years in the Williamsons' house. Young Williamson's maternal grandfather was a lapidary, and from him he learnt the art of cutting stones, an accomplishment which he found of great use in later years, when he undertook his work on the structure of fossil plants. Williamson very early made a beginning as an original contributor to science. When little more than sixteen, he published a paper on the rare birds of Yorkshire, and a little later (in 1834) presented to the Geological Society of London his first memoir on the Mesozoic fossils of his native district. In the meantime he had assisted Lindley and Hutton in the preparation of their well-known *Fossil Flora of Great Britain.* On entering the medical profession he still found time to carry on his scientific work during his student days, and for three years acted as curator of the Natural History Society's museum at Manchester. After completing his medical studies at University College, London, in 1841, he returned to Manchester to practise his profession, in which he met with much success. When Owens College at Manchester was founded in 1851 he became professor of natural history there, with the duty of teaching geology, zoology, and botany. A very necessary division of labour took place as additional professors were appointed, but he retained the chair of botany down to 1892. Shortly afterwards he removed to Clapham, where he died on 23rd June 1895. Williamson's teaching work was not confined to his university classes, for he was also a successful popular lecturer, especially for the Gilchrist Trustees. His scientific work, pursued with remarkable energy throughout life, in the midst of official and professional duties, had a wide scope. In geology, his early work on the zones of distribution of Mesozoic fossils (begun in 1834), and on the part played by microscopic organisms in the formation of marine deposits (1845), was of fundamental importance. In zoology, his investigations of the development of the teeth and bones of fishes (1842–51), and on recent Foraminifera, a group on which he wrote a monograph for the Ray Society in 1857, were no less valuable. In botany, in addition to a remarkable memoir on the minute structure of *Volvox* (1852), his work on the structure of fossil plants established British palæobotany on a scientific basis: on the ground of these researches Williamson may rank with Brongniart as one of the founders of this branch of science. His contributions to fossil botany began in the earliest days of his career, and he returned to the subject from time to time during the period of his geological and zoological activity. His investigation of the Mesozoic cycadioid fossil *Zamia* (now *Williamsonia*) *gigas* was the chief palæobotanical work of this intermediate period. (See PALÆOBOTANY: *Mesozoic.*)

His long course of researches on the structure of Carboniferous plants belongs mainly to the latter part of his life, and his results are chiefly, though not wholly, embodied in a series of nineteen memoirs, ranging in date from 1871 to 1893, in the *Philosophical Transactions of the Royal Society*. In this series, together with some works (notably the monograph on *Stigmaria ficoides*, Palæontographical Society, 1886), published elsewhere, Williamson elucidated the structure of every group of Palæozoic vascular plants. Among the chief results of his researches may be mentioned the discovery of plants intermediate between ferns and cycads, the description of the true structure of the fructification in the extinct cryptogamic family Sphenophylleæ, and the demonstration of the cryptogamic nature of the dominant Palæozoic orders Calamarieæ, Lepidodendreæ, and Sigillarieæ, plants which on account of the growth of their stems in thickness, after the manner of gymnospermous trees, were regarded as phanerogams by Brongniart and his followers. After a long controversy, the truth of Williamson's views has been fully established, and it is now known that the mode of growth, characteristic in present times, of dicotyledons and gymnosperms, prevailed in Palæozoic ages in every family of vascular cryptogams. (See PALÆOBOTANY: *Palæozoic.*) Thus, as Count Solms-Laubach has pointed out, palæobotany for the first time spoke the decisive word in an important question of general botany. Williamson's work in fossil botany was scarcely appreciated at the time as it deserved, for its great merits were somewhat obscured by the author's want of familiarity with the modern technicalities of the science. Since, however, the subject has been seriously taken up by botanists of a newer school, the soundness of the foundation he laid has become fully recognized. It may be added that he was a skilled draughtsman, illustrating all his works by his own drawings, and practising water-colour painting as his favourite recreation.

A full account of Williamson's career will be found in his autobiography, entitled *Reminiscences of a Yorkshire Naturalist*, edited by his wife, London, 1896. Among obituary notices may be mentioned that by Count Solms-Laubach, *Nature*, 5th September 1895, and one by the present writer in *Proc. R. S.*, vol. lx., 1897. (D. H. S.)

Williamsport, a city of Pennsylvania, U.S.A., capital of Lycoming county. It is situated in 41° 15′ N. and 77° 04′ W., on the west branch of the Susquehanna river, north-east of the centre of the state, at an altitude of 524 feet. The city is somewhat irregularly laid out, is divided into thirteen wards, has an excellent water-supply from springs in the hills, and its business streets are paved with brick and asphalt. Four railways enter the city—the New York Central and Hudson River, the Northern Central, the Pennsylvania, and the Philadelphia and Reading—affording ample facilities for transportation. Williamsport has extensive manufactures. In 1900 there were 396 manufacturing establishments, with a total capital of $9,863,811. They employed 5595 hands, and their product was valued at $11,199,600. The chief item of production was lumber, valued at $1,429,028. In 1898 the assessed valuation of real and personal property was $9,169,659, the net debt of the city was $721,022, and the rate of taxation $26.30 per $1000. Population (1890), 27,132; (1900), 28,757, of whom 2228 were foreign-born and 1142 negroes.

Williamstown, a town in Victoria, Australia, in the county of Bourke, 9 miles south-west of Melbourne, with which it is connected by rail. Shipping is the chief business of the place, there being commodious piers, breakwater, also provision for the repair of vessels, patent slips, and shipbuilding yards. Several quarries of superior basalt are worked near the town, and brown coal of good quality has also been found. Population (1881), 9034; (1891), 15,960; (1901), 14,083.

Willimantic, a city of Windham county, Connecticut, U.S.A., on the river Willimantic, in the eastern part of the state, at an altitude of 228 feet. It has a fairly regular plan, a good water-supply, and is sewered. It is on the Central Vermont and the New York, New Haven, and Hartford railways. It has fine water-power in the river, and extensive manufactures, especially of textiles and paper. Population (1890), 8648; (1900), 8937, of whom 2491 were foreign-born.

Wilmington, the largest and most important city and seaport of Delaware, U.S.A., and capital of Newcastle county. It is situated in 39° 44′ N. and 75° 33′ W., on the Delaware river at the mouth of Brandywine creek, in the northern part of the state. The city has a low, level site and a regular street plan, divided into twelve wards. The water-supply is obtained from Brandywine creek by pumping; the city is well sewered, and the streets are well paved, mainly with bricks and granite blocks. There are steamboat lines running up the Delaware to Philadelphia, connecting there with lines to Atlantic ports. Three railways enter the city—the Baltimore and Ohio; the Philadelphia, Wilmington, and Baltimore; and the Wilmington and Northern, the last two being parts of the Pennsylvania system. Wilmington is a manufacturing city of great importance, due in part to water power furnished by Brandywine creek. In 1900 it contained 759 manufacturing establishments, with a total capital of $28,372,043. They employed 16,054 hands, and the product had a value of $34,053,324. The most prominent products were leather, value $9,379,504; railway carriages, $3,274,922; foundry and machine-shop products, $3,299,509; shipbuilding, $2,945,267; and iron and steel goods, $2,934,993. In 1900 the assessed valuation of real property was $43,647,072, the net debt of the city was $2,163,537, and the rate of taxation was $20 per $1000. Personal property is not assessable. Population (1890), 61,431; (1900), 76,508, of whom 10,478 were foreign-born and 9736 negroes.

Wilmington, a city and seaport of North Carolina, U.S.A., capital of New Hanover county. It is situated in 34° 14′ N. and 77° 56′ W., on the east bank of the Cape Fear river at the head of its estuary, 30 miles from the sea. It is regularly laid out on a level site, divided into five wards, and has a good water-supply. It has three railways—the Atlantic Coast Line, the Seaboard Air Line, and the Wilmington Sea Coast—which bring cotton, lumber, and naval stores to the city for shipment. Its exports in 1898 had a value of $9,761,606; its imports were trifling. Being in the main a commercial city, its manufactures are not of great importance; in 1900 it had 124 manufacturing establishments, with a total capital of $1,819,333. They employed 1469 hands, and the product had a value of $2,246,237. Population (1890), 20,056; (1900), 20,976, of whom 467 were foreign-born and 10,407 negroes.

Wilson, Thomas (1525?–1581), statesman and critic, was the son of Thomas Wilson of Strubby, in Lincolnshire. He was educated at Eton and King's College, Cambridge, where he joined the school of Hellenists to which Cheke, Thomas Smith, Haddon, and others belonged. His earliest work of importance was *The Rule of Reason*, 1551, a treatise on logic, which has often been reprinted. The book on which Wilson's fame mainly rests, *The Art of Rhetorique*, is said to have been printed about the same time, but the first edition extant is dated January 1553. It is the earliest systematic work of literary criticism existing in the English language. Wilson threw in his lot with the Dudley family, and when they fell, he fled to the Continent. He was with Sir John Cheke in Padua in 1555–57, and afterwards at Rome, whither in 1558 Queen Mary wrote, ordering him to return to England to stand his trial as a heretic. He refused to come, but was arrested by the Roman Inquisition and tortured. He escaped, and fled to Ferrara, but in 1560 he was once more in London. Wilson became Master of St Katherine's Hospital in the Tower, and entered Parliament in 1562. In 1570 he published a translation, the first attempted in English, of Demosthenes, on which he had been engaged since 1556. His *Discourse upon Usury* appeared in 1572. From 1574 to 1577, Wilson, who had now become a prominent person in the diplomatic world, was principally engaged on embassies to the Low Countries, and on his return to England he was made a Privy Councillor and sworn Secretary of State; Walsingham was his colleague. In 1580, although he was not in holy orders, Queen Elizabeth made Wilson Dean of Durham. He died at his house in the Tower of London, on the 16th June 1581, and was buried next day, "without charge or pomp," at his express wish. *The Art of Rhetorique* gives Wilson a high place among the earliest artificers of English style; and it is interesting to see that he was opposed to pedantry of phrase, and above all to a revival of uncouth mediæval forms of speech, and encouraged a simpler manner of prose writing than was generally appreciated in the middle of the 16th century.

Wilson, Sir William James Erasmus, generally known as Sir ERASMUS WILSON (1809–1884), British surgeon and philanthropist, was born in London on 25th November 1809, studied at St Bartholomew's Hospital in London, and at Aberdeen, and early in life became known as a skilful operator and dissector. It was his sympathy with the poor of London and a suggestion from Mr Thomas Wakley of *The Lancet*, of which Wilson acted for a time as sub-editor, which first led him to take up skin diseases as a special study. The horrible cases of scrofula, anæmia, and blood-poisoning which he saw made him set to work to alleviate the sufferings of persons so afflicted, and he quickly established a reputation for treating this class of patient. It was said that he cured the rich by ordering them to give up luxuries; the poor, by prescribing for them proper nourishment, which was often provided out of his own pocket. In the opinion of one of his biographers, we owe to Wilson in great measure the habit of the daily bath, and he helped very much to bring the Turkish bath into use in Great Britain. He wrote much upon the diseases which specially occupied his attention, and his books, *A Healthy Skin* and *Student's Book of Diseases of the Skin*, though they were not received without criticism at the time of their appearance, long remained text-books of their subject. He visited the East in order to study leprosy, Switzerland that he might investigate the causes of goître, and Italy with the purpose of adding to his knowledge of the skin diseases affecting an ill-nourished peasantry. He made a large fortune by his successful practice and by skilful investments, and, since he had no family, he devoted a great deal of his money to charitable and educational purposes. He founded in 1869 the chair and museum of dermatology in the Royal College of Surgeons, of which he was chosen president in 1881, and which just before his death awarded him its honorary gold medal, founded in 1800 and only six times previously awarded. He also founded a professorship of pathology at Aberdeen University. After the death of his wife the bulk of his property, some £200,000, went to the Royal College of Surgeons. In 1878 he earned the thanks of the nation, upon different grounds, by defraying the expense of bringing the Egyptian obelisk inaccurately called Cleopatra's Needle from Alexandria to London, where it was erected on the Thames Embankment. The British Government had not thought it worth the expense of transportation. He was knighted by Queen Victoria in 1881, and died at Westgate-on-Sea on 7th August 1884.

Wilton, municipal borough and parish, in the Wilton or southern parliamentary division of Wiltshire, England, 3 miles north-west of Salisbury by rail. The borough returned two members to Parliament from 1293 to 1832, when the number was reduced to one, and in 1885 its representation was merged in that of the county. The parish church of SS. Mary and Nicholas was built in 1844 at a cost of £40,000 in Romanesque style. This town claims to have been the first in England to manufacture carpets. There is a large carpet factory, which produces Axminster as well as Wilton carpets. Population (1891), 2120; (1901), 2203.

Wilts, or WILTSHIRE, a south-western county of England, bounded on the W. by Somerset, on the N.W. and on the N. by Gloucester, on the E. by Berkshire and Hampshire, and on the S. by Hampshire and Dorset.

Population.—The area of the ancient and administrative county is 880,248 acres, or 1375 square miles, with a population in 1881 of 258,970, in 1891 of 264,997, of whom 130,662 were males and 134,335 females, and in 1901 of 273,845, the number of persons per square mile being 199, and of acres to a person 3·2. Since 1891 various changes have been made in the administrative area. In 1895 the part of the parish of Hungerford in Wilts was transferred to Berks, part of the parish of Shalbourn in Berks to Wilts, the parts of the parishes of Maiden Bradley with Yarnfield and Stourton with Gaspar in Somerset to Wilts, and the parishes of Bramshaw, Martin, Melchet Park, Plaitford, South Damerham, Toyd Farm with Allenford, and part of the parish of Whichbury, from Wilts to Hampshire; and in 1896 the parishes of Kemble, Poole Keynes, and Somerford Keynes in Wilts were transferred to Gloucester, and the parish of Kilmington, Somerset, was transferred to Wilts. The area of the registration county is 811,367 acres, with a population in 1891 of 255,119, of whom 95,304 were urban, 159,815 rural; and in 1901 of 263,921, of whom 130,758 were males and 133,163 were females. Within this area the percentage of increase between 1881 and 1891 was 2·68, and between 1891 and 1901, 3. The excess of births over deaths between 1881 and 1891 was 31,366, and the increase in population was 6653. The following table gives the numbers of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1898:—

Year.	Marriages.	Births.	Deaths.	Illegitimate Births.	
				Males.	Females.
1880	1528	7598	4407	196	173
1890	1662	6997	4114	153	149
1898	1780	6770	3807	155	128

The number of marriages in 1899 was 1915, of births 6725, and of deaths 4267. The following table gives the marriage-, birth-, and death-rates per thousand of the population, with the percentage of illegitimate births, for a series of years:—

	1870–79.	1880.	1880–89.	1890.	1888–97.	1898.
Marriage-rate .	13·1	12·3	12·6	13·1	13·1	13·7
Birth-rate . .	31·3	31·5	29·7	27·5	27·2	26·1
Death-rate . .	18·9	17·7	17·1	16·2	16·0	14·7
Percentage of illegitimacy . .	5·1	4·8	4·8	4·3	4·2	4·2

In 1891 there were in the county 660 natives of Scotland, 758 natives of Ireland, and 274 foreigners.

Constitution and Government.—The county contains seven municipal boroughs: Calne (3456), Chippenham (5074), Devizes

(6532), Malmesbury (2854), Marlborough (3046), Salisbury (17,117), and Wilton (2203). The following are urban districts: Bradford-on-Avon (4514), Melksham (2450), Old Swindon (44,996), Trowbridge (11,526), Warminster (5547), and Westbury (3300). The ancient county, which is chiefly in the diocese of Salisbury, contains 312 ecclesiastical districts or parishes, and parts of 11 others.

Education.—The total number of elementary schools in the county on 31st August 1899 was 359, of which 35 were board and 324 voluntary schools, the latter including 295 National Church of England schools, 5 Roman Catholic, and 24 "British and other." The average attendance at board schools was 10,775, and at voluntary schools 31,473. The total school board receipts for the year ended 29th September 1899 were over £34,065. The income under the Technical Instruction Act was over £135, and that under the Agricultural Rates Act was over £947.

Agriculture.—There is a college for agriculture at Downham. About five-sixths of the total area of the county is under cultivation, and of this nearly three-fifths is in permanent pasture. There are less than 15,000 acres in hill pasture, about 52,000 acres under woods, and over 3600 acres are under orchards. The acreage under corn crops has decreased nearly one-third, the decrease being chiefly in the acreages under wheat and oats, the acreage under barley showing comparatively little variation. Wheat still, however, occupies nearly two-fifths of the corn crop acreage, and oats more than two-sevenths. Turnips and swedes occupy more than half the acreage under green crops, and there are large acreages under mangold and under cabbage, &c.; while tares and vetches occupy more than one-fifth of the acreage, and potatoes usually only a little more than one-thirteenth. The following table gives the acreages of the larger main divisions of the cultivated area at intervals from 1885:—

Year.	Total Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885	757,196	184,906	99,879	80,020	380,042	12,349
1890	758,564	171,731	92,839	80,142	402,764	10,968
1895	759,472	153,033	87,771	81,205	424,369	12,760
1900	733,409	146,706	80,201	74,213	423,884	8,238

The following table gives particulars regarding the principal live stock for the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or in Calf.	Sheep.	Pigs.
1885	23,214	108,788	58,486	660,029	64,534
1890	23,274	108,336	59,746	613,399	77,008
1895	23,595	106,072	60,129	534,389	79,195
1900	22,942	115,900	64,316	520,888	60,334

Industries and Trade.—According to the return for 1898 of the chief inspector of factories (1900), the total number of persons employed in factories and workshops in 1897 was 22,071, as compared with 21,291 in 1896. Of these 2423 were employed in textile factories, woollen industries employing 2117. Non-textile factories employed 16,837 persons, there being an increase between 1895 and 1896 of 13·4 per cent., and between 1896 and 1897 of 5·4 per cent. About three-fourths (12,073) were employed in the manufacture of machines, appliances, conveyances, and tools, the majority in connexion with the locomotive works of the Great Western Railway at Swindon. There is now some manufacture of paper. Of the 2811 persons employed in workshops, 1114 were employed in clothing industries. The total number of persons employed in connexion with mines and quarries in 1898 was 1417. In the same year 196,795 tons of limestone were raised, and 29,735 tons of clay. The most valuable mineral is, however, iron ore, obtained from quarries over 20 feet deep, the total output in 1899 being 67,603 tons, valued at £43,942. The annual pig-iron production at Westbury is included in the return for Worcestershire.

AUTHORITIES.—Sir H. SAINT-GEORGE. *Visitation of Wiltshire.* London, 1882.—GOLDIE. *Saints of Wiltshire.* London, 1885.—NIGHTINGALE. *Church Plate in Wilts.* Devizes, 1884; new ed. Salisbury, 1891.—SMITH. *Guide to the British and Roman Antiquities of the Wiltshire Downs.* Devizes, 1885.—DARTNELL and GODDARD. *Glossary of Words in Wiltshire* (English Dialect Society). London, 1893.—DOWDING. *Old Wiltshire Market Towns and Villages.* London, 1896.—See also *Wiltshire Notes and Queries,* and the publications of the Wiltshire Archæological Society. (T. F. H.)

Wimbledon, an urban district (1894) and suburb of London, in the county of Surrey, 7¼ miles south-west of London by rail. Population (1881), 15,950; (1901), 41,604.

Winburg. See ORANGE RIVER COLONY.

Winchester, a city, municipal and parliamentary borough, and market town of Hampshire, England, on the Itchen, 66 miles south-west by west of London by rail. The cathedral has undergone extensive repairs. The barracks (which developed out of the unfinished palace of Charles II.) were burned down in 1894, and new ones erected. The Royal Hants County Hospital has been extended, and a new building provided for. There is a Jubilee Victoria Hospital. Area of parliamentary borough, 1049 acres; population (1891), 19,073; (1901), 19,001. Area of municipal borough (extended in 1900), 1931 acres; population (1891), 20,563; (1901), 20,929.

Winchester, a town of Litchfield county, Connecticut, U.S.A., with an area of 36 square miles of hill country, interspersed with lakes and ponds, in the north-western part of the state. It contains several villages, the most important of which is the borough of Winsted, situated on Still and Mad rivers at their junction, and at the intersection of the Central New England and the New York, New Haven, and Hartford railways. It derives a fine water-power from Mad river, and has extensive manufactures, largely of cutlery and other iron and steel goods. Population of the town (1880), 5142; (1890), 6183; (1900), 7763; of Winsted borough (1880), 4195; (1890), 4846; (1900), 6804, of whom 1213 were foreign-born.

Winchester, a town of Kentucky, U.S.A., capital of Clark county, on the Chesapeake and Ohio, the Lexington and Eastern, and the Louisville and Nashville railways, not far from the centre of the state, at an altitude of 964 feet. It is in the Blue Grass region, devoted to agriculture and stock raising, for which it serves as a supply and distributing point. It contains several minor institutions of learning, among them the Kentucky Wesleyan College, a Methodist Episcopal South institution. Population (1880), 2277; (1890), 4519; (1900), 5964, of whom 65 were foreign-born and 3128 negroes.

Winchester, a town of Middlesex county, Massachusetts, U.S.A., 8 miles north-east of Boston, of which it is a suburb, on a line of the Boston and Maine Railroad, in the north-eastern part of the state. Its principal industries are the manufacture of leather and furniture. Population (1880), 3802; (1890), 4861; (1900), 7248, of whom 1968 were foreign-born and 140 negroes.

Winchester, a city of Virginia, U.S.A. It is situated in 39° 11′ N. and 78° 10′ W., in the fertile Shenandoah valley, at the intersection of a branch of the Baltimore and Ohio with the Cumberland Valley Railroad, in the northern part of the state, at an altitude of 717 feet. Though within the limits of Frederick county and containing the court-house, it is not subject to county government. It is regularly laid out on an undulating site, and has a variety of small manufactures. Near here during the Civil War the Federals under Shields defeated the Confederates under Jackson (23rd March 1862), and the Confederates under Early defeated the Federals under Crook (24th July 1864). More important, however, was the battle fought near here 19th September 1864, between the Federals under Sheridan and the Confederates under Early, in which the former were victorious. Population (1890), 5196; (1900), 5161, of whom 62 were foreign-born and 1106 negroes.

Windsor, or New Windsor, a municipal and parliamentary borough, in the Eastern, or Wokingham, parliamentary division of Berkshire, England, on the right bank of the Thames, 21 miles west of London by rail. The Royal Albert Institute was opened in 1881, and a small hall was added in 1898. A Government school of art and technical classes are held here. The Jubilee statue of Queen Victoria was unveiled in 1887, and a bronze equestrian statue of Prince Albert in 1890. Old Windsor is a parish and village adjoining; Cumberland Lodge and the greater portion of Windsor Park are in this parish. Population (1881), 12,273; (1891), 12,327; (1901), 13,958.

Windsor, a city and port of entry of Essex county, Ontario, Canada, on the left bank of the Detroit river, opposite Detroit city. It is the terminus of the Grand Trunk, Canadian Pacific, and Michigan Central railways, which connect at this point with the railways of the United States by means of large and powerful car-ferries. There is electric railway communication. Salt works, flour-mills, typograph and bicycle works are the principal industries. Exports for the year 1900–01, $2,236,035, and imports, $2,283,062. Population (1891), 10,322; (1901), 12,153.

Windthorst, Ludwig (1812–1891), German politician, was born on the 17th of January 1812 at Kaldenhof, a country house about 8 miles from the city of Osnabrück. He sprang from a Roman Catholic family which for some generations had held important posts in the Hanoverian civil service. He was educated at the Carolinum, an ancient endowed school at Osnabrück, and studied at the universities of Göttingen and Heidelberg. In 1836 he settled down as an advocate in Osnabrück: his abilities soon procured him a considerable practice, and he was appointed president of the Catholic Consistorium. In 1848 he received an appointment at the supreme Court of Appeal for the kingdom of Hanover, which sat at Celle. In the next year the revolution opened for him, as for so many of his contemporaries, the way to public life, and he was elected as representative for his native district in the Second Chamber of the reformed Hanoverian Parliament. He belonged to what was called the Great German party, and opposed the project of reconstituting Germany under the leadership of Prussia; he defended the Government against the Liberal and Democratic opposition: at this time he began the struggle against the secularization of schools, which continued throughout his life. In 1851 he was elected president of the Chamber, and in the same year minister of justice, being the first Catholic who had held so high an office in Hanover. As minister he carried through an important judicial reform which had been prepared by his predecessor, but had to retire from office because he was opposed to the reactionary measures for restoring the influence and privileges of the nobility. Though he was always an enemy to Liberalism, his natural independence of character prevented him from acquiescing in the reactionary measures of the king. In 1862 he again was appointed minister, but with others of his colleagues resigned when the king refused his assent to a measure for extending the franchise. Windthorst took no part in the critical events of 1866; contrary to the opinion of many of his friends, after the annexation of Hanover by Prussia he accepted the *fait accompli*, took the oath of allegiance, and was elected a member both of the Prussian Parliament and of the North German Diet. At Berlin he found a wider field for his abilities. He acted as representative of his exiled king in the negotiations with the Prussian Government concerning his private property and opposed the sequestration, thus for the first time being placed in a position of hostility to Bismarck. He was recognized as the leader of the Hanoverians and of all those who opposed the "revolution from above." He took a leading part in the formation of the party of the Centre in 1870–71, but he did not become a member of it, fearing that his reputation as a follower of the king of Hanover would injure the party, until he was formally requested to join them by the leaders. After the death of Malincrodt in 1874 he became leader of the party, and maintained that position till his death. It was chiefly owing to his skill and courage as a parliamentary debater and his tact as a leader that the party held its own and constantly increased in numbers during the great struggle with the Prussian Government. He was especially exposed to the attacks of Bismarck, who attempted personally to discredit him and to separate him from the rest of the party. And he was far the ablest and most dangerous critic of Bismarck's policy. The change of policy in 1879 led to a great alteration in his position: he was reconciled to Bismarck, and even sometimes attended receptions at his house. Never, however, was his position so difficult as during the negotiations which led to a repeal of the May Laws. In 1887 Bismarck appealed to the Pope to use his authority to order the Centre to support the military proposals of the Government. Windthorst took the responsibility of keeping the Papal instructions secret from the rest of his party and disobeying them. In a great meeting at Cologne in March 1887 he defended and justified his action, and claimed for the Centre full independence of action in all purely political questions. In the social reform he supported Bismarck, and as the undisputed leader of the largest party in the Reichstag he was able to exercise great influence over the action of the Government after Bismarck's retirement. His relations with the Emperor William II. became very cordial, and in 1891 he achieved a great parliamentary triumph by defeating the School Bill and compelling Gossler to resign. A few days afterwards he died, 14th March 1891, at Berlin. He was buried in the Marienkirche in Hanover, which had been erected from the money subscribed as a testimonial to himself. His funeral was a most remarkable display of public esteem, in which nearly all the ruling princes of Germany joined, and was a striking sign of the position to which, after twenty years of incessant struggle, he had raised his party. Windthorst was undoubtedly one of the greatest of German parliamentary leaders: no one equalled him in his readiness as a debater; his defective eyesight compelled him to depend entirely upon his memory. It was his misfortune that nearly all his life was spent in opposition, and he had no opportunity of showing his abilities as an administrator. He enjoyed unbounded popularity and confidence among the German Catholics, but he was in no way an ecclesiastic: he was at first opposed to the Vatican Decrees of 1870, but quickly accepted them after they had been proclaimed. He was a very agreeable companion and a thorough man of the world, singularly free from arrogance and pomposity; owing to his small stature, he was often known as "der kleine Excellenz." He married in 1839. Of his three children, two died before him; his wife survived him only a few months.

See the biographies of Windthorst by Manzenbach, 1891–92, and Knopp, 1898. (J. W. He.)

Windward Islands, a group of British West Indian islands, comprising Grenada, St Vincent, the Grenadines (half under St Vincent, half under Grenada), and St Lucia. There is a governor and commander-in-chief (resident at St George, Grenada). Each island has its own institutions: there is no common legislature, laws, revenue, or tariff; there is a common court of appeal, and the colonies unite for other common purposes. (See articles on the separate islands.)

Winfield, a city of Kansas, U.S.A., capital of Cowley county, on the river Walnut, and the Atchison, Topeka, and Santa Fé, the Missouri Pacific, and the St Louis and San Francisco railways, in the southern part of the state, at an altitude of 1121 feet. It is surrounded by a rich farming country, for which it serves as a supply and distributing point. It is the seat of St John's (Lutheran) and South-west Kansas (Methodist-Episcopal) Colleges. The former had in 1899 a faculty of 8 and an attendance of 84, the latter a faculty of 15 and an attendance of 322 students. Both are co-educational. Population (1880), 2844; (1890), 5184; (1900), 5554, of whom 203 were foreign-born and 282 negroes.

Winnipeg, a lake and river, Canada. The lake is in Manitoba and Keewatin, and is situated between 50° 20′ and 53° 50′ N. and 96° 20′ and 99° 15′ W. It covers an area of 8555 square miles, is at an altitude of 710 feet above the sea, is 260 miles long, 25 to 60 miles wide, and contains several large islands, including Reindeer, 70 square miles, and Big Island, 60 square miles. The principal affluent rivers are: Red, from the south; Winnipeg, Bloodvein, Berens, and Poplar from the east; and the Dauphin and Saskatchewan from the west. It discharges its waters by the river Nelson into Hudson Bay. The river Winnipeg rises near Savanne station, in 48° 47′ N. and 89° 57′ W., and flows in a westerly direction under the names of Savanne, Seine, and Rainy rivers to the Lake of the Woods; issuing thence as the Winnipeg, it flows north-westerly to the lake of the same name. It is navigable from the foot of the Lake of the Woods to the head of Rainy Lake—with a short portage at Fort Frances falls—a distance of 208 miles. Its principal tributary is English river.

Winnipeg, the capital of Manitoba, Canada, situated at the confluence of Red and Assiniboine rivers, midway between the Atlantic and Pacific, 1424 miles (by rail) west of Montreal, and 1472 miles east of Vancouver. It is an important station on the Canadian Pacific and Canadian Northern railways, and is the terminus of the Emerson, Pembina, South-western, Stonewall, and West Selkirk branches of the former, and of the Portage la Prairie branch of the latter. The proposed lock at St Andrews rapids, a few miles below the city, will give steamboat communication with all parts of Lake Winnipeg. The wheat exports of the province in 1901—including flour—all of which was grown in the territory tributary to the city, aggregated 55,000,000 bushels. The total assessment in 1881 was $9,196,435, and in 1901, $28,305,200; clearings at the clearing-house in 1896, $64,146,438, and in 1901, $134,199,483; exports in 1887, $816,260, and in 1901, $1,014,263; imports in 1887, $1,929,120, and in 1901, $5,125,262. Population (1891), 25,639; (1901), 42,340.

Winnipegosis, a lake of Manitoba and Saskatchewan, Canada, situated between 51° 34′ and 53° 11′ N. and 99° 37′ and 101° 06′ W. Its greatest length is 122 miles; greatest width 17 miles; shore-line 570 miles; and area, exclusive of islands, 2000 square miles. Its greatest ascertained depth is 38 feet, and mean altitude 828 feet above the sea. Mossy, Swan, and Red Deer rivers are the only considerable streams that fall into it. It was discovered by the Chevalier de la Verendrye in 1739.

Winona, a city of Minnesota, U.S.A., capital of Winona county. It is situated in 44° 04′ N. and 91° 42′ W., on the west bank of the Mississippi, in the south-eastern part of the state, at an altitude of 660 feet. It is on a level terrace in the bottom lands surrounded by high bluffs, is regularly laid out, is divided into four wards, has a good water-supply by the Holly system, and is well sewered. It is an important railway centre, being the meeting point of five lines—the Chicago, Burlington and Quincy; the Chicago and North-Western; the Chicago, Milwaukee and St Paul; the Green Bay and Western; and the Winona and Western—which give it a large trade, mainly in wheat and other cereals. Besides a trade in lumber, there are manufactures of agricultural implements and waggons. Population (1890), 18,208; (1900), 19,714, of whom 5000 were foreign-born.

Winsford, a town in the Northwich parliamentary division of Cheshire, England, on the Weaver, 6 miles south of Northwich by rail. Large salt-works employ about 2000 persons. The salt, obtained chiefly from brine, but also from rock-salt, is carried down the Weaver, here navigable for vessels of 300 tons, and exported from Liverpool to the extent of over 500,000 tons annually. Owing to the subsidence of the ground caused by the pumping of the brine, about 200 acres near the river have been submerged. An iron bridge, erected in 1856, was raised in 1871, in 1876, and in 1882; the town hall, built of wood and plaster in 1872, was raised 8 feet and the foundations relaid in 1879. There are public baths, recreation grounds, a public library, and a market hall. Area of urban district, 5780 acres. Population (1891), 10,440; (1901), 10,382.

Winsor, Justin (1831–1897), an American writer and librarian, was born at Boston, Massachusetts, on 2nd January 1831. At the age of nineteen, while a freshman in Harvard College, he printed a *History of Duxbury*, Massachusetts, the home of his ancestors. In the beginning of his senior year he left Cambridge, and sought greater freedom and enlarged opportunity of study in Germany. While still at Harvard he planned to write an extended memoir of *Garrick and his Contemporaries*, and to compile a critical edition of Shakespeare's works. For fourteen years he had the *Garrick* more or less on his mind, and in 1864 he completed the first draft of it. The manuscript, occupying ten folio volumes with a mass of notes, is accessible to students in the library of Harvard University. In 1866 Winsor was appointed a trustee of the Boston public library, one of the most important libraries in America. Becoming chairman of the examining committee, he presented to the trustees in 1867 a masterly report on the condition of the library, which led to his appointment in 1868 as superintendent. In 1877 he became librarian of Harvard University, and retained the position until his death. He kept clearly in mind what librarians had mainly ignored, namely, that books are collected to be used, and by their use to influence not only scholars but the mass of the people. He may almost be said to have founded the modern American library system. While at the Boston public library he edited a most useful catalogue of books in history, biography, and travel, and compiled the first of a series of separate lists of works of historical fiction. On his transfer to the Harvard library he forwarded every plan to make it the laboratory for those departments of learning whose evidence consists mainly in printed books. In 1876 he began a series of monumental publications. The first of the series was a *Bibliography of the Original Quartos and Folios of Shakespeare, with particular reference to copies in America.* It was illustrated with sixty-eight heliotype facsimiles of title-pages, &c. Unfortunately, all save about a hundred copies of this great work were burned. The preparation of the illustrations seems to have turned his attention to the possibility of reproducing by photography rare bits of original material. He planned *The Facsimilist*, a quarterly record of rarities in bibliography, archæology, palæography, and cartography. The same fire that consumed the *Shakespeares* destroyed the sheets of the first number of *The Facsimilist* and the negatives of the illustrations of several other numbers. From this time he devoted himself to American history and cartography. A small volume entitled *The Reader's Handbook of the American Revolution* is still the model of a reasonable bibliography. In 1880 he began the editing of the *Memorial History of Boston* in four quarto volumes, with the co-operation of seventy writers. He so manipulated the contributions and supplemented them with notes as to give an air of unity to the whole work, and completed it in twenty-three months. He at once set to work on a still larger co-operative book, *The Narrative and Critical History of America*, which was completed in eight royal octavo volumes. These great tasks had compelled Winsor to make a careful and systematic study of historical problems with the aid of contemporaneous cartography. Among the early results of this study were the *Bibliography of Ptolemy's Geography* and the *Catalogue of the Kohl Collection of Maps relating to America*, published in the Harvard Library Bulletins. His vast knowledge took the final form of four volumes in which history and cartography are so interwoven as to be almost undistinguishable. These volumes are entitled *Christopher Columbus*, *Cartier to Frontenac*, *The Mississippi Basin*, and *The Westward Movement.* Besides great stores of information hitherto accessible only to the specialist, these contain many strong expressions of dissent from currently received views. Winsor served for many years on the Massachusetts Archives Commission. His *Report on the Maps of the Orinoco–Essequibo Region* was prepared at the request of the Venezuela Boundary Commission, and is a most careful geographical statement. Winsor died on the 22nd of October 1897.

Many of the facts contained in this sketch are taken from Horace E. Scudder's "Memoir of Justin Winsor" in the *Proceedings of the Massachusetts Historical Society*, 2nd series, vol. xii. A bibliography of Mr Winsor's writings is in Harvard College library, *Bibliographical Contributions*, No. 54. (E. CH.)

Winsted, a borough of Connecticut, U.S.A., capital of Litchfield county, on the Mad river, and the New York, New Haven, and Hartford, and the Central New England railways, in the north-western part of the state. It obtains excellent water-power for manufacturing from Mad river. Population (1890), 4846; (1900), 6804, of whom 1213 were foreign-born.

Winston, a city of North Carolina, U.S.A., capital of Forsyth county, in the northern part of the state, at the intersection of lines of the Norfolk and Western and the Southern railways, at an altitude of 858 feet. The city is continuous with Salem, so that the two places are commonly coupled as Winston-Salem. Winston has had a rapid growth, due in a large measure to the tobacco trade and manufacture, for which it contains many large factories and warehouses. It has also cotton factories and various minor manufactures. Population of Winston (1880), 2854; (1890), 8018; (1900), 10,008, of whom 610 were foreign-born and 5043 negroes; of Salem (1880), 1340; (1890), 2711; (1900), 3642, of whom 18 were foreign-born and 488 negroes.

Winterthur, a town in the Swiss canton of Zürich, 16¼ miles from Zürich by rail. Its population in 1880 was 13,502, and in 1888 (when it ranked as the tenth most populous town in Switzerland) 15,805, while in 1900 it was 22,320. It is practically wholly German-speaking, and nearly four-fifths of the inhabitants are Protestants, the remainder being Roman Catholic, with a sprinkling of Jews.

Winther, Christian (1796–1876), the Danish lyrical poet, was born on the 29th of July 1796 at Fensmark, in the province of Præstö, where his father was priest. He went to the University of Copenhagen in 1815, and studied theology, taking his degree in 1824. He began to publish verses in 1819, but no collected volume appeared until 1828. Meanwhile, from 1824 to 1830, Winther was supporting himself as a tutor, and with so much success that in the latter year he was able to go to Italy on his savings. In 1835 a second volume of lyrics appeared, and in 1838 a third. In 1841 King Christian VIII. appointed Winther to travel to Mecklenburg to instruct the Princess Caroline, on the occasion of her betrothal to the Crown Prince of Denmark, in the Danish language. Further collections of lyrics appeared in 1842, 1848, 1850, 1853, 1865, and 1872. When he was past his fiftieth year Winther married. In 1851 he received a pension from the State as a poet, and for the next quarter of a century he resided mainly in Paris. Besides the nine or ten volumes of lyrical verse mentioned above, Winther published *The Stag's Flight*, an epical romance in verse, 1855; *In the Year of Grace*, a novel, 1874; and other works in prose. He died in Paris on the 30th of December 1876, but the body was brought to Denmark, and was buried in the heart of the woods. In the verse of Christian Winther the scenery of Denmark, its beech-woods, lakes, and meadows, its violet-scented dingles, its hollows perfumed by wild strawberries, found such a loving and masterly painter as they are never likely to find again. He is the most spontaneous of lyrists; his little poems are steeped in the dew and light and odour of a cool, sunshiny morning in May. His melodies are artless, but full of variety and delicate harmony. When he was forty-seven he fell in love, and at that mature age startled his admirers by publishing for the first time a cycle of love-songs. They were what were to be expected from a spirit so unfaded; they still stand alone for tender homage and simple sweetness of passion. The technical perfection of Winther's verse, in its extreme simplicity, makes him the first song-writer of Denmark. (E. G.)

Wisbech, a river port, municipal borough, and market town, Cambridgeshire, England, in the Wisbech parliamentary division of the county, in the Isle of Ely, 21 miles east-north-east of Peterborough by rail. The river Nene flows through the town, the greater part of which stands on its south side, where in 1891 piling to strengthen the bank was undertaken at a cost of £20,000. Vessels of 789 tons can enter the port. Coal is exported. Nearly all the foreign trade is with the northern ports of Russia. Population (1891), 9395; (1901), 9831.

Wisby, a seaport, seaside resort, and bishop's see of Sweden, capital of the county and island of Gothland, on the west coast. It is thoroughly mediæval in appearance, possessing several ancient houses (13th and 17th centuries) and nearly a dozen ruined churches, mostly built in the 13th century. The only ancient church now used is St Mary's, the cathedral (1190–1225), restored in the end of the 19th century, and rich in memorials of the 17th century. The modern buildings include the Gothland museum of antiquities, the high school, with a museum and library, and a chemical station (1899). The harbour, consisting of two basins, and lying south of the ancient Hanseatic harbour (now filled up), does not afford much protection, and the roads are even more exposed. Population (1880), 6922; (1900), 8376.

Wisby — a word derived from the old Norse *ve* (sanctuary) and *by* (town)—was no doubt a place of religious sacrifice in heathen times. At any rate, it was a notable trading-place and emporium as early as the Stone Age, and continued to enjoy its importance as such through the Bronze and Iron Ages, as is proved, *inter alia*, by the large number of Arabic, Anglo-Saxon,[1] and other coins which have been found on the island.

Gothland was subject to Sweden in 890, and earlier; and in 1030 was in all probability Christianized by St Olaf, king of Norway, when returning from his exile at Kieff. At that time it was one of the most important trading towns in the Baltic, and the chief distributing centre of the Oriental commerce which came to Europe along the rivers of Russia. It became in the early years of the Hanseatic League, or about the middle of the 13th century, the chief depôt for the produce of the eastern Baltic countries, including, in a commercial sense, its daughter colony (11th century or earlier) of Novgorod the Great. Although Wisby was an independent member of the Hanseatic League, the influence of Lübeck was paramount in the city, and half her governing body were men of German descent. Indeed, Björkander endeavours to prove that the city was a German (Hanseatic) foundation, dating principally from the middle of the 12th century, and that down to the year 1288 there were two town corporations, which became fused in the year just mentioned. However that may be, the importance of Wisby in the sea trade of the North is conclusively attested by the famous code of maritime law which bears its name. This *Water-recht dat de Kooplüde en de Schippers gemakt hebben to Visby* ("sea-law which the merchants and seamen have made at Wisby") was a compilation based upon the Lübeck code, the Oléron code, and the Amsterdam code, and was first printed in Low German in 1505, but in all probability had its origin about 1240, or not much later. By the middle of the 14th century the reputation of the wealth of the city was so great that, according to an old ballad, "the Gotlanders weighed out gold with stone weights and played with the choicest jewels. The swine ate out of silver troughs, and the women spun with distaffs of gold." This fabled wealth was too strong a temptation for the energetic Waldemar Atterdag of Denmark. In 1361 he invaded the island, routed the defenders of Wisby under the city walls (a monolithic cross marks the site), and plundered the city. From this blow it never recovered, its decay being, however, materially helped by the fact that for the greater part of the next 150 years it was the stronghold of successive freebooters or sea-rovers—first, of the Hanseatic privateers called Vitalienbrödre or Viktualienbrüder, who made it their stronghold during the last eight years of the 15th century; then of the Teutonic Knights, whose Grand Master drove out the "Victuals Brothers," and kept the island until it was redeemed by Queen Margaret, the "Semiramis of the North." There too Erik XIII. (the Pomeranian), after being driven out of Denmark by his own subjects, established himself in 1437, and for a dozen years waged piracy upon Danes and Swedes alike. After him came Olaf and Ivar Thott, two Danish lords, who down to the year 1487 terrorized the seas from their pirates' stronghold of Wisby. Lastly, the Danish admiral Sören Norrby, the last supporter of Christian I. of Denmark, when his master's cause was lost, waged a guerilla war upon the Danish merchant ships and others from the same convenient base. But this led to an expedition by the men of Lübeck, who partly destroyed the city in 1525. By the peace of Stettin (1570) Wisby was confirmed to the Danish Crown, to which it had been given by Queen Margaret. But at the peace of Brömsebro in 1645 it was at length restored to Sweden. It was then, however, a mere wreck of its former self; its commercial supremacy and its prosperity had alike disappeared. Except for the three years 1676–79, when it was forcibly occupied by the Danes, and a few weeks in 1808, when the Russians landed a force, the island has remained subject to the Swedish Crown.

See *Visby och dess Minnesmärken*, by HANS HILDEBRAND (Stockholm, 1892 *et seq.*), and *Till Wisby Stads Ældsta Historia*, by A. BJÖRKANDER (1898), where most of the literature dealing with the subject is mentioned; but some of Björkander's arguments require criticism. (J. T. BE.)

Wisconsin, one of the north central states of the American Union. It had in 1890 a population of 1,686,880, with a density of 30·98 to the square mile, and in 1900 a population of 2,069,042, with a density of 38 to the square mile, the rate of increase during the decade being 22·2 per cent. In 1900, 1,067,562 were males and 1,001,480 were females; 1,553,071 were native-born and 515,971 (24·9 per cent.) were foreign-born; 2,057,911 were white and 11,131 were coloured (2542 negroes, 217 Chinese and Japanese, and 8372 Indians). Out of 570,715 adult males, 31,136 were illiterate (unable to write), of whom 23,956 were foreign-born and 1294 were Indians. In 1900 there were forty incorporated cities and villages with a population of more than 2000 and less than 5000, fifteen of more than 5000 and less than 10,000, and eighteen with more than 10,000. The ten largest cities in 1900 were Milwaukee, 285,315; La Crosse, 28,895; Oshkosh, 28,284; Superior, 31,091; Racine, 29,102; Sheboygan, 22,962; Eau Claire, 17,517; Green Bay, 18,684; Madison, 19,164; Marinette, 16,195. During the financial depression of 1893–97 there was a marked movement from the cities to the cheap wild lands of northern Wisconsin, but since the latter year the cities, especially Milwaukee, have grown rapidly. In 1890 the urban population (classing as such all persons in places of more than 4000 inhabitants) comprised 30·9 per cent. of the total population; in 1900 the percentage had risen to 34·5.

Agriculture.—In 1900 there were 169,795 farms, of an average size of 117 acres. The total acreage of farms was 19,862,727, of which 8,615,755 acres were improved land. Of these farms 146,799 were cultivated by the owners, and 10,249 were occupied by cash tenants and 12,747 by share tenants. The total value of farm property was given as $811,712,319, and the value of the farm products for the preceding year was $157,445,713. The produce was estimated as follows: Wheat, 9,005,170 bushels; Indian corn, 53,309,810; oats, 84,040,800; barley, 18,699,690; rye, 5,142,606; potatoes, 24,641,498; hay, 3,667,212; sorghum, 160,414 gallons; tobacco, 45,500,480 ℔. Of cheese, 1,635,618 ℔ were produced, and of butter, 44,739,147 ℔. There were on farms 521,867 horses, 2,314,105 cattle, 1,675,453 sheep and lambs, and 2,014,631 swine. The dairy interest in the north as well as in the south has greatly developed, the northern counties from which the timber has been cut having been devoted to agriculture.

Manufactures, Railways, &c.—Large water-powers are found, chiefly on the Fox, Wisconsin, and Chippewa rivers. The following table shows the condition of the manufacturing industries in 1890 and 1900:—

	1890.	1900.	Per cent. of Increase.
Number of establishments	10,417	16,187	55·4
Capital	$246,515,404	$330,568,779	34·1
Wage-earners, average number	120,006	142,076	18·4
Wages	$42,958,267	$58,407,597	36·0
Value of product	$248,546,164	$360,818,942	45·2

The leading industries, with the values of their products, are: lumber and timber, $57,634,816; flouring and grist mills, $26,327,942; foundries and machine-shops, $22,252,730; butter, cheese, and condensed milk factory product, $20,120,147; leather, $20,074,373; malt liquors, $19,394,709; wholesale slaughtering and meat-packing, $13,601,125; and wood pulp, $10,895,576. The mining industry is gradually increasing in importance. In 1899 there were 6592 miles of railway, valued at $247,502,364.

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[1] The Stockholm Royal Numismatic Collection contains no less than 11,000 pieces of Anglo-Saxon coinage found in Gothland, some of date 901–924, but the bulk of a later date.

Administration.—The state sends ten representatives to Congress. The Supreme Court is composed of a chief-justice and four associate justices; there are seventeen judicial circuits, each with a judge; and besides these are county and municipal judges and justices of the peace. The state legislature meets biennially. The Wisconsin National Guard numbered, in October 1900, three regiments and a battalion of infantry, a troop of cavalry, and a battery. This force aggregates 2899 enlisted men and 191 officers.

Finance.—The value of all taxable property for 1890, as determined by the state board of assessment, was as follows:—Personal property, $122,041,032; real estate, $477,958,960; total assessed value of all property, $599,999,992. Taxes in 1896 were as follows:—Town, city, village, and county taxes, $15,018,687; roads, bridges, poll-tax, &c., $4,289,166. The total county, municipal, and school district indebtedness in 1890, less the sinking fund, was $8,145,189. The combined debt of the state, less the sinking fund, was $10,440,580. The bonded indebtedness of towns, cities, villages, and school districts on 31st December 1895 was $10,712,569. In July 1900 the several state banks had a combined capital of $6,417,725 and deposits of $45,929,285. The private banks had resources aggregating $12,257,519.

Charities and Correction.—The state supports two hospitals for the insane; in 1900 these contained 604 inmates, and there were 3397 insane in county asylums, gaols, and poorhouses. The school for the deaf has an average attendance of 175; school for blind, 111; industrial school for boys, 324. The number of prisoners in reformatories in 1900 was 945. The state board of control has charge of these institutions.

Education.—The number of persons of school age in 1899–1900 was 731,063. Of these 445,172 attended public schools, 4115 normal schools. In 1896 there were 27 colleges, academies, and seminaries, with a total of 3484 pupils. There were 394 private schools, with an attendance of 24,077. The number of free high schools was 197. The school fund in 1898 amounted to $792,502. The State University at Madison had in 1900 a total income of $426,663. In 1901–02 it had in all departments, including a summer session, an attendance of 2777. The number of teachers employed in common and high schools in 1900 was 13,063, and in private schools 1500.

Libraries.—The State Historical Society at Madison, the capital, has 230,000 titles. Its beautiful new fireproof building was completed in October 1900. It is of Bedford (Indiana) limestone, and is the finest building owned by the state. The university library, housed in the State Historical Society's building, has 72,000 titles. The library of the Wisconsin Academy of Sciences, in the same building, has 12,000 titles. The state law library, in the state house, has 45,000 titles.

Politics.—With the economic change of the last fifteen years of the 19th century in Wisconsin has gone a decided political change. It is no longer an agricultural state, but a decided manufacturing and commercial state. In the Presidential election of 1896, the succeeding Congressional election of 1898, and the Presidential election of 1900, Wisconsin was firmly in favour of the money policy of the Republican party. The large German and Scandinavian elements constitute important conservative factors in the state politics. (F. J. T.)

Wiseman, Nicholas Patrick Stephen (1802–1865), English cardinal, was born at Seville 2nd August 1802, the child of Anglo-Irish parents recently settled in Spain for business purposes. On his father's death in 1805 he was brought to Waterford, and in 1810 he was sent to Ushaw College, near Durham, where he was educated until the age of sixteen, when he proceeded to the English College in Rome, re-opened in 1818 after having been closed by the Revolution for twenty years. He graduated doctor of theology with distinction in 1825, and was ordained priest in the following year. He was appointed vice-rector of the English College in 1827, and rector in 1828, when not yet twenty-six years of age. This office he held until 1840. From the first a devoted student and antiquary, he devoted much time to the examination of Oriental MSS. in the Vatican library, and a first volume, entitled *Horæ Syriacæ*, published in 1827, gave promise of a great scholar. Leo XII. appointed him curator of the Arabic MSS. in the Vatican, and professor of Oriental languages in the Roman University. At this date he had close relations, personal and by correspondence, with Mai, Bunsen, Burgess (bishop of Salisbury), Tholuck, and Kluge. His student life was, however, broken by the Pope's command to preach to the English in Rome; and a course of his lectures *On the Connexion between Science and Revealed Religion*, though now necessarily out of date, deservedly attracted much attention, his general thesis being that whereas scientific teaching has repeatedly been thought to disprove Christian doctrine, further investigation has shown that a reconstruction is possible. He visited England in 1835–36, and delivered lectures on the principles and main doctrines of Roman Catholicism in the Sardinian Chapel, Lincoln's Inn Fields, and in the church at Moorfields, now pulled down. Their effect was considerable; and at Pusey's request Newman reviewed them in the *British Critic* (December 1836), treating them for the most part with sympathy as a triumph over popular Protestantism. To another critic, who had taken occasion to point out the resemblance between Catholic and pagan ceremonies, Wiseman replied, boldly admitting the likeness, and maintaining that it could be shown equally well to exist between Christian and heathen doctrines. In 1836 he founded the *Dublin Review*, partly to infuse into the lethargic English Catholics higher ideals of their own religion and some enthusiasm for the Papacy, and partly to enable him to deal with the progress of the Oxford Movement, in which he was keenly interested. At this date he was already distinguished as an accomplished scholar and critic, able to converse fluently in half-a-dozen languages, and well informed on most questions of scientific, artistic, or antiquarian interest. In the winter of 1838 he was visited in Rome by Macaulay, Manning, and Gladstone. An article by him on the Donatist schism appearing in the *Dublin Review* in July 1839 made a great impression in Oxford, Newman and others seeing the force of the analogy between Donatists and Anglicans. Some words he quoted from St Augustine influenced Newman profoundly: "Quapropter securus judicat orbis terrarum bonos non esse qui se dividunt ab orbe terrarum." And preaching at the opening of St Mary's church, Derby, in the same year, he anticipated Newman's argument on religious development, published six years later. In 1840 he was consecrated bishop, and sent to England as coadjutor to Bishop Walsh, vicar-apostolic of the Central district, and was also appointed president of Oscott College near Birmingham. Although he had not the gifts requisite to make a successful college head, he was beloved by the students, and Oscott under his presidency became a centre for English Catholics, where he was also visited by many distinguished men, including foreigners and non-Catholics. The Oxford converts (1845 and later) added considerably to Wiseman's responsibilities, as many of them found themselves wholly without means, while the old Catholic body looked on the new-comers with distrust. It was by his advice that Newman and his companions spent some time in Rome before undertaking clerical work in England. Shortly after the accession of Pius IX. Wiseman was appointed temporarily vicar-apostolic of the London district, the appointment becoming permanent in February 1849. On his arrival from Rome in 1847 he acted as informal diplomatic envoy from the Pope, to ascertain from the Government what support England was likely to give in carrying out the liberal policy with which Pius inaugurated his reign. In response Lord Minto was sent to Rome as "an authentic organ of the British Government," but the policy in question proved abortive. Residing in London in Golden

Square, Wiseman threw himself into his new duties with many-sided activity, working especially for the reclamation of Catholic criminals and for the restoration of the lapsed poor to the practice of their religion. He was zealous for the establishment of religious communities, both of men and women, and for the holding of retreats and missions. He preached (4th July 1848) at the opening of St George's, Southwark, an occasion unique in England since the Reformation, 14 bishops and 240 priests being present, and six religious orders of men being represented. The progress of Catholicism was undeniable, but yet Wiseman found himself steadily opposed by a minority among his own clergy, who disliked his Ultramontane ideas, his "Romanizing and innovating zeal," especially in regard to the introduction of sacred images into the churches and the use of devotions to the Blessed Virgin and the Blessed Sacrament, hitherto unknown among English Catholics. In July 1850 he heard of the Pope's intention to create him a cardinal, and he took this to mean that he was to be permanently recalled to Rome. But on his arrival there he ascertained that a part of the Pope's plan for restoring a diocesan hierarchy in England was that he himself should return to England as Cardinal and Archbishop of Westminster. The Papal brief establishing the hierarchy was dated 29th September 1850, and on 7th October Wiseman wrote a pastoral, dated "from out of the Flaminian Gate"—a form diplomatically correct, but of bombastic tone for Protestant ears—in which he spoke enthusiastically, if also a little pompously, of the "restoration of Catholic England to its orbit in the ecclesiastical firmament." Wiseman travelled slowly to England, round by Vienna; and when he reached London (11th November) the whole country was ablaze with indignation at the "Papal aggression," which was misunderstood to imply a new and unjustifiable claim to territorial rule. Some indeed feared that his life was endangered by the violence of popular feeling. But Wiseman displayed calmness and courage, and immediately penned an admirable *Appeal to the English People* (a pamphlet of over 30 pages), in which he explained the nature of the Pope's action, and argued that the admitted principle of toleration included leave to establish a diocesan hierarchy; and in his concluding paragraphs he effectively contrasted that dominion over Westminster, which he was taunted with claiming, with his duties towards the poor Catholics resident there, with which alone he was really concerned. A course of lectures at St George's, Southwark, further moderated the storm. In July 1852 he presided at Oscott over the first Provincial Synod of Westminster, at which Newman preached his sermon on the "Second Spring"; and at this date Wiseman's dream of the rapid conversion of England to the ancient faith seemed not incapable of realization. But many difficulties with his own people shortly beset his path, due largely to the suspicions aroused by his evident preference for the ardent Roman zeal of the converts, and especially of Manning, to the dull and cautious formalism of the old Catholics. The year 1854 was marked by his presence in Rome at the definition of the dogma of the immaculate conception of the Blessed Virgin (8th December), and by the publication of his historical romance, *Fabiola*, a tale of the Church of the Catacombs, which had a very wide circulation and was translated into ten languages. In 1855 Wiseman applied for a coadjutor, and George Errington, bishop of Plymouth, his friend since boyhood, was appointed, with the title of Archbishop of Trebizond. Two years later Manning was appointed by the Pope Provost of Westminster, and he established in Bayswater his community of the "Oblates of St Charles"; and all Wiseman's later years were darkened by Errington's conscientious but implacable hostility to Manning, and to himself in so far as he was supposed to be acting under Manning's influence. The story of the estrangement, which was largely a matter of temperament, is fully told in Ward's biography. Ultimately, in July 1860, Errington was deprived by the Pope of his coadjutorship with right of succession, and he retired to Prior Park, near Bath, where he died in 1886. In the summer of 1858 Wiseman paid a visit to Ireland, where, as a cardinal of Irish race, he was received with enthusiasm. His speeches, sermons, and lectures, delivered during his tour, were printed in a volume of 400 pages, and show an extraordinary power of rising to the occasion and of speaking with sympathy and tact. Wiseman was able to use considerable influence with English politicians, partly because in his day English Catholics were wavering in their historical allegiance to the Liberal party. As the director of votes thus doubtful, he was in a position to secure concessions that bettered the position of Catholics in regard to poor schools, reformatories and workhouses, and in the status of their army chaplains. In 1863, addressing the Catholic Congress at Malines, he stated that since 1830 the number of priests in England had increased from 434 to 1242, and of convents of women from 16 to 162, while there were 55 religious houses of men in 1863 and none in 1830. The last two years of his life were troubled by illness and by controversies in which he found himself, under Manning's influence, compelled to adopt a policy less liberal than that which had been his in earlier years. Thus he had to condemn the Association for the Promotion of the Unity of Christendom, with which he had

Cardinal Wiseman.

(From a photograph by Russell and Sons, London.)

shown some sympathy in its inception in 1857; and to forbid Catholic parents to send their sons to Oxford or Cambridge, though at an earlier date he had hoped (with Newman) that at Oxford at least a college or hall might be assigned to them. But in other respects his last years were cheered by marks of general regard and admiration, in which non-Catholics joined; and after his death (16th February 1865) there was an extraordinary demonstration of popular respect as his body was taken from St Mary's, Moorfields, to the cemetery at Kensal Green, where it was intended that it should rest only until a more fitting place could be found in a Roman Catholic cathedral church of Westminster.

Wiseman was undoubtedly an eminent Englishman, and one of the most learned men of his time. He was the friend and correspondent of many foreigners of distinction, among whom may be named Döllinger, Lamennais, Montalembert, and Napoleon III. As a writer he was apt to be turgid and prolix, and there was a somewhat un-English element of ostentation in his manner. But his accomplishments and ability were such as would have secured for him influence and prominence in any age of the Church; and besides being highly gifted intellectually and morally, he was marked by those specially human qualities which command the interest of all students of life and character. He combined with the principles known as Ultramontane no little liberality of view in matters ecclesiastical. He insisted on a poetical interpretation of the Church's liturgy; and while strenuously maintaining her Divine commission to teach faith and morals, he regarded the Church as in other respects a learner; and he advocated a policy of conciliation with the world, and an alliance with the best tendencies of contemporary thought. It was, in his judgment, quite in accordance with the genius of the Catholic Church that she should continuously assimilate all that is worthy in the civilization around.

The authority for his life is the excellent biography by Wilfrid Ward, *The Life and Times of Cardinal Wiseman*, 2 vols., 1897; fifth and cheaper edition, 1900. (A. W. Hu.)

Wishaw, a mining town and police burgh of Lanarkshire, Scotland, 15 miles east-south-east of Glasgow by rail. It has important railway works, a sewing factory, and engineering works. A parish hall has been erected, and there are a town hall, a Victoria Hall, and a public park. Gravitation waterworks have been constructed, and a large public school with secondary department has been built, as well as an Episcopal church. Population (1891), 15,252; (1901), 20,869.

Wislicenus, Johannes (1835– ——), German chemist, was born on the 26th of June 1835 at Klein-Eichstedt, in Thuringia. In 1865 he became professor of chemistry at Zürich University, and in 1870 also at the polytechnic of that town; in 1872 he was appointed to the ordinary chair of chemistry at Würzburg, and in 1885 he took up the same post at Leipzig. As an original investigator he has devoted himself almost exclusively to organic chemistry, and especially to stereochemistry. His work on the lactic acids cleared up many difficulties concerning the combination of acid and alcoholic properties in oxy-acids in general, and resulted in the discovery of two substances differing in physical properties though possessing a structure of proved chemical identity. To this phenomenon, then noticed for the first time, he gave the name of geometrical isomerism. So far back as 1869, before the publication of the doctrine of van 't Hoff and Le Bel, he expressed the opinion that the ordinary constitutional formulæ did not afford an adequate explanation of certain carbon compounds, and suggested that account must be taken of the *verschiedene Lagerung ihrer Atome im Raume*. Later (see *Die räumliche Anordnung der Atome in organischen Molekülen*, 1887) he extended the application of the van 't Hoff–Le Bel theory, believing that it, together with the supposition that there are "specially directed forces, the affinity-energies," which control the spatial relations of atoms towards each other, afforded a method by which the spatial arrangement of atoms in particular cases may be ascertained by experiment. Wislicenus is also known for his work on aceto-acetic ether and its application as a synthetical agent. He was awarded the Davy medal by the Royal Society in 1898.

Wismar, a town and seaport of Germany, grand-duchy of Mecklenburg-Schwerin, on a bay of the Baltic, 20 miles by rail north of Schwerin. The town hall (rebuilt in 1819) contains a collection (1898) of pictures. St George's church was restored in 1887–88. Wismar has an industrial school and a school of navigation. The port is accessible to vessels drawing 17 feet, and in 1899 was cleared by 875 vessels of 120,841 tons engaged in foreign trade. Population (1885), 15,797; (1900), 19,758.

Witkowitz (Czech, *Vitkovic*), a mining village in eastern Moravia, in the district of Mährisch-Ostrau. Over 10,000 hands are employed in the coal-mines and iron-works. The bulk of the population (10,294 in 1890, 19,128 in 1900) is German, Witkowitz and its environs constituting a small German enclave.

Witney, market town and urban district, Oxfordshire, England, in the Woodstock parliamentary division of the county, 11 miles west by north of Oxford by rail. The urban district was extended in 1898 to include portions of the scattered villages of Hailey and Curbridge. The blanket-making was in 1710 of such importance that the weavers of the town and neighbourhood were then incorporated by royal charter. In 1899 the industry employed 250 looms and between 700 and 800 hands, and the production was larger than at any previous time. Gloves and other woollen goods are also made. Population (1891), 3731; (1901), 3574.

Witte, Serge Julievitch (1849– ——), Russian Minister of Finance, was born in 1849 at Tiflis, where his father (of German extraction) was a member of the Vice-regal Council of the Caucasus. His mother was a lady of the Fadeyef family, by whom he was brought up as a member of the Eastern Orthodox Church and thoroughly imbued with nationalist feeling in the Russian sense of the term. After completing his studies at Odessa University, in the faculty of mathematics and physical science, and devoting some time to journalism in close relations with the Slavophils and M. Katkoff, he entered in 1877 the service of the Odessa State Railway, and so distinguished himself in the transport operations necessitated by the Turkish campaign of 1877–78, that he was soon afterwards appointed general traffic manager of the South-Western Railway of Russia and member of an Imperial commission which had to study the whole question of railway construction and management throughout the empire. His speciality was an intimate acquaintance with the problem of railway rates in connexion with the general economic development of the country, and in 1883 he published a work on the subject which attracted some attention in the official world. Among those who had discovered his exceptional ability in matters of that kind was M. Vishnegradski, Minister of Finance, who appointed him head of the railway department in the finance ministry. In 1892 he was promoted to be Minister of Ways of Communication, and in the following year, on the retirement of M. Vishnegradski, he succeeded his patron as Minister of Finance. In this important post he displayed extraordinary activity, and applied practically many of the principles of the German economist, Friedrich List, of whom he had long been an ardent disciple. Following the teachings of his master, who had advocated, in opposition to the cosmopolitan principles of Adam

Smith, a genuinely national system of political economy, he sought to develop home industries by means of moderate protection and the introduction of foreign capital for industrial purposes. At the same time he succeeded by drastic measures in putting a stop to the great fluctuations in the value of the paper currency and in resuming specie payments. The rapid extension of the railway system was also largely due to his energy and financial ingenuity, and he embarked on a crusade against the evils of drunkenness by organizing a Government monopoly for the sale of alcohol. In the region of foreign policy he greatly contributed to the extension of Russian influence in northern China and Persia. Naturally of a combative temperament, and endowed with a persevering tenacity rare among his countrymen, he struggled for what he considered the liberation of his country from the economic bondage of foreign nations. Germany was, in his opinion, the neighbour whose aggressive tendencies had to be specially resisted. He was therefore not at all *persona grata* in Berlin, but the German Imperial authorities learned by experience that he was an opponent to be respected, who understood thoroughly the interests of his country, who was ready to assume heavy responsibilities, who was not to be intimidated, and who was quite capable of adopting if necessary a vigorous policy of reprisals.

Wittenberg, a town of Prussia, province of Saxony, on the right bank of the Elbe, 59 miles by rail south-west of Berlin. The castle church was restored in 1885–92; in front of it stands a bronze statue of the Emperor Frederick III. (1894). The industries of the town include cloth and other textiles, flower-cultivation, brewing, and distilling. Population (1885), 13,865; (1900), 18,333.

Wittenberge, a town of Prussia, on the Elbe, near the influx of the Stepenitz into that river, 54 miles north-north-west of Brandenburg by rail, in the circle of Westprignitz, government district of Potsdam. The bridge here spanning the Elbe, 5300 feet long, was built in 1851 at a cost of £237,500. There are wool, cloth, shoddy, and oil factories, brickyards, shipping, and transport trade. Population (1890), 12,587; (1900), 16,258.

Wittingau (Czech, *Třeboň*), the chief town of a government district in southern Bohemia, Austria, 14 miles E. by N. of Budweis. It is situated on the Goldbach, a small tributary of the Luschnitz, in a marshy district. The parish church is a Gothic edifice of the 14th century, with fine cloisters; and the Schwarzenberg château, dating from the 15th century, is reputed to contain the most extensive and valuable archives in Bohemia. The artificial cultivation of fish, now chiefly carp, in the numerous ponds that surround the town is the most interesting feature of its industry, and dates from the 14th century. Several of these have latterly been drained and converted into meadows, or utilized as arable land, while others are alternately used for both purposes. The industry further comprises the manufacture of beer, bricks and tiles, turpentine, and the products of the steam rolling-mills and saw-mills. Population (1890), 5421; (1900), 5467, mostly Czech.

Woburn, a city of Middlesex county, Massachusetts, U.S.A., 10 miles north-west of Boston, in the north-eastern part of the state. It contains an area of 14 square miles, and is divided into seven wards. The closely-built urban part is irregularly laid out, and has an excellent water-supply from Horn Pond. It has a fine public library, containing over 40,000 volumes, besides artistic and antiquarian collections. The city is traversed by the Boston and Maine Railroad, and has extensive manufactures of leather and boots and shoes. It received a city charter in 1888. Population (1890), 13,499; (1900), 14,254, of whom 3840 were foreign-born and 261 negroes.

Woking, a town in the Chertsey parliamentary division of Surrey, England, 24 miles south-west of London by rail. The river Wey and the Basingstoke canal pass through the parish. St Peter's church dates from the 13th century. Modern structures include a public hall, an Oriental institute (in the building erected for the Royal Dramatic College, containing a museum of Eastern antiquities, a mosque, and residences for Orientals), Surrey county asylum, a female convict prison, barracks, St Peter's Memorial Home, and two cottage hospitals. At Woking is Brookwood cemetery, belonging to the London Necropolis Company, with a crematorium containing a chapel. Area of civil parish (an urban district), 8889 acres. Population (1891), 9776; (1901), 16,222.

Wokingham, municipal borough (since 1885) and market town, Berkshire, England, in the Wokingham parliamentary division of the county, 14 miles south-west of Windsor, with a station on a branch of the South-Western Railway. Population (1891), 3254; (1901), 3551.

Wolf, Joseph (1820–1899), Anglo-German artist, the son of a German farmer, was born in 1820 at Münstermaifeld, on the river Moselle, in the Rhine Province. In his boyhood he was an assiduous student of bird and animal life, and showed a remarkable capacity as a draughtsman of natural history subjects. His powers were first recognized by Professor Schlegel of the Leyden museum, who gave him employment as an illustrator. In 1848 he settled in London, where he remained till his death on 20th April 1899. He made many drawings for the Zoological Society, and a very large number of illustrations for books on natural history and on travel in various countries; but he also won a considerable success as a painter.

See A. H. Palmer. *The Life of Joseph Wolf.* London, 1895.

Wolfenbüttel, a town of Germany, duchy of Brunswick, 7 miles by rail south of Brunswick. The Roman Catholic church of St Peter was built in 1889–91, and a synagogue in 1893. There are also ducal archives and a Bismarck monument. The chief industries include the making of machinery, iron-foundries, wood-turning, preserves factories, and gardening. Population (1885), 13,453; (1900), 17,873.

Wolgast, a seaport town of the province of Pomerania, Prussia, on the river Peene, which separates it from the island of Usedom, 30 miles by rail east of Greifswald. It has a trade in timber, iron, granite (imports), and in wheat, cement, and chemicals (exports); manufactures cement, chemicals, woollen and silk embroidery, steel goods and machinery; and has iron-foundries, granite working and polishing, and amber working. It was formerly fortified, but endured great vicissitudes during the Thirty Years' War; was captured by the Great Elector in 1675, by the Russians in 1713, and by the Swedes in 1715. Population (1890), 7880; (1900), 8251.

Wollaston Land. See North-West Territories.

Wolseley, Garnet Joseph Wolseley, Viscount (1833– ——), British field-marshal, eldest son of Major Garnet Joseph Wolseley of the King's Own Borderers (25th Foot), was born at Golden Bridge, County Dublin, on the 4th June 1833. Educated at Dublin, he obtained a commission as ensign in the 12th Foot in March 1852, and was transferred to the 80th Foot, with which he served in the second Burmese war. He was severely wounded on the 19th March 1853 in the attack of Donabyú, was mentioned in despatches, and received the war medal. Promoted to be lieutenant and invalided home, he exchanged into the 90th Light Infantry, then in Dublin. He accompanied the regiment to the Crimea, and landed at Balaklava in December 1854. He was selected to be an assistant engineer, and did duty with the Royal Engineers in the trenches before Sebastopol. He was promoted to be captain in January 1855, after less than three years' service, and served throughout the siege, was wounded at the Quarries on the 7th June, and again in the trenches on the 30th August. After the fall of Sebastopol Wolseley was employed on the quartermaster-general's staff, assisted in the embarkation of the troops and stores, and was one of the last to leave the Crimea in July 1856. For his services he was twice mentioned in despatches, was noted for a brevet majority, received the war medal with clasp, the 5th class of the French Legion of Honour, the 5th class of the Turkish Mejidie, and the Turkish medal. After six months' duty with the 90th Foot at Aldershot, he went with it again, in March 1857, to join the expedition to China under Major-General the Hon. T. Ashburnham. Wolseley embarked in command of three companies in the transport *Transit*, which was wrecked in the Strait of Banka. The troops were all saved, but with only their arms and a few rounds of ammunition, and were taken to Singapore, whence, on account of the Indian Mutiny, they were despatched with all haste to Calcutta. Wolseley distinguished himself at the relief of Lucknow under Sir Colin Campbell in November, and in the defence of the Alambagh position under Outram, taking part in the actions of the 22nd December 1857, the 12th and 16th January 1858, and the repulse of the grand attack of the 21st February. In March he served at the final siege and capture of Lucknow. He was then appointed deputy-assistant quartermaster-general on the staff of Sir Hope Grant's Oudh division, and was engaged in all the operations of the campaign, including the actions of Bari, Sarsi, Nawabganj, the capture of Faizabad, the passage of the Gumti, and the action of Sultanpur. In the autumn and winter of 1858 he took part in the Baiswara, trans-Gogra, and trans-Rapti campaigns, ending with the complete suppression of the rebellion. For his services he was frequently mentioned in despatches and, having received his Crimean majority in March 1858, was in April 1859 promoted to be lieutenant-colonel, and received the Mutiny medal and clasp. Wolseley continued to serve on Sir Hope Grant's staff in Oudh, and when Grant was nominated to the command of the British troops in the Anglo-French expedition to China in 1860, accompanied him as deputy-assistant quartermaster-general. He was present at the action at Sin-ho, the capture of Tang-ku, the storming of the Taku Forts, the occupation of Tientsin, the battle of Pa-le-cheau, and the entry into Peking. He assisted in the re-embarkation of the troops before the winter set in. He was mentioned in despatches, and for his services received the medal and two clasps. On his return home he published the *Narrative of the War with China in 1860.*

Viscount Wolseley.
(From a photograph by Elliott and Fry, London.)

In November 1861 Wolseley was one of the special service officers sent to Canada to make arrangements for the reception of troops in case of war with the United States in connexion with the mail steamer *Trent* incident, and when the matter was amicably settled he remained on the headquarters staff in Canada as assistant quartermaster-general. In 1865 he became a brevet colonel, was actively employed the following year in connexion with the Fenian raids from the United States, and in 1867 was appointed deputy quartermaster-general in Canada. In 1869 his *Soldiers' Pocket Book for Field Service* was published, and has since run through many editions. In 1870 he successfully commanded the Red River expedition to put down a rising under Louis Riel at Fort Garry, now the city of Winnipeg, the capital of Manitoba, then an outpost in the wilderness, which could only be reached through a network of rivers and lakes extending for 600 miles from Lake Superior, traversed only by Indians, and where no supplies were obtainable. The admirable arrangements made and the careful organization of the transport reflected great credit on the commander, who on his return home was made K.C.M.G. and C.B.

Appointed assistant adjutant-general at the War Office in 1871, he worked hard in furthering Mr Cardwell's schemes of army reform, was a member of the Localization Committee, and a keen advocate of short service, territorial regiments, and linked battalions. From this time till he became commander-in-chief Wolseley was the prime mover and the deciding influence in practically all the steps taken at the War Office for promoting the efficiency of the army under the altered conditions of the day. In 1873 he commanded the expedition to Ashanti, and, having made all his arrangements at the Gold Coast before the arrival of the white troops in January 1874, was able to complete the campaign in two months, and re-embark them for home before the unhealthy season began. This was the campaign which made his name a household word in England. He fought the battle of Amoaful on the 31st January, and, after five days' fighting, ending with the battle of Ordahsu, entered Kumasi, which he burned. He received the thanks of both Houses of Parliament and a grant of £25,000, was promoted to be major-general for distinguished service in the field, received the medal and clasp, and was made G.C.M.G. and K.C.B. The freedom of the City of London was conferred upon him with a sword of honour, and he was made honorary D.C.L. of Oxford and LL.D. of Cambridge Universities. On his return home he was appointed inspector-general of auxiliary forces, but had not held the post for a year when he was sent on a mission to Natal as administrator and general commanding. In November 1876 he accepted a seat on the Council of India, from which in 1878, having been promoted lieutenant-general, he went as High Commissioner to the newly-acquired possession of Cyprus, and in the following year to South Africa to supersede Lord Chelmsford in command of the forces in the Zulu war, and as Governor and High Commissioner of South-East Africa. But the Zulu war was practically over, and after effecting a settlement and seizing a Kaffir chief, Sekukuni, who had given trouble, he returned home in 1880 and was appointed quartermaster-general to the forces. For his services in South Africa he received the Zulu medal with clasp, and was made G.C.B.

In 1882 he was appointed adjutant-general to the forces, and in August of that year was given the command of the British forces in Egypt to suppress the rebellion of Arabi Pasha. Having seized the Suez Canal, he disembarked his troops at Ismailia, and after a very short and brilliant campaign completely defeated Arabi Pasha at Tel-el-Kebir, and suppressed the rebellion. For his services he received the thanks of Parliament, the medal with clasp, the bronze star, was promoted general for distinguished service in the field, raised to the peerage as Baron Wolseley of Cairo and Wolseley, and received from the Khedive the 1st class of the order of the Osmanieh. In 1884 he was again called away from his duties as adjutant-general to command the Nile expedition for the relief of General Gordon and the besieged garrison of Khartum. The expedition arrived too late: Khartum had fallen, and Gordon was dead; and in the spring of 1885 complications with Russia over the Penjdeh incident occurred, and the withdrawal of the expedition followed. For his services he received two clasps to his Egyptian medal, the thanks of Parliament, and was created a viscount and a Knight of St Patrick. He continued at the War Office as adjutant-general to the forces until 1890, when he was given the command in Ireland. He was promoted to be field-marshal in 1894, and was nominated colonel of the Royal Horse Guards in 1895, in which year he was appointed by the Unionist Government to succeed the Duke of Cambridge as commander-in-chief of the forces. This was the position to which his great experience in the field and his previous signal success at the War Office itself had fully entitled him. His powers were, however, limited by a new Order in Council, and after holding the appointment for over five years, he handed over the command-in-chief to Earl Roberts at the commencement of 1901. The fact that the unexpectedly large force required for South Africa was mainly furnished by means of the system of reserves which Lord Wolseley had originated was in itself a high tribute to his foresight and sagacity; but the new conditions at the War Office had never been to his liking, and on being released from responsibility he brought the whole subject before the House of Lords in a speech which resulted in some remarkable disclosures. Lord Wolseley had been appointed colonel-in-chief of the Royal Irish Regiment in 1898, and in 1901 was made gold-stick in waiting. He married in 1867 Louisa, daughter of Mr A. Erskine, his only child, Frances, being heiress to the viscountcy under special remainder. A frequent contributor to periodicals, he has also published *The Decline and Fall of Napoleon* (1895) and *The Life of John Churchill, Duke of Marlborough, to the Accession of Queen Anne* (1894).

Wolverhampton, a municipal, parliamentary, and, since 1888, county borough of Staffordshire, England, 125 miles north-west of London by rail. Modern institutions include a higher-grade, board and national schools, a nursing institution, a theatre, and west and east end (1895) parks. In 1891, 1401 persons were engaged in the making of machines and tools; 4153 in iron and steel manufactures (turning out some 370,000 locks alone in a week); 1303 in tin and zinc manufactures; 643 in the making of bicycles and tricycles. There are 2 daily newspapers. An industrial and art exhibition was held in 1902. Area of municipal borough, 3525 acres. Population (1891), 82,662; (1901), 94,179.

Wombwell, a township, urban district, and parish, in the Barnsley parliamentary division of the West Riding of Yorkshire, England, 4½ miles south-east of Barnsley by rail. The ancient church of St Mary's has been replaced by a modern building erected in 1896. Population (1891), 10,942; (1901), 13,252.

Women.—Remarkable changes affected the lives and work of women in the second half of the 19th century. The industrial, religious, educational, and philanthropic work of women increased out of all proportion compared with what was done before that period, and it is desirable not only to know what has been accomplished, but to have also some knowledge of the agencies that have been instrumental in carrying it out. There is no complete history of the movement, though there is ample fragmentary information on certain subjects. The larger objects of women's work have occupied the attention of the public, while many of the equally useful but smaller objects attained are unknown.

Education.

Before the accession of Queen Victoria there was no systematic education for English women, but as the first half of the 19th century drew to a close, broader views began to be held on the subject, while the humanitarian movement, as well as the rapidly-increasing number of women, helped to put their education on a sounder basis. It became more thorough; its methods were better calculated to stimulate intellectual power; and the conviction that it was neither good, nor politic, for women to remain intellectually in their former state of ignorance, was gradually accepted by every one. The movement owed much to Frederick Denison Maurice. He was its pioneer; and Queen's College, which he founded, was the first to give a wider scope to the training of its scholars. Out of its teaching, and that of its professors (including Charles Kingsley), grew nearly all the educational advantages which women enjoy to-day; and to the women who were trained at Queen's College we owe some of the best teaching in England. Bedford College, Cheltenham College, the North London Collegiate School for Girls, the Girls' Public Day School Company's schools, are some of those which sprang into life in different parts of England, and were filled, as rapidly as they were opened, by the girls of the middle and professional classes. From their teaching came the final stage which gave women the same academic advantages as men. Somerville College and Lady Margaret Hall at Oxford, Girton and Newnham Colleges at Cambridge, Westfield College in London, St Hilda's College, St Hugh's Hall, Holloway College, Owens College, the Manchester and Birmingham and Victoria Universities, and other colleges for women in all parts of the United Kingdom, are some of the later but equally successful results of the movement. The necessity for testing the quality of the education of women, however, soon began to be felt. The University of Cambridge was the first to institute a special examination for women over eighteen, and its example was followed by Oxford; but while London, Dublin, Victoria, Edinburgh, Glasgow, and St Andrews Universities now grant degrees, Oxford and Cambridge do not. Women, however, may point with justifiable pride to the fact that within a very few years of their admission to university examinations they provided both a senior classic and a senior wrangler. The temperate, calm, earnest demeanour of women, both in the schools and in university life, has awakened admiration and respect from all; while it is impossible to exaggerate the effect the women's educational movement has had on the community, for it has brought into existence a vast number of women as well educated as men. Anxious for employment, hard-working, persevering, and capable, they have invaded many professions, and hold their ground where a sound education is the foundation of success.

Public work.

The pioneers of female education spent their energies in developing their higher and more intellectual ideals, but the later years opened up other positions which their better education has enabled women to fill. It is not possible for every woman to be a scholar, a professor, a doctor, a lawyer, or possibly to attain the highest positions in professions where competition with men is keen, but the development of women's work has opened many other outlets for their energies. As members of school boards, factory inspectors, poor law guardians, sanitary inspectors, they have had ample scope for gratifying their ambition and energy. The work that has been done in factory inspection by Mrs Tennant and her successors, and was initiated by Mrs Senior in the metropolitan poor law schools, can scarcely be equalled for comprehensiveness and thoroughness, and their appointments have been followed by others equally successful. The Board of Trade in 1893 appointed Miss Clara Collet as a labour correspondent of the Labour Department of the Board of Trade, especially to collect statistics and watch over the interests of the women workers. At the Home Office there are seven factory inspectors who are women. The Local Government Board has three boarding-out inspectorships which are held by women. The Board of Education employs fifteen women among its various departments, and in the office at Whitehall sixteen girls act as clerks. Four women are employed in the General Post Office as lady superintendents. In England, Scotland, Wales, and Ireland women are serving in large numbers on urban, district, and parish councils, as well as on school boards and boards of guardians. The London County Council employs about 135 women, and town councils and county councils are yearly employing them in increasing numbers.

Technical work.

There are a few successful women architects now working in England; a large number of women travel for business firms; in decorative work, as silversmiths, dentists, law copyists, proof-readers, and in plan tracing, women have begun to work with success; while wood-carving has become almost as recognized a career for them as that of typewriting and shorthand, in which an increasing number are finding employment. Agriculture and gardening have opened up a new field of work, and, with it, kindred occupations. A large number of women are employed to give instruction in dairy work in the United Kingdom, as well as in Canada; and the Horticultural College at Swanley in Kent is not only giving practical training in horticulture, but is sending out a large number of women, who are proving excellent head gardeners on private properties, good market gardeners, and lecturers on horticulture and botany. The Warwick Hostel at Reading exists for the practical and scientific teaching of women in the lighter branches of agriculture, such as dairy work and poultry keeping; and a special department has been opened for colonial training. A large number of students have availed themselves of the opportunity for studying this branch of work, which is specially adapted for women.

Scientific work.

There are many women also engaged in scientific work and research in the United Kingdom and the colonies. Astronomy, bacteriology, botany, chemistry, geology, geography, physics, physiology, mathematics, and zoology are some of the subjects in which they are working successfully, and a scientific woman specialist holds an appointment under the Board of Agriculture in Ireland. There is an examiner in physics to the University of Dublin who is a woman, as well as over fifty women lecturers in various colleges and medical schools throughout the kingdom. A few women have found employment as curators and librarians of museums, and the demand for women to fill such posts is increasing.

Literature.

In literature women have more than held their own. It would be impossible to enumerate all, but there are some whose names are inseparably connected with social developments since 1850, such as Harriet Martineau, George Eliot, Elizabeth Barrett Browning, Mrs Humphry Ward, and Mrs Jameson. Harriet Martineau typified, more completely than any other woman, the modern phase of literary activity, being a novel writer, essayist, historian, and journalist. She entered into the routine everyday work of literature, and her writings perhaps represent, better than any others, the tone and feeling which characterize the women's movement of to-day. The branch of literature in which women have been most prominent is that of fiction. The names of well-known women authors are but a small part of the large number who make a good income by their writings. There are degrees in this as in other work, and many authors, whose works, though they do not rise to the highest standard, are in good demand at the libraries, have a large circulation, and always command an appreciative public. A large quantity of second-rate fiction is written by women who have the power of producing pleasant, brightly-written, and readable stories. Journalism is, for the moment, the most fashionable profession for the literary woman, for women generally have a light touch, and can throw off readable, if sometimes superficial, articles on any subject which is the interest of the hour. The large increase of papers for women is largely accounted for by the importance which is attached to fashion in dress and other matters on which women can write with special knowledge, and which now occupy so important a place in public interest that they cannot be disregarded. Nearly all the great daily journals in the United Kingdom and in the colonies have women on their staffs, whose work principally consists in chronicling information which will interest their women readers. This work is poor and unimportant enough from a literary standpoint, but it is of sufficient importance to enable many women to make a good living. In the colonies and America the work of women, both in fiction and in journalism, is increasing rapidly. In journalism they are pressing their male competitors very severely. Their command of language, vividness of expression and description, though not denoting a high standard of education or taste, happens to suit the popular fashion better than a more temperate and less highly-coloured style. The large numbers of women who live by writing must further increase with the demand for cheap literature and the low rate at which they are paid for their work compared with men.

Industrial work and combination.

The industrial development has increased the number of trades in which women are employed outside their homes. The returns of people employed in factories showed a total in 1898–99 of 472,587 women engaged in textile factories, as against 290,797 men, and in cotton factories the figures showed a slight increase in women and a decrease in men. In non-textile factories 368,634 women were employed and 2,033,868 men, but the trades in which men are engaged include those of machinery, working in metals, and others in which women are unable to compete. The wages paid to women are much lower than those paid to men, partly because their labour is worth less; it is also difficult to compare it, as in very few industries do they perform the same work. The absence of a uniform rate of payment to women for the work similar to that done by men is partly due to their want of organization, lack of combination, and the few opportunities that they have of discussing their industrial condition. The principal reason is, however, to be found in the fact that a man adopts a profession, and has to make his living and support a family on his earnings, while a woman is content to take unskilled work at lower wages, as the physical effort is less and she has more independence. The domestic servants of England represented in 1891, 1,748,954, the largest industry in the kingdom; but the numbers show a decrease owing to the growing spirit of independence among women of all classes, and the facilities for getting employment where there is less restraint. The difficulty of getting good general servants has become a very serious question in domestic life, especially in the rural districts. In towns the effect is already seen in the large number of flats, which are increasing every year, where fewer servants are required. Laundry work employs many women, and the extension of the Factory Acts to this industry has improved the conditions under which they work. The Home Office Report of 1897 gave a total of 5223 women working in mines. The Shop Assistants' Union gave 750,000 as the number of people employed in shops, of which 60 per cent. were women and young persons under eighteen years of age; and a large number of women are employed as barmaids and waitresses, but there are no statistics as to their numbers. The same reasons which cause the lower wages earned by women lead to their weakness in trade unions. The best organizations are those where they work with men and belong to the same unions. There are no accurate statistics as to the number of women unionists, but one return gives it as 122,047, of whom 108,982 are in the textile trades, 4315 in the clothing trades, 1200 in metal trades and the various other trades which employ women.

Politics.

The great Conservative political organization, the Primrose League, owes its success to women, who have adapted it to the political exigencies of the period. The political interests of women have made them platform speakers, not only in political contests, but on all subjects in which they are interested. Women speak well, have good voices and address, they are generally voluble, and when keenly interested are often eloquent, and many a cause has gained largely by its feminine advocates. They speak with an enthusiasm, straightforwardness, and conviction which touch their hearers. The temperance movement, and that for the protection of women and children, as well as most of the humanitarian questions of to-day, have some of their ablest advocates in women. Probably no organization has in so short a time enrolled so large a number of members as the Primrose League, for they amounted in 1902 to 1,571,490, and were increasing yearly. The Women's Liberal Federation, a comparatively youthful body, has a large and important council, 447 branches, and 55,000 members. There are also three or four other branches of the same organization, but there are no statistics forthcoming about them or their work. The Women's Liberal Unionist Association, also a large and powerful political organization, came into existence at the period of the Home Rule agitation. The question of women's suffrage has not advanced in the United Kingdom. There is an active and enthusiastic minority of the female community which attaches great importance to the question; but the great majority of women in England are either indifferent or opposed to any change in their political position. The question has not made any advance with either political party, the magnitude of such an addition to the electorate, and the uncertainty of the effect it would have, making both parties unwilling to adopt it; and while women show so much indifference on the subject, there is no reason to suppose that they are in favour of having the suffrage extended to them. In New Zealand and in South and West Australia, on the other hand, the franchise has been granted to women; in New South Wales the Government of 1902 brought in a Bill to enfranchise women, and in Victoria a Bill passed the Assembly in 1896, 1898, 1899, and 1900, with an increased majority every year, but was rejected by the Legislative Council.

Religious work.

By the constitution of the Church of England laymen can take little part, officially, in its management, only one office—that of churchwarden—being open to them, though this is equally available to women. But in the great voluntary associations in connexion with Church work women have taken a recognized and undisputed place. Their assistance has become a necessity to the welfare of the Church, for in all the great branches of Church work and labour, both in Great Britain and in the colonies, they have shown a devotion and capacity without which the Church would be in a less powerful position than she now occupies. There are about twelve parishes in England where women act as churchwardens. The Evangelical, and later the High Church, movements opened up another vocation and a wider field of work for women at home, and provided, by means of religious communities, sisterhoods, and deaconesses, a career for those whose capacity for work, under proper control and supervision, was infinite. It would be difficult to over-estimate the work of Mrs Sellon, Mrs Monsell, the All Saints' Sisterhood, the Sisters of the Church, St Mary's, Wantage, St John the Baptist at Clewer, or the labours of Miss Neale in connexion with Mr Lowder's work at the London docks. The large centres of population bear testimony to the work done by the sisterhoods in England, and by the deaconesses, who represent another school of religious thought, without whose labour many of the civilizing and humanizing movements which have revolutionized the social life of England would not have existed. The religious work of the great Dissenting bodies in England is as thorough and comprehensive as that of the Church, and in missionary enterprise they have done splendid service, especially for the London Missionary Society, which now sends out seventy female workers all over the world. The Salvation Army is an organization which owes its success in a remarkable measure to the ministry of its women, and to Mrs Bramwell Booth belongs the honour of having been the pioneer of one of the greatest opportunities women have had of exercising their influence in the cause of religion. Roman Catholic and Jewish women work as unceasingly for their faith; and Roman Catholic communities and sisterhoods have increased, while many women of high rank and great wealth among them have given up their position and riches to work in hospitals and prisons. Long before the religious vocation of women had begun in England, they had thrown themselves with great enthusiasm into missionary work. Some of the earliest and most devoted of English missionaries were women who, in Japan, China, India, and Africa, devoted their lives to attempting to improve and evangelize the inhabitants of the countries to which they were sent. The Zenana missions were started under their auspices, and many women have lost their lives in their endeavours to benefit others in distant parts of the world. The lives of these missionaries were isolated and solitary; but the mystery and sorrow which shadowed the women of the East appealed strongly to them, and no soldier ever died a nobler death than some of these pioneers of Christianity. The work they began has grown and flourished, as the innumerable societies for missionary work testify. There is no lack of workers; as fresh territories come under the influence of Western civilization, there are women ready to step out of the ranks of the great army of Church workers to carry the message of Christianity to their inhabitants.

It is impossible without statistics, of which there are none, to say how many women are engaged in missionary work, but the reports of the various societies, such as the London Missionary Society, the Zenana Medical Mission, the Presbyterian Missionary Society, the Moravian Mission, the Wesleyan Mission, show that there are hundreds belonging to each, as well as those belonging to smaller agencies, working in every continent. The religious organization of Mildmay Park, the Church guilds, the Anglican sisterhoods and deaconesses, as well as the largest religious body of women devoted to religious and missionary work—the sisters of St Vincent de Paul, numbering 40,000, who work all over the globe—cannot be overlooked in any article treating of the religious work of women. The social purity question, which has become a distinct branch of religious work, was initiated and advocated almost wholly by women, notably Mrs Josephine Butler, and shows how strongly the religious feeling of the day has raised the standard of life and morality, and how earnestly women are striving to attain to their ideal.

Philanthropic work.

The philanthropic work of women, as apart from that of religion, is so vast that anything like a detailed narrative is impossible, but it may be divided into a few heads. The associations for progress and social reform, such as the International Council of Women, "to promote unity, mutual understanding, and trust between women workers of all nations," which has numerous councils affiliated to it in the United States, the colonies, Germany, France, and many other countries, as well as branches in every large town in England, and endless associations and societies which it is fostering and increasing, is one of the most important. The organizations which deal directly with the poorer classes in charitable and parish work (such as the Charity Organization Society), though not entirely woman's work, are largely carried on by them. The women's settlements also date from the year 1887, when the women's colleges started their university settlement in south-east London. These settlements are now scattered over various districts in London, and are taking root in the large provincial towns. The lines on which settlement work is carried on are social, educational, remedial, and religious to a certain extent, but not distinct enough to class them as religious organizations. The influence for good that well-educated, devoted women, living among the poor, exercise is incalculable, and the work done by the various settlements is admirable. There are about twenty-eight settlements now existing in England, and one in India—the missionary settlement for university women at Kamballa Hill, Bombay. Emigration work is largely in the hands of women in the United Kingdom and in the colonies, where various organizations exist for the purpose of assisting women and girls who are sent out to Australia, Africa, and Canada. A certain number of homes for children and women, such as Dr Barnardo's Homes, and the Church of England Home for Waifs and Strays, and the Colonial Training Home for Ladies, and the Lady Warwick Hostel give a training to women and girls to fit them for colonial life. The preventive agencies for the protection of girls and young women, and the Ladies' Association for the care of Friendless Girls have branches all over the United Kingdom; the Reformatory and Refuge Union, the certified Reformatory and Industrial School for women and girls, and the large number of homes and centres of rescue work, such as the Church Penitentiary Association, the London Diocesan Council for preventive, penitentiary, and rescue work, and the National Vigilance Association, besides hundreds of kindred homes and centres, are all under the supervision and control of women. The number of homes, convalescent homes, hospitals, and societies worked by women for women are multiplying every year, and a superficial glance at any list of charitable institutions will bear testimony to the remarkable work that women are doing in helping others who have been unable to fight the battle of life. There are three societies for the benefit of women too interesting and important to be overlooked—the Young Women's Christian Association, the Girls' Friendly Society, and the Metropolitan Association for Befriending Young Servants. They each owe their existence to the devoted work of three women—Lady Kinnaird, Mrs Nassau Senior, and Miss Townsend. The first was founded for the purpose of providing a home and suitable lodgings for young women who were engaged in business, who were left to spend their leisure alone, or in walking about the streets for want of somewhere else to go to; out of the small homes then started there are now, in London alone, fifty institutes, homes, and restaurants for their use. Educational classes, libraries, gymnasiums, social evenings, reading rooms, give scope for every taste, and no girl in London need be at a loss where to live and spend her leisure. The ramifications of the association are endless: in London there are thirty thousand members, besides numbers all over the kingdom, where the work is also carried on. The society has spread to America and Canada, and the International Committee of the United States and Canada has 355 associations and 26,000 members. In Germany, and every country in Europe but Russia, in South America, Africa, Australia, India, the West Indies, Japan, and China there are associations in co-operation with it, and a large and successful one in Cape Town, besides others at Durban, Johannesburg, and in Basutoland. The Y.W.C.A., which has its headquarters in London at 17 Old Cavendish Street, now possesses a membership of five hundred thousand women, scattered all over the world. The Metropolitan Association for Befriending Young Servants, the work of Miss Frances Power Cobbe, Mrs Senior, and Miss Elliott, was founded for the purpose of looking after young girls placed in service from the parish or pauper schools. It now numbers 8000 members in London alone and 1000 lady visitors. The Girls' Friendly Society, which befriends only virtuous girls, is perhaps the largest society of its kind, as it shows a total in England and Wales of 150,000 members, 47,210 candidates, 16,750 associates, and 15,445 honorary associates, as well as 43,006 members and 9986 associates in America, India, Africa, and the colonies. There are many working girls' and women's clubs in London and the large towns of England, in which education and recreation are provided for those who are employed during the day. District visiting provides work for many women, but is badly paid in many cases, and it is not an occupation that is popular with the better class of women workers.

It would be impossible to enumerate all the organizations which exist for charitable and humanitarian work under the control or supervision of women—one branch alone, which embraces convalescent homes, being of great magnitude. Reformatory work, training homes for servants, and work among young children, which is so pronounced a feature of the day, are all carried out by women. The care of feeble-minded children, and the special schools, of which the London School Board have opened a large number in London, are some of the most interesting and most remarkable results of the work which women are doing. Any account of women's efforts for the good of the world must be imperfect which omitted to make reference to their labours in the cause of temperance. It has, of necessity, been largely directed to the social and personal aspect of the movement, though their associations have been most energetic in furthering and promoting legislative reform. It was a woman who first started the Band of Hope, one of the largest of the temperance societies. In 1899 it numbered 8,430,117 boys and girls as members. The large and increasing amount of drunkenness among women has aroused a special interest among temperance reformers, and women have been more anxious than any other class for the abolition of "grocers' licences." There are several important temperance organizations: the National British Woman's Temperance Association, of which Lady Henry Somerset is president, and the Women's Total Abstinence Union, are the best known; they have kindred associations in Scotland and Ireland, while in Canada and the colonies temperance work is just as strenuously advocated as in Great Britain. There are several temperance societies for young people besides the Band of Hope, and many homes for the care and cure of inebriates. In all these institutions women work or are associated, for they have long learnt by experience that drunkenness lies at the root of nearly all the crime, vice, and suffering of the world.

Nursing.

The philanthropic work of women also laid the foundation of what has become one of the most popular, as well as the most useful, of their occupations, namely, nursing. As nearly all women are natural nurses, there was little novelty in their adoption of nursing as a recognized calling; but until the Crimean war there was no such organized system of nursing in England as existed in Germany and Italy. The condition of the sick and wounded during the Crimean campaign was so terrible that Miss Nightingale, who was well known for her interest in all charitable works, and who had gone through a course of training at Kaiserswerth, then the only school of nursing of any importance, was requested by the Secretary for War to organize a nursing staff for the hospital at Scutari. Her achievements there gave her undying fame; and she crowned her noble enterprise by giving the sum of £50,000, subscribed for her by the country, towards founding a training school for nurses, which had its beginning in the old buildings of St Thomas's Hospital in Southwark. That nursing school has been the *alma mater* of thousands of women who have made successful careers for themselves as nurses, not only in England, but all over the world. The work Miss Nightingale initiated has been developed and improved on, and the system of nursing in England is the best in the world. The class of women who enter the profession has improved, the training is longer and more complete, and the standard required so high, that only the most capable women succeed. Nearly every important hospital has its own nursing school, and the period of training is seldom less than three years. What has been done in improving hospital nursing has also been carried out in workhouse infirmaries and in midwifery. Miss Nightingale said truly, "Hospitals are but an intermediate stage of civilization. The ultimate object is to nurse all sick at home," and her words are being realized, for nursing the sick poor at their own homes now gives occupation to thousands of nurses, who are trained not altogether on the same plan as those who are employed only in hospital work. No more necessary or useful work has ever been undertaken, and it has brought comfort, relief, and peace to millions of sick poor in England. The Metropolitan and National Training Association and the East London Nursing Society were the parent institutions out of which have grown many smaller associations all over the kingdom. The greatest development in district nursing was, however, brought about in 1899 by the establishment of Queen Victoria's Jubilee Institute for Nurses, founded by means of £70,000 presented to Queen Victoria on her Diamond Jubilee by the women of England. Nearly 20,000 women are employed as nurses in England, and the number in the colonies is proportionately large, so that the Queen's Jubilee gift towards further developing the work was a fitting tribute to their devotion and excellence.

Medical women.

A natural consequence of the capacity shown by women in nursing was the inauguration of one of the most important changes affecting their future careers, namely, their admission to the medical profession. No practical progress was made until 1858, when Miss Elizabeth Blackwell and Miss Garrett (Mrs Garrett Anderson) resolved to study medicine with a view to practising in England. The struggle was a long and bitter one, and nothing but the ability, courage, and tenacity of the women who fought it could have ensured success. After rebuffs, disappointments, and defeats, the Government passed a Bill conferring the same rights on women as on men, and in 1876 the battle was won. The bitterest opponents of medical women cannot deny that they have justified the demands they made, for not only has experience shown that there was a wide field for women doctors, but by their wisdom, tact, and ability they have won the respect of the community, and are occupying positions of responsibility not only in the United Kingdom, but all over the world. The London Medical School for Women is sending out, daily, well-qualified practitioners; and after years of the keenest opposition and the most minute scrutiny, there has been no case in which women have shown themselves either incompetent or unworthy of the position they occupy. Whatever difference of opinion may have existed as to the need for medical women in England, no one can deny the urgent necessity for the services of fully-qualified medical women in India, where religion and native custom make it impossible for women to be attended by a man. In 1872, Surgeon-General Balfour reported that out of the hundred million women in India, at least two-thirds were debarred by social custom from receiving the visits of a medical man, and that the suffering and disease in consequence were incalculable. No more useful or beneficent field of work was ever inaugurated than the labours of medical women in the East: the establishment of one hospital after another, the crowds waiting for admission, together with the number of native women who at once enrolled themselves as students at the various medical schools in India, added to the initiative taken by native residents, as well as the large funds collected by them, was sufficient evidence of the necessity which existed for female doctors. The recognized position of medical women in India is one of the greatest victories won by them, and with their success will be associated, in ever grateful remembrance, the name of Lady Dufferin, whose energy and kindness placed it on a safe financial footing. The number of medical women now practising in the United Kingdom, and all over the world, is very large, and the number of medical institutions in which women hold office is rapidly increasing. A few hospitals have admitted them on their boards of management. The London Royal Free Hospital School of Medicine for Women, with Mrs Garrett Anderson as its dean, has a large number of students, and has trained and sent out most of the medical women who are practising, both in the United Kingdom and in the British colonies. There are several valuable scholarships attached to the Royal Free Hospital, the London School of Medicine for Women, which are offered to students who require assistance in the pursuit of their medical studies, as well as the Stuart Mill scholarship, given to women willing to practise in India.

The arts and various professions.

Music, painting, and the stage offer still a great charm to women of the artistic temperament, and the schools of music, such as the Royal Academy of Music, the Royal College of Music, and the Guildhall School of Music, provide an excellent musical training at a moderate cost. Each school has scholarships which are of great assistance to girls who need some extra help to enable them to get through the long training which is necessary. The Royal Academy of Art schools at Burlington House admit women as well as men to their instruction, and the Royal College of Art at South Kensington has a large number of female students. The Central School of Arts and Crafts, established by the technical branch of the London County Council, provides instruction in all branches of design bearing on the various artistic trades; and the Female Royal School of Art, in connexion with the Science and Art Department at South Kensington, teaches drawing, painting, modelling, as well as decorative design; while the metropolitan art schools in connexion with the Board of Education have centres in all parts of London and evening classes for women. There are endless minor arts in which women are engaged, and at which they earn a fair salary, such as chromo-lithography, lace designing, bookbinding, fashion-plate drawing, illustrating books and newspapers, designing Christmas cards, &c. The designing of wall-papers is largely carried out by women, who possess not only taste, but have generally gone through a long course of artistic training. The stage does, and always will, possess a fascination for women which no other profession can offer them, and many women go on the stage without much training. Even if they do not attain to a high position in their profession, they can earn a small salary, while to those who study seriously there are high prizes and opportunities of public success; but the life is a hard one, and full of temptation. Fortunately the standard of conduct has risen, and a woman can be on the stage and at the same time lead a virtuous life. Many women of good birth have become actresses, though only occupying unimportant positions.

In the great demand for work which exists among women, housewifery has come to the front, and to the schools of cookery, which have improved the gastronomy of the country, have been added other training schools for teaching housekeeping. The National Training School of Cookery still carries on its excellent work, and the classes are well attended. There are a few "lady cooks" in London who go out and cook dinners, and some ladies trained in the housekeeping schools do well. The various hygienic and sanitary associations which exist employ women as lecturers, and those who are capable find employment easily. The National Health Society trains women to qualify as lecturers on the laws of health and sanitary subjects under the County Council scheme of technical education, and also as factory inspectors, sanitary inspectors, and lecturers. The Manchester Ladies' Health Society employs twenty-three women as health visitors in Manchester and Salford.

Athletics.

In athletics women are now almost as much interested as men. Archery, which formerly was exclusively a woman's sport, is now seldom practised, and cycling, golf, tennis, rowing, swimming, and skating have taken its place. Fishing, hunting, and shooting are the pastimes of the well-to-do, but there are many good fisherwomen as well as good shots, and there are some packs of harriers hunted by women. Some are yachtswomen, and sail their own boats; and there are some good whips, as the competitions in team and tandem driving show.

Clubs.

As women of the working classes have their clubs, so, in the other classes, women have found them a great advantage. The majority are for women only, though there are a few for both sexes, but in nearly every club men are admitted as guests. In many of the clubs the subscription is large, but there are also humbler ones which supply a want much felt by women engaged in daily work, such as clerks, journalists, typists, actresses, and those occupied in social and charitable business. Reading, writing, and refreshment rooms are provided, and as many of the ordinary conveniences of a club as may be possible. The foundation of women's clubs was a great innovation, and they were viewed with much suspicion and distrust, but experience has justified their introduction, many of them having several hundred members. The clubs are non-residential, with one or two exceptions. There are a few flats in London for women only, which are let at reduced rents, and are intended for single women who earn their own livelihood, but more accommodation of a like nature is one of the most crying wants of to-day.

Legal position of women.

Modern legislation has also favoured the protection and liberation of women. The Married Women's Property Act dealt a severe blow at the power of men over women, and though it has been beneficial to thousands of working women, it has entirely altered the position of the sexes with regard to each other. The Act affecting the custody and guardianship of children gave women a further independent position, which undoubtedly many hard cases justified. The position of a woman with regard to her children, where a father might be unworthy or bad, was, before the passing of these measures, both unjust and cruel as regarded herself, and often most injurious for her offspring.

General reflections.

The foregoing facts demonstrate how varied and comprehensive the work of women became during the last quarter of the 19th century, and how much it must certainly increase with their higher education and training. In addition to the confidence that experience of their capacity, their perseverance, and the quality of their work has given them, their honest conscientiousness produces results hardly, if at all, inferior. It is the earnest and serious spirit which animates the women who have embraced a professional or independent career, added to their high standard of work, which has laid the woman's movement on such deep foundations, and has justified the position now accorded to them on every side. A less ambitious, a less heartfelt effort would not have sufficed, and the pioneers of the movement have long ago justified their contention that if women were to enter into competition on anything approaching an equality with men, they could only succeed by producing work and results so high as to silence criticism and prove their ability. That their adoption of such careers *quâ* women would always be attacked, they fully realized, and also that their justification would lie in success; but the great persistency with which they have laboured, and carried their position, does not admit of dispute as to their absolute victory over critics and opponents.

One of the most remarkable facts connected with the woman's movement lies in the rapidity of its growth—barely the work of fifty years. Their whole mode of life has been revolutionized in that time, and it is much to their credit that they have borne their new position with such dignity. The moment was opportune. The large mass of unemployed women were seeking not only an outlet for their energy, but a means of making a livelihood. Necessity made them take advantage of the new conditions of life, and they thankfully entered the open door which led to the future they had long hoped for. There is no more creditable page in the history of a great movement than the part played by women in the industrial revolution of the 19th century. Two causes had undoubtedly contributed to bring it about; one, the gradual disappearance of the domestic life which, before the invention of machinery, had made women the producers of all the necessaries of the house: the wife and daughters were the slaves of the household; not only were they the purveyors and makers of food, but they performed all the menial work, and in their spare time spun the wool, and wove and made up the material, which provided their mankind with clothes. The spinning-wheel and the spinning-jenny destroyed the distaff, and the factory took the place of the home worker, and though women still found employment, it was as an occupation, not as a household duty. With the sewing-machine and the cheapening of ready-made clothing, the principal occupation for the women of a household disappeared. The second cause was the demand for a higher standard of education, and the founding of innumerable high schools for girls, which destroyed the only occupation then open to women, namely, that of teaching. The daily governess and the teacher of the small school, insufficiently educated, but knowing enough to impart the rudiments of knowledge, were swept away, and terribly sad are the stories of the suffering and want of the large and helpless class of inferior governesses and teachers.

What was to be the fate and future of women? Their natural career, that of marriage, was impossible to many in a country where there were half a million more women than men, and the difficulties which beset them in their struggle for an outlet and a profession were gigantic. A few women saw the moment, the difficulty, and the way of salvation; and Miss Martineau, Miss Cobbe, Mrs Garrett Anderson, Miss Buss, Miss Florence Nightingale, with others too numerous to mention, demonstrated what women could do, and by their example gave encouragement to others. The woman's movement in America found its echo in England, and the influence of American thought and life on the United Kingdom largely contributed to promote the higher education and the spirit of independence which have enabled women to attain their present position. The facilities of communication, the increasing power of the press, the cheapening of literature, could not fail to produce great changes, especially in a society where so preponderating an element existed of superfluous women. The narrow, dreary existence which custom had assigned to them was no longer possible, and the example of their sisters in America gave a precedent for their encouragement. The standard of work that women have set before them is a high one, and they have not been contented to attain less than their ideal, and it is that which has given the movement its reality and strength; moreover, English women are physically a strong class, and strenuous as has been the battle, they have had that great reserve to fall back upon. By their use of athletics and exercise they have preserved that standard of health without which no one can do really good work. It is too soon yet to judge what the effect of work and the expenditure of energy will be on the coming generation, or whether the mothers of the future will produce the like healthy offspring of their progenitors. One effect is that women of the higher working classes marry less early, and have fewer children; and another result of the emancipation they enjoy, coupled with the fact that they need not depend on marriage as their only career, is a disinclination among many to marry. Among working women the infant mortality is large, owing to the absence of the mothers at their work, and the consequent neglect of the children; and the deterioration in the health of the survivors is undoubted, and cannot be otherwise where they are brought up on unhealthy food, without maternal care, breathing bad air, and living without light and sunshine. Legislation has improved both the lives of the women and the conditions under which they work, with a corresponding improvement in the health of their offspring; but with the higher standard of comfort, the increased expense of living, and the demand for cheaper labour which women's work supplies, it is not possible to prevent their augmenting the family income by taking employment, whether it be healthy or not.

Over the bright future of a gallant struggle and fair fulfilment there looms a cloud, "small as a man's hand," yet one that grows. The demand for women's work, consequent on their successful capture of the field of labour, has flooded Great Britain with educated women, and the supply has become greater than the demand. The prejudice against domestic service also has created a class of half-educated women clerks, bookkeepers, &c., for whom there is little demand; they are unfitted by training for other employment, and the market is full. The best educated women can always command employment, but the majority are not the best, and the warning note of the unemployed women has already been sounded. There is no room in the labour market in England for all the women who are willing and able to work, but there is an outlet and a place where they can do the same work that other women have done for England. In the British colonies women are wanted for all purposes, even the elementary occupation of wife and mother, and emigration must be the solution of the difficulty that is looming over their future.

In reviewing the effects of the last half of the 19th century on the lives of women, it is impossible, in looking to the future, not to ponder on how much further the movement will increase, and what will be the ultimate result. As far as the past is concerned, the effect on the character of women has been beneficial. It has strengthened and elevated them, and in giving them a career has developed the best and highest part of their nature, while it has not unsexed or destroyed any of the qualities which give them their charm and power. The excrescences which inevitably appeared during so rapid and complete a transition have disappeared or become submerged in the wholesome ebb and flow of their life. The influence of religion has still maintained its hold, and the serious spirit in which women undertake their new mission is the outcome of the religious sentiment which pervades their life and which they pour into their work. The consciousness that in elevating themselves they are helping to make their life higher and more useful to others, was the faith mainly which helped them through the opposition, scorn, and hard struggles they underwent; and that religious sentiment still animates them and is in reality the spring from which their efforts flow. Religion is a necessity for women, and if their belief in the dogmatic truths of Christianity has waned, the spirit of humanitarianism, which is the foundation of its teaching, has survived. That feeling will retain its supremacy; and if, in the first youth and exuberance of women's emancipation, they have shown the calm dignity which is the distinctive characteristic of their conduct, there need be no apprehension as to the future, under the softening and mellowing influence of time and custom. (M. J.)

Wood, Ellen [generally known as Mrs Henry Wood] (1814–1887), English novelist, was born at Worcester on 17th January 1814. Her maiden name was Price. In 1836 she was married to Henry Wood, and the next twenty years of her life were passed abroad. Though she had previously contributed short stories to *Bentley's Miscellany* and the *New Monthly Magazine*, her literary career may be said to have begun with her winning (in 1860) a £100 prize offered by the Scottish Temperance League, with a novel entitled *Danesbury House.* About a year afterwards *East Lynne* appeared, and achieved extraordinary popularity. It was widely translated, and a number of dramatic versions of it were made, and proved very much to the taste of unsophisticated lovers of melodrama. In 1865 Mrs Wood started the *Argosy* magazine, which she edited till her death, assisted in her later years by her son, C. W. Wood. In this she wrote anonymously a series of tales, which were afterwards republished under her name as *Johnny Ludlow.* These stories, which contain some of her best work, differ considerably from her longer novels, the majority of which are melodramatic in character. She published in all about thirty-five novels, some of the most popular (besides those mentioned above) being *The Channings* (1862), *The Shadow of Ashlydyat* (1863), *Roland Yorke* (1869), *Within the Maze* (1872), *Edina* (1876). She died in London on 10th February 1887. Her husband predeceased her in 1866.

Wood, John George (1827–1889), English writer and lecturer on natural history, was born in London on 21st July 1827. He was educated at Ashbourne grammar school and at Merton College, Oxford; and after he had taken his degree in 1848 he worked for two years in the anatomical museum at Christ Church under Sir Henry Acland. In 1852 he was ordained a deacon of the Church of England, became curate of the parish of St Thomas the Martyr, Oxford, and also took up the post of chaplain to the Boatmen's Floating Chapel at Oxford. He was ordained priest in 1854, and in that year gave up his curacy to devote himself for a time to literary work. In 1858 he accepted a readership at Christ Church, Newgate Street, and he was assistant-chaplain to St Bartholomew's Hospital, London, from 1856 until 1862. Between 1868 and 1876 he held the office of precentor to the Canterbury Diocesan Choral Union. After 1876 he devoted himself to the production of books and to delivering in all parts of the country lectures on zoology, which he illustrated by drawing on a blackboard or on large sheets of white paper with coloured crayons. These "sketch lectures," as he called them, were very popular, and made his name widely known both in Great Britain and in the United States. In 1883–84 he delivered the Cornell lectures at Boston. Wood was for a time editor of the *Boy's Own Magazine*, to which he constantly contributed papers on natural history. His most important work was a *Natural History* in three volumes, but he was better known by the series of books which began with *Common Objects of the Sea-Shore*, and which included popular monographs on shells, moths, beetles, the microscope, and *Common Objects of the Country. Our Garden Friends and Foes* was another book which found hosts of appreciative readers. He wrote in a pleasant style, and as much as possible avoided technicalities; and many who would never have taken up the study of animal life at the instance of more scientific writers, owed to Wood a lifelong interest in beasts and birds and insects. He compiled also a number of educational works connected both with his special subjects and with Old Testament and New Testament history. He died at Coventry on 3rd March 1889. (H. H. F.)

Wood Engraving. See Engraving.

Woodstock, a municipal borough and market town in the Woodstock parliamentary division of Oxfordshire, England, 8 miles north-north-west of Oxford by rail. The town hall is now also used as a public library. The manufacture of gloves has somewhat decayed. As constituted since 1886, the borough includes the old borough with parts of two adjacent parishes. Area, 157 acres; population (1881), 1649; (1891), 1628. Half a mile distant is the parish of Blenheim Park, which takes its name from the seat of the duke of Marlborough.

Woodstock, a town and port of entry of Oxford county, Ontario, Canada, 30 miles east-north-east of London by rail, on the Thames river, and the Grand Trunk and Canadian Pacific railways. It is in one of the best agricultural sections of the province, and has a large export trade in cheese, butter, and farm produce. It contains a college, affiliated with McMaster University, Toronto, court-house, town hall, hospital, and reformatory, and manufactories of musical instruments, furniture, waggons, and stoves. Population (1891), 8612; (1901), 8833.

Woolner, Thomas (1825–1892), English sculptor and poet, was born at Hadleigh, Suffolk, 17th December 1825. He went to school at Ipswich, and later in London. When quite a boy he distinguished himself to such a degree by modelling in clay and carving marble, that when barely thirteen years old he was taken as an assistant, without a premium, into the studio of William Behnes, and trained with exceptional care by that accomplished executant and stringent teacher during nearly six years, so that he became a master of the technique of his art. In December 1842 Woolner was admitted a student in the Royal Academy, and in 1843, amid the applause of his fellow artists, contributed to the Exhibition there "Eleanor sucking poison from the wound of Prince Edward," and again at the British Institution in the following year. Continuing his studies with unabated zeal, Woolner did not at first meet with the rewards his genius, industry, and extraordinary skill deserved. When English art was, in 1844, stirred to its depths by the competitions for decorating the Houses of Parliament, Woolner was represented by a life-size group of "The Death of Boadicea," which was so excellent that it did not suffer from the juxtaposition of Foley's beautiful "Youth at a Stream." Hard work and small gains did not discourage the artist. In 1846 he had at the Royal Academy a graceful recumbent figure of Shelley's dreamy "Alastor." All this while he was working on and off for Behnes. Then came (1847) "Feeding the Hungry," a bas-relief, at the Academy; and at the British Institution a brilliant and animated statuette of "Puck" perched upon a toadstool and with his toe rousing a frog which had couched beneath. "Eros and Euphrosyne" and an elegant figure of "The Rainbow" were seen at the Academy in 1848.

Woolner, who, like all the leading members of the circle to which he belonged, had lofty ideas of the nature and functions of art, spiritual, inventive, and technical, became, in the autumn of 1848, one of the seven Pre-Raphaelite Brethren who formed themselves into a society in order to carry their views into effect by means of their works. These students, of whom the sculptor was the oldest, found what may be called their point of crystallization at a meeting of Rossetti, Holman Hunt, and Millais in the studio of the last. Here was formulated the pregnant idea of a brotherhood to which Woolner and two other artists immediately acceded, with Mr W. M. Rossetti as a lay secretary. There was no propaganda nor any conversion whatever. Each man had his own views before the union, and maintained them thereafter. Without this it was impossible that Woolner or his companions could have been included; nor had Pre-Raphaelitism any effect upon his art, which, unlike that of some of the Brethren, was already Pre-Raphaelite of the higher strain. In this capacity the sculptor took a leading part in *The Germ*, 1850, the opening poem in which, called "My Beautiful Lady," was by him. He had already modelled and exhibited portraits of Carlyle, Browning, and Tennyson. Unable to make his way in art as he wished, Woolner in 1852 tried his luck as a gold-digger in Australia, when the "gold fever" was at its height. Failing in this, he returned to England in 1857, where during his absence his reputation had been increased by means of a statue of "Love" as a damsel lost in a day-dream. Then came his second portraits of Carlyle, Tennyson, and Browning, a pulpit for Llandaff Cathedral, the memorial portrait of Wordsworth in Grasmere church, the likenesses of Sir Thomas Fairbairn, Rajah Brooke of Sarawak, Mrs Tennyson, Sir W. Hooker, and Sir F. Palgrave. The fine statue of Bacon in the New Museum at Oxford was succeeded by very important public commissions, which proved how rapidly the sculptor's powers were vindicating themselves. The examples included full-size statues of Prince Albert for Oxford, Macaulay for Cambridge, William III. for the Houses of Parliament, London, and Sir Bartle Frere for Bombay; busts of Tennyson, for Trinity College, Cambridge, Dr Whewell, and Archdeacon Hare; statues of Lord Lawrence for Calcutta, Queen Victoria for Birmingham, Field for the Law Courts, London, Palmerston for Palace Yard, the noble colossal standing figure of Captain Cook that overlooks the harbour of Sydney, New South Wales, which is Woolner's masterpiece in that class; the recumbent effigy of Lord F. Cavendish (murdered in Dublin) in Cartmel church, the seated Lord Chief Justice Whiteside for the Four Courts, Dublin, and John Stuart Mill for the Thames Embankment, London; Landseer, and Bishop Jackson for St Paul's, Bishop Fraser for Manchester, and Sir Stamford Raffles for Singapore. Among Woolner's busts are those of Newman, Darwin, Sedgwick, Huxley, Cobden, Professor Lushington, Dickens, Kingsley, and Sir William Gull, besides the repetition, with variations, of Gladstone for the Bodleian, Oxford, and Mansion House, London, and Tennyson. The last has since been acquired for Adelaide, South Australia.

Woolner's poetic and imaginative sculptures include "Elaine with the Shield of Lancelot," three fine panels for the pedestal of the Gladstone bust at Cambridge, the noble and original "Moses" which is on the apex of the gable of the Manchester Assize Courts, and two other works in the same building; "Ophelia," a statue, 1869; "In Memoriam"; "Virgilia sees in a vision Coriolanus routing the Volsces"; "Guinevere"; "Mercury teaching a shepherd to sing," for the Royal College of Music; "Ophelia," a bust, 1878; "Godiva," and "The Water Lily." In these, as in his portraits, it was Woolner's ambition to embody something of Pheidian dignity, simplicity, and naturalness, with exhaustive representation of detail, sculpturesque repose, and exquisite rendering of flesh. He was elected an Associate of the Royal Academy in 1871, and a full member in 1875 in place of Foley, deceased. Apart from his art, Woolner wrote and published two amended versions of "My Beautiful Lady" from *The Germ*, as well as the poems "Silenus," "Tiresias," and "Nelly Dale." Having been elected professor of sculpture in the Royal Academy, he began to prepare lectures in that capacity, but he did not deliver them; he resigned the office in 1879. Woolner died somewhat suddenly, 7th October 1892, and was buried at Hendon. (F. G. S.)

Woolsey, Theodore Dwight (1801–1889), American author, was born in New York, 31st October 1801. He graduated at Yale in 1820; studied in Europe for three years; was professor of Greek in Yale from 1831 to 1846; and was president of the college (also holding the Greek chair for a few years) from 1846 to his resignation in 1871, after which date he continued for some time to act as a lecturer on international law. He edited for college use some of the works of Euripides, Sophocles, Æschylus, and Plato. In his later years he made a thorough study of international law, on which he prepared a treatise (1860) which was subsequently revised and enlarged in successive editions, and was widely used as a college text-book and diplomatic authority; and he published in 1877 *Political Science; or, The State Theoretically and Practically Considered* (2 vols.), and in 1880 a discussion of *Communism and Socialism.* He also contributed voluminously to the scholarly periodicals of his time, on philological, theological, sociological, and governmental subjects, and was chairman of the American company of revisers of the New Testament, 1871–81. The most noteworthy fact in his work at Yale was that, while his tastes and labours were largely those of a classical scholar, his writings and influence strongly tended to give Yale the prominence in political and social science which it has since retained. He died in New Haven, 1st July 1889.

Woolwich, a metropolitan borough and garrison town, and the principal artillery arsenal of England, in the county of London, 10 miles from Charing Cross by rail and 12 by river; a parish in the ancient county of Kent. The borough includes Eltham, Plumstead, and Woolwich, and occupies 13 square miles. In area it holds the second place among the metropolitan boroughs, and is more than twenty times as big as the smallest borough, which is Holborn. Woolwich Common is partly in the borough of Greenwich and partly in that of Woolwich. Population (1891), 98,994; (1901), 117,178. North Woolwich was locally within the county of Essex before it was included in the county of London. The North Woolwich Gardens were formerly somewhat notorious, but are now under the control of the London County Council, and are open to the public under the name of the "Royal Victoria Gardens, North Woolwich" (10 acres).

Woonsocket, a city of Providence county, Rhode Island, U.S.A., on the river Blackstone, and the New York, New Haven, and Hartford and the New England railways, in the northern part of the state, at an altitude of 162 feet. It is irregularly laid out, being a consolidation of several villages, is divided into five wards, has an ample water-supply and good sewerage system. In 1900 it contained 242 manufacturing establishments, with a total capital of $14,279,361. They employed 8093 hands, and their product had a value of

$15,627,539. Of this $2,389,586 consisted of cotton goods, and $3,559,507 of woollen and worsted goods. Woonsocket received a city charter in 1888. Population (1890), 20,830; (1900), 28,204, of whom 12,518 were foreign-born.

Wooster, a city of Ohio, U.S.A., capital of Wayne county, north-east of the centre of the state, at the intersection of the Baltimore and Ohio and the Pennsylvania railways, at an altitude of 900 feet. It is in a rich farming region, for which it serves as a market-place, and it has varied manufactures. It is the seat of Wooster University, a co-educational Presbyterian institution opened in 1870. In 1899 this had a faculty of 23 and was attended by 548 students, including 169 women. The city is one of the oldest in the state, having been founded in 1808. Population (1880), 5880; (1890), 5901; (1900), 6063, of whom 407 were foreign-born.

Worcester, a midland county of England, bounded on the N. by Stafford, on the E. by Warwick, on the S. by Gloucester, on the W. by Hereford, and on the N.W. by Shropshire; but several parishes of the ancient county are detached from the main portion.

Area and Population.—The area of the ancient county is 480,500 acres, or 751 square miles, with a population in 1881 of 380,283, in 1891 of 413,760, of whom 197,867 were males and 215,893 females; and in 1901 of 488,401, the number of persons per square mile being 650, and of acres to a person 0·98. The area of the administrative county in 1891 was 473,542 acres, with a population of 296,661, or, including the county boroughs of Dudley and Worcester, 480,342 acres, with a population of 385,309. Since 1891 certain changes have, however, been made in the administrative area: in 1893 a small portion was transferred to Hereford; in 1895 the parish of Dowles in Shropshire and the parish of Upper Arley in Stafford were transferred to Worcester; in 1896 the parish of Oldberrow in Worcester was transferred to Warwick; and in 1897 the parishes of Acton Beauchamp and Mathon Rural were transferred from Worcester to Hereford, and part of the parish of Cradley and the parish of Stoke Bliss from Hereford to Worcester. The area of the registration county in 1891 was 441,510 acres, with a population of 422,530, of whom 242,384 were urban and 180,146 rural; and in 1901 of 500,792, of whom 237,229 were males and 263,563 were females. Within the registration area the percentage of increase between 1881 and 1891 was 10·31 per cent., and between 1891 and 1901, 15·6 per cent. The excess of births over deaths between 1881 and 1891 was 56,071, and the increase in the resident population was 39,497. The following table gives the numbers of marriages, births, and deaths, with the number of illegitimate births, for 1880, 1890, and 1898:—

Year.	Marriages.	Births.	Deaths.	Illegitimate Births.	
				Males.	Females.
1880	2539	12,399	6494	317	319
1890	3067	12,129	7293	269	265
1898	3696	13,707	7539	270	260

The number of marriages in 1899 was 3860, of births 14,027, and of deaths 7674. The following table gives the marriage-, birth-, and death-rates per thousand of the population, with the percentage of illegitimate births, for a series of years:—

	1870–79.	1880.	1880–89.	1890.	1888–97	1898.
Marriage-rate .	15·1	13·3	13·8	14·6	14·6	16·4
Birth-rate . .	34·4	32·6	31·4	28·9	29·6	30·3
Death-rate . .	19·3	17·1	17·1	17·4	16·7	16·7
Percentage of illegitimacy . .	5·3	5·1	4·9	4·4	4·3	3·9

In 1891 there were in the county 1410 natives of Scotland, 1797 natives of Ireland, and 672 foreigners.

Constitution and Government.—There are six municipal boroughs: Bewdley (2866), Droitwich (4163), Dudley (48,809), Evesham (7101), Kidderminster (24,692), and Worcester (46,623). Dudley and Worcester are county boroughs. The urban districts are: Bromsgrove (8416), King's Norton and Northfield (57,120), Lye and Wollescote (10,972), Malvern (16,448), North Bromsgrove (5687), Oldbury (25,191), Redditch (13,493), Stourbridge (16,302), and Stourport (4529). The ancient county, which is mostly in the diocese of Worcester, with a few parishes in that of Hereford, contains 217 entire ecclesiastical parishes or districts, with parts of 12 others.

Education.—At Dudley there is a board deaf school. The total number of elementary schools on 31st August 1898 was 313, of which 62 were board and 251 voluntary schools, the latter including 215 National Church of England schools, 4 Wesleyan, 14 Roman Catholic, and 18 "British and other." The average attendance at board schools was 18,601, and at voluntary schools 46,440. The total school board receipts for the year ended 29th September 1898 were over £90,121. The income under the Technical Instruction Act was £55, and that under the Agricultural Rates Act was £1818.

Agriculture.—About five-sixths of the total area of the county is under cultivation, and of this about five-eighths is in permanent pasture. There are also over 21,000 acres under orchards—the county ranking in this respect fifth among English counties—and over 19,000 under woods. Since 1880 the acreage under corn crops has diminished by about one-fifth, the main diminution being in the wheat acreage, which still, however, amounts to about two-fifths of the whole, oats coming next with about one-fifth, while there are considerable acreages under barley, beans, and peas. Turnips are grown on only about one-third of the green crop acreage, and potatoes on about one-fourth. About 4000 acres are usually under hops, and over 3000 acres under small fruit. In the neighbourhood of Worcester there are large nurseries. The following table gives the larger main divisions of the cultivated area at intervals from 1885:—

Year.	Total Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885	402,845	95,234	33,518	34,482	223,527	13,174
1890	405,839	91,142	30,454	28,661	240,694	10,191
1895	404,103	77,997	31,189	30,386	248,248	9,104
1900	406,254	78,710	28,757	28,316	252,005	5,048

The following table gives particulars regarding the principal live-stock for the same years:—

Year.	Total Horses.	Total Cattle.	Cows or Heifers in Milk or in Calf.	Sheep.	Pigs.
1885	19,871	72,461	29,067	183,442	41,402
1890	19,925	64,956	26,206	179,794	44,785
1895	21,486	60,319	24,613	164,909	51,007
1900	21,008	69,057	26,458	170,617	39,794

Manufactures and Minerals.—According to the report for 1898 of the chief inspector of factories (1900), the total number of persons employed in factories and workshops in 1897 was 55,972, as compared with 54,457 in 1896. Of these 7070 were employed in textile factories, woollen industries employing 6744. Non-textile industries employed 40,551, there being an increase between 1895 and 1896 of 10 per cent., and between 1896 and 1897 of 2·2 per cent. As many as 15,014 were employed in the manufacture of machines, appliances, conveyances, and tools (including engines and iron bridges at Dudley; iron tanks, iron and chain cables, &c., at Netherton; agricultural implements and other machines at Worcester; and needles, fish-hooks, &c., at Redditch); 5692 in the founding and conversion, galvanizing, finishing, and extracting of metals; 3849 in food industries; 2589 in furniture-making; 2636 in clothing industries; 1840 in clay and stone industries (including china ware, &c.); 1468 in the manufacture of chemicals; and 1015 in paper-making, &c. The total number employed in workshops was 8351, of whom 2727 were employed in clothing industries, 2677 in the manufacture of machines, &c. The total number of persons employed in connexion with mines and quarries in 1899 was 3182. In the same year 718,959 tons of clays were raised, 49,021 tons of limestone, 67,868 tons of sandstone, 20,351 tons of gravel and sand, and 16,045 tons of igneous rocks. Salt is produced wholly from brine. Pig iron to the amount of 67,639 tons was made in 1885, and of 37,343 tons in 1890. In later years the returns are bracketed with those of Wilts, the total pig iron of the combined counties amounting in 1899 to 76,547 tons, of which probably about five-sixths was made in Worcestershire. There are six blast-furnaces, all in the neighbourhood of Dudley. The following table gives the tonnage and value of the more valuable minerals in 1890 and 1899:—

Year.	Fire-clay.		Coal.		Iron Ore.		Salt.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
		£		£		£		£
1890	97,540	26,011	923,581	296,300	12,228	6114	267,848	120,306
1899	112,019	31,075	842,951	263,422	3,881	1594	171,562	77,364

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Worcester, a municipal, parliamentary, and county (1888) borough, episcopal city, county in itself, and county town of Worcestershire, England, on the Severn—here crossed by a stone bridge of five arches and an iron railway bridge of two spans—120 miles by rail west-north-west of London. In 1885 the municipal borough became coextensive with the parliamentary. A Victoria Institute, including a library, museum, and art gallery, has been erected, and there are a cathedral school, choir school, a free grammar school, municipal art, science, and technical schools, and a large recreation ground. The Royal Porcelain Works cover 5 acres. Railway signal works and iron foundries have been added to the industries. Some progress has been made in deepening the river, and further improvements are contemplated. There are two daily newspapers. At Worcester, alternately with Hereford and Gloucester, is held the festival of the "Three Choirs." Area, 3185 acres. Population (1891), 42,908; (1901), 46,623.

Worcester, a town of Cape Colony, near the sources of the river Breede, north by east of Cape Town, with which it is connected by rail. It stands 2000 feet above sea-level, in one of the most extensive wine-growing districts of the colony, and is a busy agricultural centre with a population which rose from 4000 in 1887 to 5400 in 1891. In the neighbourhood is a copious thermal spring credited with valuable medicinal properties.

Worcester, a city of Massachusetts, U.S.A., capital of Worcester county. It includes an area of 32 square miles of hill country, dotted with lakes and ponds, and is situated near the centre of the state. The urban, closely-built portion comprises but a small part of the area of the city. It is irregular in plan, is divided into eight wards, has excellent water-supply and sewerage systems, and its business streets are paved with granite blocks, the residence streets macadamized or gravelled. Its altitude is 475 feet at the Union central railway station. Worcester contains several institutions for advanced education, among them Clark University, a non-sectarian institution, opened in 1889 for graduate study, which in 1898 had a faculty of 11 and was attended by 44 students. There is also the College of the Holy Cross, a Roman Catholic institution opened in 1843, which in 1898 had a faculty of 25 and an attendance of 341 students. The Worcester Polytechnic Institute, which was opened in 1868, had in 1898 a faculty numbering 30 and an attendance of 216. Worcester is a railway centre of much importance, four companies having lines which enter the Union station; these are the Boston and Albany, the Boston and Maine, the Fitchburg (also of the Boston and Maine), and the New York, New Haven, and Hartford railways. It is, however, chiefly as a manufacturing city that Worcester is prominent. In 1900 it had 1071 manufacturing establishments, with a total capital of $42,966,743. They employed 25,593 hands, and the products were valued at $53,348,783. These were in great variety, the principal being the following: foundry and machine-shop products, value $8,492,686; boots and shoes, $1,610,605; woollen goods, $1,531,047; wire-work, $1,531,047. Envelopes, musical instruments, clothing, firearms, food preparations, marble and stone work, leather and cotton goods were also produced in large quantities. The assessed valuation of real and personal property in 1900 was $112,043,973, the net debt of the city was $5,676,237, and the rate of taxation was $16.40 per $1000. The total income, exclusive of loans, was $3,205,458, and the expenditure for maintenance and operation was $2,516,118. Population (1890), 84,655; (1900), 118,421, of whom 37,652 were foreign-born and 1215 coloured, including 1104 negroes.

Wordsworth, Dorothy (1771–1855), diarist, was the third child and only daughter of John Wordsworth of Cockermouth, and his wife, Anne Cookson-Crackenthorpe. The poet William Wordsworth was her brother and a year her senior. On the death of her father in 1783, Dorothy found a home at Penrith, in the house of her maternal grandfather, and afterwards for a time with a maiden lady at Halifax. In 1787, on the death of the elder William Cookson, she was adopted by her uncle, and lived in his Norfolk parish of Forncett. She and her brother William, who dedicated to his sister the *Evening Walk* of 1792, were early drawn to one another, and in 1794 they visited the Lakes together. They determined that it would be best to combine their small capitals, and that Dorothy should keep house for the poet. From this time forth her life ran on lines closely parallel to those of her great brother, whose companion she continued to be till his death. It is thought that they made the acquaintance of Coleridge in 1797.

From the autumn of 1795 to July 1797 William and Dorothy Wordsworth took up their abode at Racedown, in Dorsetshire. At the latter date they moved to a large manor-house, Alfoxden, in the northern slope of the Quantock hills, in West Somerset, S. T. Coleridge about the same time settling near by in the town of Nether Stowey. On the 20th of January 1798 Dorothy Wordsworth began her invaluable *Journal*, used by successive biographers of her brother, but first printed in its quasi-entirety by Professor W. Knight in 1897. The Wordsworths, Coleridge, and Chester left England for Germany on the 14th of September 1798; and of this journey also Dorothy Wordsworth preserved an account, portions of which were published in 1897. On the 14th of May 1800 she started another *Journal* at Grasmere, which she kept very fully until the 31st of December of the same year. She resumed it on the 1st of January 1802 for another twelve months, closing on the 11th of January 1803. These were printed first in 1889. She composed *Recollections of a Tour made in Scotland*, in 1803, with her brother and Coleridge; this was first published in 1874. Her next contribution to the family history was her *Journal of a Mountain Ramble*, in November 1805, an account of a walking tour in the Lake district with her brother. In July 1820 the Wordsworths made a tour on the continent of Europe, of which Dorothy preserved a very copious and careful record, portions of which were given to the world in 1884, the writer having refused to publish it in 1824 on the ground that her "object was not to make a book, but to leave to her niece a neatly-penned memorial of those few interesting months of our lives." Meanwhile, without her brother, but in the company of Joanna Hutchinson, Dorothy Wordsworth had travelled over Scotland in 1822, and had composed a *Journal* of that tour. Other MSS. exist and have been examined carefully by the editors and biographers of the poets, but the records which we have mentioned and her letters form the principal literary relics of Dorothy Wordsworth. In 1829 she was attacked by very serious illness, and was never again in good health. After 1836 she could not be considered to be in possession of her mental faculties, and became a pathetic member of the interesting household at Grasmere. She outlived the poet, however, by several years, dying at Grasmere on the 25th of January 1855. Her life, by Mr E. Lee, appeared in 1886.

It would be difficult to exaggerate the importance of Dorothy Wordsworth's companionship to her illustrious brother. He has left numerous tributes to it, and to the sympathetic originality of her perceptions. "She," he said,

> "gave me eyes, she gave me ears ;
> And humble cares, and delicate fears ;
> A heart the fountain of sweet tears ;
> And love, and thought, and joy."

The value of the records preserved by Dorothy Wordsworth, especially in earlier years, is hardly to be overestimated by those who desire to form an exact impression of the revival of English poetry. When Wordsworth and Coleridge refashioned imaginative literature at the close of the 18th century, they were daily and hourly accompanied by a feminine presence exquisitely attuned to sympathize with their efforts, and by an intelligence which was able and anxious to move in step with theirs. "S. T. C. and my beloved sister," William Wordsworth wrote in 1832, "are the two beings to whom my intellect is most indebted." In her attitude to nature, in the quickness of her eye, in the alertness of her observation, in her ductility to new impressions, Dorothy Wordsworth is revealed in her marvellous *Journals* as keeping on a level with and even pushing sometimes ahead of the great authors of the *Lyrical Ballads.* In her pages we can put our finger on the very pulse of the machine; we are present while the New Poetry is evolved, and the sensitive descriptions in her prose lack nothing but the accomplishment of verse. Moreover, it is certain that the sharpness and fineness of Dorothy's observation, "the shooting lights of her wild eyes," actually afforded material to the poets. Coleridge, for instance, when he wrote his famous lines about "The one red leaf, the last of its clan," used almost the very words in which, on the 7th of March 1798, Dorothy Wordsworth had recorded "One only leaf upon the top of a tree . . . danced round and round like a rag blown by the wind."

It is not merely by the biographical value of her notes that Dorothy Wordsworth lives. She claims an independent place in the history of English prose as one of the very earliest writers who noted, in language delicately chosen, and with no other object than to preserve their fugitive beauty, the little picturesque phenomena of homely country life. When we speak with very high praise of her art in this direction, it is only fair to add that it is called forth almost entirely by what she wrote between 1798 and 1803, for a decline similar to that which fell upon her brother's poetry early invaded her prose; and her later journals, like her *Letters*, are less interesting because less inspired. It is only since 1897, when Professor Knight collected and edited her scattered MSS., that Dorothy Wordsworth has taken her independent place in literary history. (E. G.)

Workington, a municipal borough, market and seaport town, in the Cockermouth parliamentary division of Cumberland, England, 34 miles south-west of Carlisle by rail, at the mouth of the river Derwent. A cycle and motor-carriage factory has been introduced. In 1898, 129,584 tons of coal were shipped coastwise from this port. Since 1892 it has been subordinate to the port of Maryport. The municipal borough incorporated in 1888 did not include the whole area of the previously-existing urban district. Population (1891), 23,836; (1901), 26,141.

Worksop, a market town, urban district, and parish, in the Bassetlaw parliamentary division of Nottinghamshire, England, 16 miles east-south-east of Sheffield by rail. The mechanics' institute was converted in 1896 into a free public library. A new cemetery of 15 acres has been opened. There is a considerable trade in Windsor chairs and wood for packing-cases for Sheffield cutlery. Population (1891), 12,734; (1901), 16,112.

Worm.—This article deals with the true worms or Chætopoda, and is divided into two sections, the first treating of the Oligochæta, land and fresh-water forms, the second of the Polychæta, marine forms. Some other animals popularly known as worms are discussed under the articles NEMATODA, NEMERTINI, PLANARIANS.

I. OLIGOCHÆTA.

In this section the principal advances in our knowledge of the Oligochæta since the publication of the article WORM in the ninth edition of this Encyclopædia will be dealt with under the heads of structure, classification, and distribution.

Structure.

Respiratory Organs.—Cuvier's definition of the Oligochæta as "Annélides abranches sétigères" no longer holds good. The finger-like processes arranged round the anus of *Dero* have been long known, but the retractile gills upon the hinder end of the largely aquatic genus *Alma* (=*Siphonogaster* and *Digitibranchus*), though correctly described by Levinsen, were generally regarded as pertaining to some Polychæt worm until the existence of these gills (though in one only of the three or four species of the genus) was proved by Michaelsen. Several aquatic Oligochæta belonging to Claparède's group Limicolæ are also provided with gills. Bourne found in a Naid, *Chætobranchus*, a series of paired and lateral processes of the body, containing an extension of the cœlom, and provided with capillary loops; these are situated on the anterior part of the body, and many of the gills lodge also the long setæ of the worm. Others are free from the setæ. *Branchiura* is a genus of unknown habitat (found in the *Victoria regia* tank at the Botanical Society's gardens in London) which belongs to the family Tubificidæ. This genus, discovered by Beddard, is provided at the tail end of the body with dorsal and ventral simple gills, containing a prolongation of the cœlom and supplied with blood-vessels. A somewhat similar form, *Hesperodrilus branchiatus*, was described by the same author from South America, but in it the quite similar gills are lateral in position. The last-mentioned instance recalls *Alma*, for only one out of the four species of the genus is gilled. Since the Tubificids breathe chiefly at the tail end of the body, which is thrust out of the mud in which they live, the differentiation of gills in this region is intelligible.

Cœlom.—In all Oligochæta the cœlom consists of a series of chambers divided from each other by transverse partitions, which correspond with the external metamerism. Only at the head end is this arrangement confused by the degeneration of the septa into more irregular masses of muscles. In certain earthworms the cœlom is further subdivided. In *Deinodrilus* the dorsal vessels (there are two dorsal vessels in this genus, in *Octochætus*, and in some others, a state of affairs which is a retention of an embryonic condition) are entirely enclosed within a sac; this seems to be clearly a part of the cœlom, which is thus differentiated into a "pericardium." The same cœlomic sac envelops the dorsal vessel of *Megascolides*, and in other worms other vessels may be thus contained in separate cœlomic spaces. The gills of *Branchiura* are shut off from the general cœlom by septa (Fig. 1); and in the same worm and in *Libyodrilus* there are lateral cavities shut off from the rest of the cœlom which are comparable to similar spaces in the Capitellidæ. Investigations into the structure of the cœlom will be further dealt with in the section devoted to the organs of reproduction.

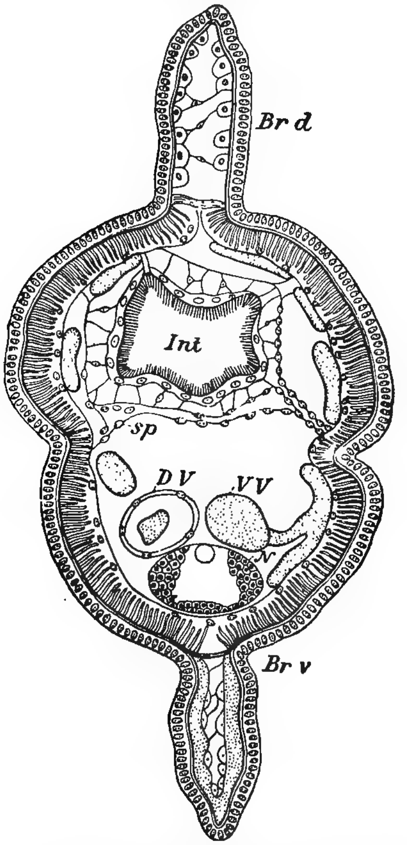

FIG. 1.—Cross-section through *Branchiura*.—*Br d* and *Br v*, dorsal and ventral branchiæ; *Int*, intestine; *sp*, septum dividing cœlom; *DV*, dorsal blood-vessel; *VV*, ventral blood-vessel; *N*, nerve cord.

Nephridia.—It has been known since the year 1885 that among the Megascolicidæ the typical paired nephridia of the Oligochæta were often replaced by more numerous nephridia in a single segment. There are many details which require further investigation; but it has been ascertained that in such genera as *Pheretima* (=*Perichæta*), *Octochætus*, *Benhamia*, &c., there are exceedingly numerous nephridiopores upon each segment to which correspond as many micronephridia, as they have been termed. These micronephridia may, or apparently may not, be provided with cœlomic funnels. It is disputed whether they are connected with each other in the same segment or in consecutive segments, or whether each nephridium is entirely separate from its neighbours. In any case it has been shown (in *Octochætus*, *Pheretima*, and *Megascolides*) that the "plectonephric" or "micronephric" condition is preceded by a pair of nephridia in each segment which ultimately break up into many; since the many nephridia thus produced are in connexion for a time before they break loose, the persistence of the connexion in the adult of *Pheretima* which has been asserted becomes of less importance. This discovery does away with the difficulty which was at one time felt—and embodied in a classification—which divorced such manifestly related forms as *Perionyx* and *Megascolex*, since the former had paired nephridia and the latter a complex of many micronephridia. These micronephridia may become connected with the gut at the posterior end as well as the anterior, where the existence of salivary glands which are undoubtedly nephridia has been long known. In *Octochætus* not only is there a nephridium opening into the buccal cavity, but numerous tubes open into the intestine in the last few segments of the body, an arrangement which recalls the "respiratory trees" of certain Echiuroidea. A highly remarkable modification of the nephridial system is to be seen in certain Eudrilidæ. It was first discovered by Beddard in *Libyodrilus*, but occurs in other genera of that family. The nephridia are paired structures, a pair to each segment, as usual, but the body-wall is pervaded by a system of branching and anastomosing tubes, which open on to the exterior by numerous pores, and are formed out of the terminal portion of the nephridium, not out of the excretory tubules themselves.

Alimentary Canal.—The principal fresh discoveries with regard to the gut of Oligochæta relate to the calciferous glands. These glands may be absent; if present, there are from one to six pairs appended to the œsophagus. They are not simple diverticula, but the interior is complicated by an abundant folding of the lining membrane. Among the lower aquatic families these glands are not present except in the Enchytræidæ, which are possibly to be looked upon as simplified members of the higher earthworms. These glands are differentiated in some of the Eudrilidæ into two series. In *Polytoreutus*, for example, and in other allied genera there are a pair of calciferous glands, usually in the thirteenth segment, and in addition to these a single unpaired ventral gland of the same structure in each of segments ix, x, xi. The latter have been distinguished by Michaelsen under the name of "chylus-taschen," but their minute structure is so similar that it is hard to believe in a difference of function. Moreover, it has been shown that both kinds of glands secrete similar crystals. In any case, the calciferous glands do undergo a remarkable modification in some other genera of Eudrilidæ. In *Stuhlmannia*, for example, there are six pairs of glands appended to the œsophagus which appear from their position and relations to be the equivalents of these glands. Their structure, however, is different. There is a short lumen opening into the œsophagus and lined with an unfolded layer of epithelium. This is surrounded by a mass of cells permeated everywhere by blood-vessels, which pursue a devious course through the gland. Along the edges of the vessel the granular cells become arranged in a regular fashion suggestive of the cells lining the lumen of a gland; but here the lumen is a blood-vessel. This mass of cells presents no resemblance to the cells lining the short lumen of the gland connected with the œsophagus, which latter is, moreover, less developed in some genera than in others. They are more like chloragogen cells. But in any case, *i.e.*, whatever the origin of these glands, it seems clear that their function differs from that of the "normal" calciferous glands of Oligochæta, and the large blood-vessel with its coating of modified cells suggests that they have acquired some function connected with the blood. Their communication with the gut by a much shrunken epithelium-lined duct leads to the belief that they are in reality modified calciferous glands.

Reproductive Organs.—It has been shown that in all Eudrilidæ which have been studied with sufficient minuteness, except *Nemertodrilus*, the ovaries are not freely dependent into the general body cavity as they are in all other Oligochæta. They occupy the usual position, *i.e.*, on the anterior wall of segment xiii, but are invested by a sac which communicates with a system of large sacs which perform in most cases the office of spermathecæ. There is thus brought about a direct communication between ovary and oviduct, a state of affairs comparable to that obtaining in the male organs of the bulk of earthworms, where the testes are similarly enclosed in seminal sacs, into the interior of which open the sperm-duct funnels. In spite of the system of often very spacious sacs which communicate with the space surrounding the ovary, these worms also possess egg sacs (*receptacula ovorum*) of the ordinary terricolous pattern. Into these latter, moreover, open the oviducts, which are perfectly normal, and presumably serve as the conduit for the eggs to the exterior, though the eggs might pass out through the large sacs already spoken of. The arrangement and degree of complication of these sacs vary considerably. This complex female apparatus is either single or double; in the former case the orifices of the oviducts remain as the normal two, but the sacs into which the ovarian chamber open reach the exterior by a single pore. This aperture is placed in front of or behind that of the male ducts. The sac which directly communicates with the exterior seems to perform the office of a spermatheca. In many genera of Eudrilidæ, such as *Polytoreutus*, there is no other spermatheca. An interesting series of transitions exists between those cœlomic spermathecal sacs and spermathecæ of the usual pattern. In *Heliodrilus* (Fig. 3) there is a long, single, and median spermatheca, which opens on to the exterior in the middle line of segment xi. At the opposite extremity it ends blindly, but the extremity dips into the system of cœlomic sacs connected with the ovarian chamber. In *Hyperiodrilus* (Fig. 2) there is also a single median spermatheca, which is precisely of the same structure as in *Heliodrilus*, but much smaller; its distal blind extremity is also concealed within the interior of the cœlomic sac. In both these cases the ova can only leave the body through the oviducts. It is plain, too, that the sperm cannot reach the interior of the large sacs which involve the end of the spermatheca, unless indeed it enters by the oviducts. In other genera of Eudrilidæ blindly-ending spermathecæ have entirely vanished, and the large median sac or sacs open directly on to the exterior by a pore or pores, which may be either near to the position of the ovaries or far away from them. The median sac, in the case of *Libyodrilus*, has been shown to contain sperm. There is thus clearly a formation of a new kind of spermatheca, which first involves and then entirely replaces the type of spermatheca possessed by *Heliodrilus*, and which is like that of other earthworms in structure, and in position especially recalls the spermathecæ of the Geoscolicidæ. The large sacs have been shown by Rosa and Beddard to be in reality sacs developed out of the septa and enclosing a space that is a part of the cœlom. Perhaps the actual orifice, or rather its walls, are in these forms the last vestiges of true spermathecæ like those of other Oligochæta. The substitution of a spermatheca morphologically quite different for the existing Oligochætous spermatheca is quite analogous to the substitution of a backbone for the notochord in vertebrates. These structures naturally appear late, comparatively speaking, in development. In *Libyodrilus* it has been ascertained that the young worm has reproductive organs like those of typical earthworms, the ovaries being free.

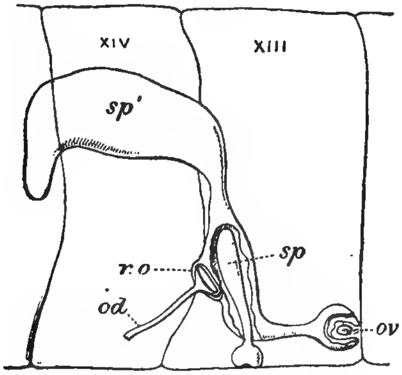

FIG. 2.—Female reproductive system of *Hyperiodrilus*. —xiii, xiv, thirteenth and fourteenth segments; *sp*, spermatheca; *sp'*, spermathecal sac involving the last; *ov*, ovary; *r.o*, egg sac; *od*, oviduct.

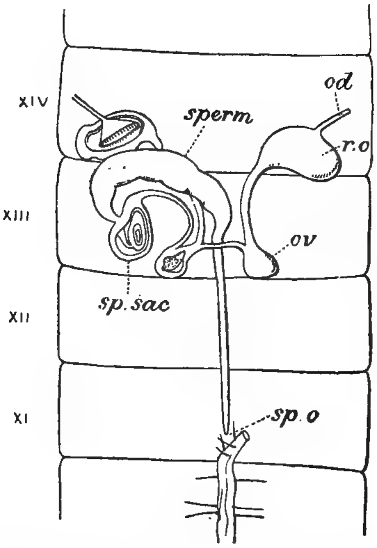

FIG. 3.—Female reproductive system of *Heliodrilus*.—xi–xiv, eleventh to fourteenth segments; *sperm*, spermatheca; *sp. o*, its external orifice; *sp. sac*, spermathecal sac; *ov*, sac containing ovary; *r.o*, egg sac; *od*, oviduct.

Classification.

Formerly the Oligochæta were divided (Claparède) into two divisions, the Limicolæ and the Terricolæ, a grouping expressive of the different mode of life which was believed to go along with differences of an important kind in structure. The former group, which embraces the first seven families, agrees with the latter in the anterior position of the clitellum, in the large size of the large yolked ova, in the simple structure of the clitellum (one cell thick), and in the shortness of the sperm ducts, which occupy but two segments. In the Terricolæ the clitellum is farther back and is more complex in structure; the ova are small, and with but little yolk; and the sperm ducts occupy several, often many, segments. *Moniligaster* and *Alluroides* prevent such a grouping. The former, though an earthworm in many characters, has abundantly yolked though not very large ova, the clitellum is anterior in position, and the sperm ducts traverse only a single segment. In *Alluroides* the ova are large and abundantly yolked, the clitellum is one cell layered, the ovaries are in segment xiii (as in all Terricolæ), and the sperm ducts traverse several segments. We shall therefore divide the Oligochæta into the following twelve families, which embody the present state of our knowledge:—

1. **Æolosomatidæ** (by Sedgwick referred to the Archiannelida).—Setæ in four bundles. Brain continuous with epidermis. Testes (unpaired) in v; ovary in vi. No sperm ducts; oviduct represented by a pore on vi. Spermathecæ in three pairs in iii–v. Asexual reproduction also occurs. *Æolosoma* (perhaps also *Ctenodrilus*).

2. **Naididæ.**—Setæ varied in form, in four bundles; dorsal bundles often deficient in anterior segments or (*Chætogaster*) throughout the body. Clitellum v–vii; testes v; ovaries vi; spermathecæ v; male pores vi associated with genital setæ. Oviducts a simple pore. Asexual reproduction also occurs. *Nais, Dero, Chætobranchus*, &c.

3. **Tubificidæ.**—Setæ varied in form, in four bundles. Clitellum usually xi, xii (sometimes x, xi, xii (xiii), or xii, xiii). Testes x or xi; ovaries xi or xii; spermiducal glands opening on xi or xii (orifice rarely single and median). Spermathecæ in x, xii, or xiii (or absent—*Bothrioneuron*). Oviducts xii/xiii. *Tubifex, Clitellio, Heterochæta, Limnodrilus, Hemitubifex, Branchiura, Vermiculus, Embolocephalus, Phreodrilus, Hesperodrilus*,[1] &c.

4. **Lumbriculidæ.**—Setæ always paired, never in bundles, sometimes bifid at extremity, sigmoid. Clitellum variable, vii–xv, x–xii, &c. Testes one or two pairs in viii or (ix), x. Ovaries one or two pairs. Spermiducal glands in viii or x (usually) or xiii, rarely single. One or usually two pairs of sperm ducts opening into spermiducal gland. Spermathecæ one to five pairs between viii–xv, rarely (*Sutroa*) single median and with diverticula. Dorsal vessel often with cæcal contractile branches. *Lumbriculus, Rhynchelmis, Sutroa, Stylodrilus, Phreatothrix, Thinodrilus*, &c.

5. **Phreoryctidæ.**—Setæ in four couples or four single setæ, simple, sigmoid. Clitellum xi–xiv. Testes x, xi; ovaries xii or xii, xiii. Sperm ducts without spermiducal glands opening in x, xi. Oviducts on following segments. Spermathecæ vii, viii, ix, without diverticula, &c., viii. *Phreoryctes, Pelodrilus.*

6. **Enchytræidæ.**—Setæ single, paired, or in groups; short, simple, straight, or sigmoid, or absent (*Anachæta*). Calciferous glands sometimes present. Clitellum xii, xiii. Testes in xi, male pores on xii. Spermiducal glands rudimentary, oviducts rudimentary. Spermathecæ in v often with diverticula, rarely two pairs. Dorsal pores sometimes present. *Enchytræus, Pachydrilus, Henlea, Marionina, Stercutus, Fridericia*, &c.

7. **Discodrilidæ.**—Parasitic forms with sucker at hind end. Pharynx with chitinous jaws. No setæ. Spermathecæ ix, opening by common orifices; testes ix, x; generally two pairs of vasa deferentia, with one median spermiducal gland in x. Oviducts pores only; ovary xi. *Bdellodrilus*, &c.

8. **Moniligastridæ.**—Large or small earthworms, with eight simple setæ per segment. Clitellum x–xiii. Testes x; ovaries xi or xiii; spermiducal glands (like those of *Lumbriculidæ* in structure) opening x/xi or two pairs of glands. Spermathecæ viii or ix, without diverticula. Many gizzards. *Moniligaster, Desmogaster.*

9. **Megascolicidæ.**—Large or small worms, with simple setæ, eight, twelve, or numerous in each segment. Clitellum usually xii or xiii or xiv to xvi–xxiii or so. Gizzard in middle of œsophagus. Nephridia diffused or paired. Testes x, xii, or xi. Spermiducal glands one or two pairs, opening with or independently of sperm ducts, generally in xvii, xviii, or xvii, xxix. Spermathecæ one to six pairs, always with diverticula; rarely many pairs in one segment. *Pheretima, Megascolex, Acanthodrilus, Benhamia, Dichogaster, Gordiodrilus*, &c.

10. **Lumbricidæ.**[2]—Size moderate. Setæ eight per segment. Clitellum rather far back. Gizzard at end of œsophagus. Male pores on xv, rarely anterior. Testes x, xi. No spermiducal glands. Spermathecæ one to eight pairs, very rarely numerous pairs in one segment. *Lumbricus, Allolobophora, Allurus*, &c.

11. **Geoscolicidæ.**—Small or large worms. Setæ eight per segment, often larger and more ornamented upon clitellum. Gizzard in middle of œsophagus. Clitellum variable. Spermiducal glands generally absent. Spermathecæ one to six pairs, without diverticula; often many pairs in one segment. *Microchæta, Pontoscolex, Kynotus*, &c.

12. **Eudrilidæ.**—Size moderate. Setæ eight per segment. Ovaries enclosed in cœlomic sacs which communicate with a spermatheca also cœlomic. True spermathecæ rarely present; if so, without diverticula. Spermiducal glands always present, into which the vasa deferentia (one or two pairs) always open. *Eudrilus, Polytoreutus, Alvania, Hyperiodrilus, Metadrilus, Eudriloides*, &c.

There are now about 1000 species of Oligochæta known; before the year 1883 the number was only about 150. No conclusions can be formulated at present concerning the distribution of the aquatic forms. The earthworms permit of some general statements. Eliminating forms which can be shown on reasonable probability to have been introduced, the world can be mapped into regions in accordance with the range of the families and genera. These are: (1) the Ethiopian, the most distinct of all, to which the Eudrilidæ are limited as well as (probably) the genus *Benhamia* and a number of Geoscolicidæ. (2) Antarctic, New Zealand to Patagonia, with intervening islands such as Kerguelen. It has no particular family, but contains the bulk of the species of *Acanthodrilus* and *Microscolex*, and the peculiar genera *Deinodrilus, Plagiochæta.* There are no Geoscolicidæ. (3) Indo-Australian, containing the vast preponderance of the Megascolicidæ. It may be subdivided into Indian (including Burma), with most Moniligastridæ, and genera *Typhoeus, Hoplochæta;* Malayan, the headquarters of *Pheretima;* and Australian, with the majority of *Megascolex, Digaster*, and other Cryptodrilids. (4) Palæarctic (with uncertain limits, but certainly Europe and Asia, not Japan), to which Lumbricidæ are nearly confined. (5) Neotropical. All South America except Patagonia, with Geoscolicidæ, and genera *Kerria, Ocnerodrilus.* (6) Nearctic. The existence or non-existence of such a region is a matter for further inquiry. North America is mainly a mixture of South American forms with Palæarctic, as is the case with its mammals. We have of the former the genera *Ocnerodrilus, Kerria, Microscolex*, and among the latter species of *Allolobophora*, some of them distinct from European forms. There is also the distinctive genus *Dichogaster*, which is mainly confined to this region, and *Sparganophilus*, which is in the same position. The alternative arrangement would be the extension northwards of the Neotropical region and the placing of the more northerly parts of North America with the Palæarctic into a Holarctic region.

Distribution.

(F. E. B.)

II. POLYCHÆTA.

A comprehensive account of the structure and habits of the Polychæta having been already given in *Ency. Brit.*, vol. ii. pp. 65–68, it will only be necessary here to refer to some special advances in our knowledge of the group made in recent years, and some general conclusions reached as to its morphology and affinities.

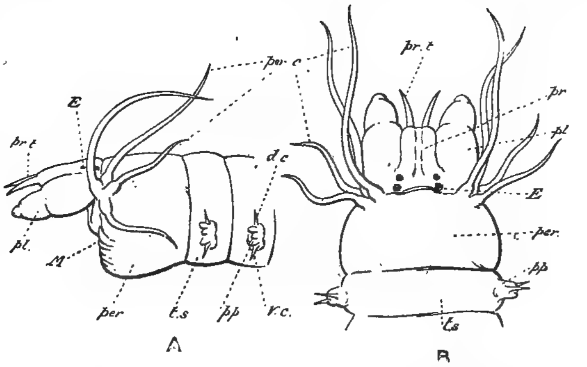

FIG. 4.—A, side view of the head region of *Nereis cultrifera.* B, dorsal view of the same. *E*, eye; *M*, mouth; *d.c*, dorsal cirrus; *per*, peristomium, probably equal to two segments; *per.c*, peristomial cirri; *pl*, prostomial palp; *pp*, parapodium; *pr*, prostomium; *pr.t*, prostomial tentacle; *t.s*, trunk segment; *v.c*, ventral cirrus.

The body of the various Polychæte worms, although differing greatly in outward shape, can be referred to a common plan of structure, common also in great part to the other members of the phylum Annelida, of which the Polychæta form an order. There is an anterior region, the prostomium, projecting above

Structure.

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[1] It has been suggested that these last two genera should be united to form a distinct family.

[2] Perhaps the Lumbricidæ and Geoscolicidæ form but one family.

the mouth, followed by a number of segments or metameres, generally provided with lateral appendages, the parapodia, and a terminal pygidium surrounding the anus. Neither the prostomium, which contains the brain, nor the pygidium is homologous with the segments lying between them. From the prostomium may spring various processes, primarily sensory in function. The more dorsal are tentacles, the ventral pair at the sides of the mouth are palps (Fig. 4). Often these processes may become converted into gills; this is especially the case with those worms which live in tubes, as this mode of life leads to the extreme modification of the anterior region, which, as a rule, alone projects to the exterior. Special sense organs are also generally situated on the prostomium, such as eyes, and two lateral ciliated pits near its posterior border, the nuchal organs, comparable to the lateral pits of Nemertines. The first true segment is the peristomium, surrounding the mouth. Together with the prostomium it constitutes the "head" of the worm, and almost always differs considerably from the more posterior segments. The paired metameric parapodia are hollow processes of the body-wall, bearing the characteristic bristles, or setæ, and typically drawn out into two lobes, a dorsal notopodium and a ventral neuropodium, each provided with a cirrus, a solid process with sensory epithelium. Such fully developed parapodia are only found among the active, freely moving, or swimming forms. In those worms which burrow in the sand, or live in tubes, the lobes and cirri often become much reduced, or disappear in certain regions altogether. The setæ also may become converted into short stout hooks, known as "crotchets," useful in moving up and down the tube or burrow. The segments and parapodia in the neighbourhood of the head often become modified (cephalization). During growth new segments are always added from a special growing zone immediately in front of the pygidium, and become differentiated from before backwards.

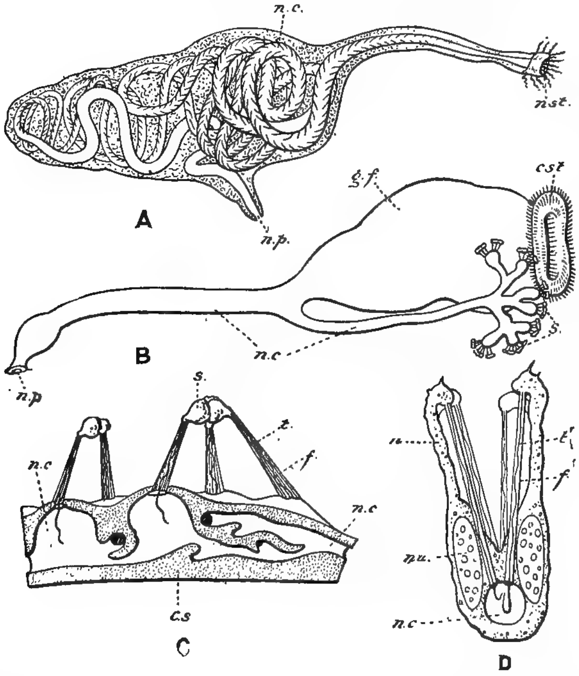

Fig. 5.—A, diagram of the nephridium of *Nereis diversicolor*. B, diagram of the nephridium of *Alciope*, into which opens the large genital funnel (cœlomostrome). C, small portion of the nephridium of *Glycera siphonostoma*, showing the canal cut through, and the solenocytes on the outer surface. D, optical section of a branch of the nephridium of *Nephthys scolopendroides*. *c.s*, cut surface; *cst*, cœlomostome; *f*, flagellum; *g.f*, genital funnel; *n*, neck of solenocyte; *n.c*, nephridial canal; *n.p*, nephridiopore; *nst*, nephridiostome; *nu*, nucleus of solenocyte; *s*, solenocytes; *t*, tube (*from Goodrich*).

Internally there is a spacious body-cavity, the cœlom, filled with a corpusculated fluid, and distinct from the blood-vascular system. The nephridia of the Polychæta are not of uniform structure. Essentially paired segmental ciliated tubular excretory organs, as in other Annelids, they are of two main varieties, one without and the other with an opening into the cœlom.

The first kind of nephridium found in the Nephthyidæ, Glyceridæ, and Phyllodocidæ consists of a tubular duct opening to the exterior, and ending internally in a more or less branched extremity. The blind branches are beset with peculiar cells, the solenocytes (Fig. 5), provided with a long narrow cuticular tube opening into the nephridial canal at one end, and fixed to the body of the cell containing the nucleus at the other; here a long flagellum is attached, which works down inside the tube, projecting into the lumen of the nephridium. Such closed nephridia seem to be comparable to the branched excretory organs, ending in flame-cells, found in Platyhelminths, Nemertines, and Rotifers, and exactly resemble the excretory organs of Amphioxus (Goodrich). In the Capitellidæ and Nereidæ (Lycoridea), the nephridium is provided with a nephridiostome opening into the cœlom. In the majority of Polychætes, however, the excretory organs appear to be formed by the fusion of the nephridium with a funnel of cœlomic origin (see below).

The reproductive cells are developed from the cœlomic epithelium, ripen in the cœlom, and are carried to the exterior at maturity by special genital ducts (cœlomostomes), probably developed from the cœlomic epithelium, as in other Annelids. In the Capitellidæ the cœlomostomes are independent funnel-like structures opening to the exterior. In the Phyllodocidæ and Glyceridæ (Fig. 5) they become grafted on to the nephridial canal, and thus open only indirectly. The Hesionidæ have compound organs, serving both as excretory and as genital ducts, formed by the grafting of the cœlomostome on to the nephridiostome. Finally, in most other Polychæta the large open funnel of the adult nephridium would appear to be formed by the cœlomostome. These compound organs, called nephromixia, may fulfil one or both of their primitive functions; generally a small number in front become specialized as renal organs, and the remainder as genital ducts—this is the case in the Terebellidæ, Sabellidæ, and their allies.

Development.

Of late years Kleinenberg, v. Drasche, Salensky, Meyer, and Hatschek have added much to our knowledge of the development of the Polychæta, while Wilson and others have worked out in detail the early cleavage of the fertilized ovum. In the majority of forms the egg, provided with a considerable amount of yolk, undergoes unequal division according to the spiral type of cleavage, giving rise to four large cells, the macromeres, from which are segmented off successive generations of small cells, the micromeres. The ectoderm

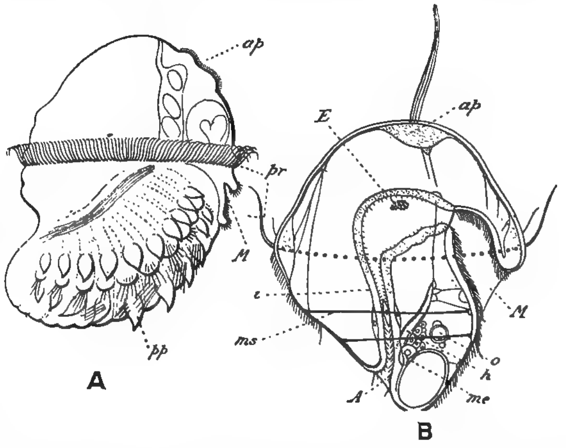

Fig. 6.—A, side view of the larva of *Lopadorhynchus* (*from Kleinenberg*), showing the developing trunk region. B, side view of the trochophore larva of *Eupomatus uncinatus* (*from Hatschek*). *A*, anus; *E*, eye; *M*, mouth; *ap*, apical organ; *h*, "head kidney"; *i*, intestine; *me*, mesoblast; *ms*, larval muscle; *o*, otocyst; *pp*, parapodium; *pr*, præoral ciliated ring, or prototroch.

is derived from the latter, the endoderm from the former, while the mesoderm is chiefly or entirely derived from one of the fourth quartet of micromeres. This cell soon divides into two mesoblastic teloblasts, which become lodged between the two primary germ-layers. It has been found that not only is there a remarkable uniformity in the early cleavages of the most diverse forms of Polychætes, but also that these early stages bear a most striking resemblance to the corresponding stages of the development of other Annelida, and of the Mollusca. This similarity is maintained even in the later development of the Mollusca and Polychæta, for in both groups is found the very characteristic free-swimming larval form known as the trochosphere larva (or trochophora).

In a Serpulid *Eupomatus*, for instance, where there is little yolk in the egg, cleavage gives rise to a blastosphere, the lower half of which invaginates to form the gut, the blastopore remaining as the mouth, and the anus being formed later. The cells at the top of the upper half of the rounded larva develop cilia, and become differentiated into the apical plate or larval brain. An equatorial belt of cells develops into a præoral ciliated ring, the prototroch, characteristic of the trochosphere. A smaller ring of cilia, the telotroch, subsequently becomes developed round the anus, and cilia also extend round the mouth and along the ventral line from mouth to anus. Meanwhile the mesoblastic teloblasts, situated one on either side of the alimentary canal, near the anus, give rise by their repeated division to the bands from which are developed the adult mesodermal tissues (muscles, connective tissue, &c.). A pair of larval excretory organs ("head-kidneys") without internal opening, the nephridia of the first segment, open laterally to the exterior (Fig. 6).

Such a larva develops into the adult worm by the elongation of the region between the prototroch and the telotroch. The growing mesoblastic bands become broken up into somites, which are hollowed out to form the cœlom. The nephridia are developed from large cells situated near the epidermis. Whilst the region in front of the prototroch gives rise to the prostomium, the brain itself is formed in connexion with the apical plate, and the ventral nerve-cord from the ectoderm along the ventral region. The parapodia arise as outgrowths of the body-wall, and the setæ as secretions of the epidermis.

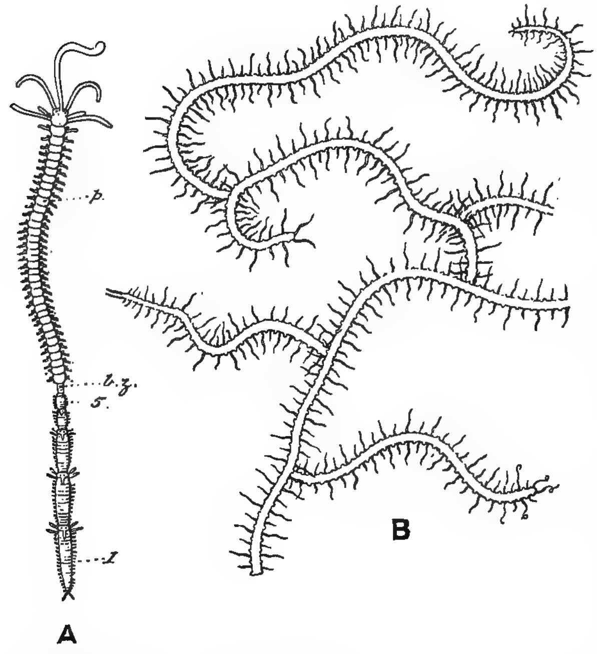

FIG. 7.—A, *Autolytus (after Mensch)* with numerous buds. B, portion of a colony of *Syllis ramosa (from M'Intosh)*. *b.z*, budding zone; *p*, anterior region of the parent worm; 1–5, buds.

Concerning reproduction by budding and fission in the Syllidæ, many details have been worked out by Malaquin and others. Some genera (*Odontosyllis*, *Exogene*) assume a heterosyllid condition, similar to the Heteronereid form of *Nereis*, in which the anterior and posterior regions of the body exhibit different parapodia and setæ, and the posterior region only is sexually developed. In *Syllis* this posterior region may become separated, and may develop a head of its own after separation; but in *Autolytus* the posterior sexual region develops a head before separation takes place. Again, in this genus and in *Myrianida* gemmation may occur, a succession of individuals being budded off from a special zone at the hinder end of the anterior non-sexual region (Fig. 7, A). The segments in each individual bud become differentiated from before backwards as usual; but the oldest and most developed buds are, of course, towards the hinder end of the chain. These chains may be formed of male or of female buds, which become free as they ripen, and often differ considerably in structure according to their sex. In *Syllis ramosa* is presented an extraordinary case of lateral budding, leading to the formation of a branched worm, first described by M'Intosh from the *Challenger's* collection (Fig. 7, B).

Classification.

The old classification of Polychætes into two groups, Errantia and Sedentaria, is now generally considered inadequate; but although Hatschek and Benham have proposed new systems, the affinities of the various families to one another remain in most cases too obscure to allow of a satisfactory classification being yet established. Adopting provisionally some of Benham's conclusions, we may group the chief families in suborders as follows:—Suborder 1: NEREIDIFORMIA, containing the Phyllodocidæ, Nephthyidæ, Glyceridæ, Nereidæ, Hesionidæ, Syllidæ, Aphroditidæ, and Eunicidæ. With the exception of a few aberrant genera, all these families have the following characters in common: the prostomium carries sensory tentacles; the palps, when present, are simple; the segments are fairly uniform; the parapodia bear well-developed cirri, and anal cirri are present on the pygidium; there are supporting acicula, and jointed setæ; the muscular pharynx is protrusible, and generally armed with chitinous teeth. The Amphinomidæ are doubtless related to some of these families, and so also are perhaps the Ariciidæ.

In the remaining families of the Polychæta the prostomial processes are either highly modified (gills of the Serpulidæ), or much reduced if not absent altogether. Similarly the parapodial cirri are rarely typically developed, and the anal cirri are absent. The setæ are never compound, and there are no acicula, the parapodia being as a rule much modified. The body is divided into regions—thoracic and abdominal—differing in external form, and frequently also in internal structure. The muscular pharynx is little developed, and never armed. These families may be grouped in suborders, as follows:—Suborder 2, SPIONIFORMIA: including the Spionidæ, Polydoridæ, Chætopteridæ, Magelonidæ, and perhaps the Ammocharidæ. Suborder 3, CAPITELLIFORMIA: Capitellidæ. Suborder 4, SCOLECIFORMIA: Maldanidæ, Arenicolidæ, and perhaps the Scalibregmidæ and Opheliidæ. Suborder 5, TEREBELLIFORMIA: Terebellidæ, Ampharetidæ, Amphictænidæ, to which the Cirratulidæ may possibly be added. Suborder 6, SABELLIFORMIA: Sabellidæ, Serpulidæ, Hermellidæ. The Chlorhæmidæ may perhaps be related to the last suborder. Sternaspis, a very aberrant form which used to be associated with the Echiuroidea, is now definitely placed among the Polychæta. In the disappearance of segmentation, the coiling of the gut, the reduction of the number of nephridia, and in many other respects, Sternaspis approaches the Chlorhæmidæ.

From a general survey of the structure of the Polychæta, and a comparison of them with the other groups of the phylum Annelida, it must be concluded that they are the least specialized of its orders; and further, that the Polychæta must have been derived from a common ancestral form differing not so very widely from the more primitive living Nereidiformia.

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III. Haplodrili.

In the group Haplodrili (Lankester), often called Archiannelida (Hatschek), may be provisionally included a number of interesting lowly-organized marine worms, whose affinities are very doubtful. *Polygordius* and *Protodrilus* live in sand, but while the former moves by means of the contraction of its body-wall muscles, *Protodrilus* can progress by the action of the bands of cilia surrounding its segments, and of the longitudinal ciliated ventral groove (see article Worm, 9th edition). *Saccocirrus*, which also lives in sand, and more closely resembles the Polychæta, has throughout the greater length of its body on each segment a pair of small uniramous parapodia bearing a bunch of simple setæ. No other member of the group is known to have any trace of setæ or parapodia at any stage of development.

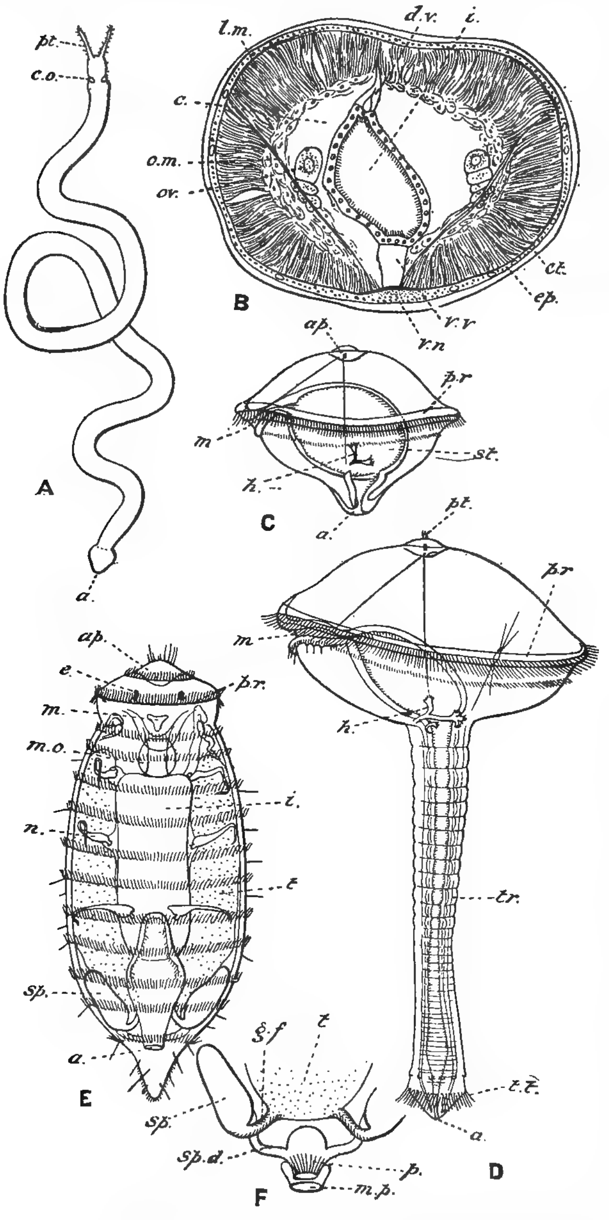

Fig. 8.—A, *Polygordius neapolitanus* (*from Fraipont*). B, transverse section of *Polygordius* (*from Fraipont*). C, trochophore of *Polygordius*; and D, later stage of the same, showing the development of the trunk (*from Hatschek*). E, dorsal view of *Dinophilus tæniatus*. F, male apparatus of the same (from Harmer). *a*, anus; *ap*, apical organ; *c*, cœlom; *c.o*, ciliated pit; *c.t*, cuticle; *d.v*, dorsal vessel; *e*, eye; *ep*. epidermis; *g.f*, genital funnel; *h*, "head kidney," with second nephridium just below it; *i*, intestine; *l.m*, longitudinal muscles; *m*, mouth; *m.o*, muscular pharyngeal organ; *m.p*, male pore; *n*, nephridium; *o.m*, oblique muscles; *ov*, ovary; *p*, penis; *pr*, prototroch; *pt*, prostomial tentacle; *sp*, sperm-sac; *spd*, sperm-duct; *st*, stomach; *t*, testes; *tr*, trunk segment; *tt*, telotroch; *v.n*, ventral nerve cord; *v.v*, ventral vessel.

These three genera have the following characters in common. The body is composed of a large number of segments; the prostomium bears a pair of tentacles; the nervous system consists of a brain and longitudinal ventral nerve cords closely connected with the epidermis (without distinct ganglia), widely separated in *Saccocirrus*, closely approximated in *Protodrilus*, fused together in *Polygordius*; the cœlom is well developed, the septa are distinct, and the dorsal and ventral longitudinal mesenteries are complete; the nephridia are simple, and open into the cœlom. *Polygordius* differs from *Protodrilus* and *Saccocirrus* in the absence of a distinct subœsophageal muscular pouch, and in the absence of a peculiar closed cavity in the head region, which is especially well developed in *Saccocirrus*, and probably represents the specialized cœlom of the first segment. Moreover, in *Saccocirrus* the genital organs, present in the majority of the trunk segments, have become much complicated (Fig. 9). In the female there is in every fertile segment a pair of spermathecæ opening at the nephridiopores. In the male there are a right and a left protrusible penis in every genital segment, into which opens the nephridium and a sperm-sac. The wide funnels of the nephridia of this region are possibly of cœlomic origin.

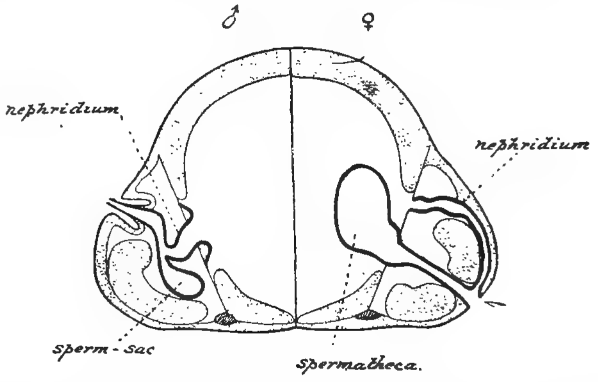

Fig. 9.—Diagram of a transverse section of *Saccocirrus* (*from Goodrich*), showing on the left side the organs in a genital segment of a male, and on the right side the organs in a genital segment of a female.

Dinophilus is a free-swimming form without tentacles, and with segmental bands of cilia (Fig. 8). The parasitic *Histriodrilus* (Histriobdella) feeds on the eggs of the lobster. It resembles *Dinophilus* in the possession of a ventral pharyngeal pouch (which bears teeth in *Histriodrilus* only), the small number of segments, and absence of distinct septa, the absence of a vascular system, the presence of distinct ganglia on the ventral nerve cords, and of small nephridia which do not appear to open internally. *Histriodrilus* resembles *Saccocirrus* in the possession of two posterior adhesive processes, and to some extent in the structure of the complex genital organs, which, however, are restricted to a single segment. In *Dinophilus* there is also only a single pair of genital ducts behind; and in the male there are sperm-sacs and a median penis. In some species of *Dinophilus* there is pronounced sexual dimorphism (the male being small and without gut) as in the Rotifera. The resemblance of *Dinophilus* to the Rotifera is, however, quite superficial, and the general structure of this genus with distinct traces of segmentation, especially in the embryo, points to its close affinity, if not to *Polygordius* in particular, at all events to the Annelida.

That *Polygordius*, *Protodrilus*, and *Saccocirrus* are on the whole primitive forms, and related to each other, there can be little doubt, but their place amongst the Annelida is difficult to determine. The development of *Polygordius* alone is well known, having been studied by Hatschek, Fraipont, and others. The larva (Fig. 8, C and D) is a typical but very specialized form of trochophore, provided with a branching nephridium bearing solenocytes. The trunk develops on the lower surface of the disc-like larva, which undergoes a more or less sudden metamorphosis into the young worm (Fig. 8). There appears to be little either in the development or in the structure of the Haplodrili to warrant the view held by Hatschek and Fraipont that *Polygordius* and *Protodrilus* are exceedingly primitive forms, ancestral to the whole group of seta-bearing Annelids (Oligochæta, Polychæta, Hirudinea, and Echiuroidea). Whatever may be the conclusion as to the position of *Dinophilus* and *Histriodrilus*, it seems only reasonable to suppose that *Polygordius* and *Protodrilus*, so far from representing a stage in the phylogeny of the Annelida before setæ were developed, have lost the setæ, which are already in a reduced state in *Saccocirrus.*

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IV. MYZOSTOMIDA.

The Myzostomida are a remarkable group of small parasitic worms which live on Crinoid echinoderms. They were first discovered by Leuckart in 1827. Some species, such as *Myzostoma cirriferum*, move about on the host; others, such as *M. glabrum*, remain stationary with the pharynx inserted in the mouth of the Crinoid. *M. deformator* gives rise to a "gall" on the arm of the host, one joint of the pinnule growing round the worm so as to enclose it in a cyst (Fig. 10, E); whilst *M. pulvinar* lives actually in the alimentary canal of a species of Antedon.

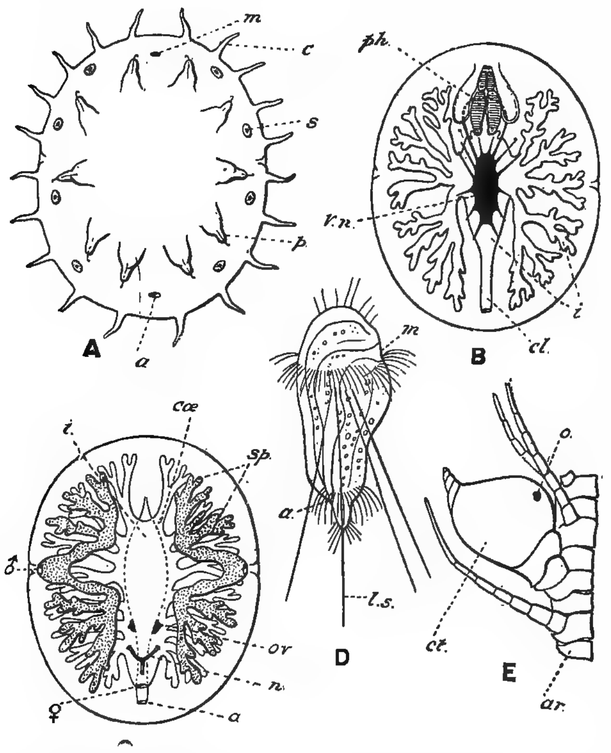

FIG. 10.—A, ventral view of *Myzostoma.* B, diagram of *Myzostoma*, showing the nervous and alimentary systems. C, diagram of *Myzostoma*, showing the genital organs (*from v. Graff and Wheeler*). D, larva of *Myzostoma glabrum* (*after Beard*). E, portion of the arm of *Pentacrinus*, showing a cyst containing *Myzostoma.* *a*, cloacal aperture; *ar*, arm; *c*, cirrus; *cl*, "cloaca"; *cœ*, cœlom; *ct*, swollen pinnule forming a cyst; *i*, intestine and its cæca; *ls*, larval setæ; *m*, mouth; *n*, ciliated tube (nephridium?); *o*, opening; *ov*, ovary; *p*, parapodium; *ph*, pharynx; *s*, sense organ; *sp*, sperm-sac; *vn*, ventral ganglionic mass; ♂, male opening; ♀, female opening.

A typical Myzostomid (Fig. 10, A, B, C) is of a flattened rounded shape, with a thin edge drawn out into delicate radiating cirri. The skin is ciliated. The dorsal surface is smooth; ventrally there are five pairs of parapodia, armed with supporting and hooked setæ, by means of which the worm adheres to its host. Beyond the parapodia are four pairs of organs, often called suckers, but probably of sensory nature, and comparable to the lateral sense organs of Capitellids (Wheeler). The mouth and cloacal aperture are generally at opposite ends of the ventral surface. The former leads to a protrusible pharynx (Fig. 10, B), from which the œsophagus opens into a wide intestinal chamber with branching lateral diverticula. There appears to be no vascular system. The nervous system consists of a circumœsophageal nerve, with scarcely differentiated brain, joining below a large ganglionic mass no doubt representing many fused ganglia (Fig. 10, B). The dorso-ventral and the parapodial muscles are much developed, whilst the cœlom is reduced mostly to branched spaces in which the genital products ripen. Full-grown Myzostomids are hermaphrodite. The male organ (Fig. 10, C) consists of a branched sac opening to the exterior on each side. The paired ovaries discharge their products into a median cœlomic chamber with lateral branches (Fig. 10, C), often called the uterus, from which the ripe ova are discharged by a median dorsal pore into the terminal region of the rectum (cloaca). Into this same cloacal chamber open ventrally a pair of ciliated tubes communicating by funnels with the cœlom (Nansen and Wheeler); these are possibly nephridia, and excretory in function.

The Myzostomida are protandric hermaphrodites, being functional males when small, hermaphrodite later, and finally functional females (Wheeler). Small "males" are in some species constantly associated with large hermaphrodites, but according to Beard there are in some cases true dwarf males, comparable to the complementary males described by Darwin in the Cirripedia. The embryology of Myzostoma has been studied by Metschnikoff and Beard. Cleavage leads to the formation of an epibolic gastrula and ciliated embryo which hatches as a free-swimming larva remarkably like that of a Polychæte worm (Fig. 10, D). The larva is provided with postoral and perianal ciliated bands, and on either side with a bunch of long provisional setæ. The mesoderm becomes segmented, and the parapodia subsequently develop from before backwards; but almost all internal traces of segmentation are lost in the adult. The structure and development of the Myzostomida seem to show that they are nearly related to Polychæta, though highly modified in relation to their parasitic mode of life.

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Worms, a town of Germany, grand-duchy of Hesse-Darmstadt, on the left bank of the Rhine, and 9 miles by rail north by west of Mannheim. The people's theatre and hall were built in 1889, and St Martin's church was restored in 1888. In 1895 an obelisk was erected to the memory of Grand-Duke Louis IV. The municipal library, technical school, academy for brewing, milling, and agriculture, and a large hospital are the principal institutions. There is a good river harbour, entered and cleared by about 175,000 tons annually. Population (1885), 21,839; (1895), 28,636; (1900), 40,714.

Worthing, a municipal borough (1890) and watering-place, in the Lewes parliamentary division of Sussex, England, 61 miles south by west of London by rail. A drainage scheme has been completed at a cost of about £50,000, and new waterworks provided at a cost of over £36,000. Modern erections are municipal buildings, a theatre, a public library, and two convalescent homes. The infirmary and dispensary have been enlarged. Fruit-growing is a thriving industry. Area, 1425 acres. Population (1891), 16,606; (1901), 20,006.

Wrangel, Friedrich Heinrich Ernst, COUNT VON (1784–1877), Prussian field-marshal, was born at Stettin, Pomerania, on 13th April 1784. He entered a dragoon regiment in 1796, and fought in the greater part of the Prussian campaigns against Napoleon, especially distinguishing himself at Heilsberg in 1807, and receiving the Order of Merit. He was a captain in 1812, and won distinction and promotion to lieutenant-colonel in the campaign of deliverance in 1813, and became colonel in 1815. He commanded a cavalry brigade in 1821, and two years later was promoted major-general. He commanded the 13th Division, with headquarters at Münster, in Westphalia, in 1834, when riots occurred owing to differences between the Archbishop of Cologne and the Crown, and the determination and resolution with which he treated the Clerical party prevented serious trouble. He was promoted lieutenant-general, received many honours from the Court, enjoyed the confidence of the Junker party, and commanded at Königsberg and Stettin successively. In 1848 he commanded the Second Corps of the German Federal army in the Schleswig-Holstein campaign, and in the autumn was summoned to Berlin to suppress the riots there. As governor of Berlin and commander-in-chief of the Marches (appointments which he held till his death) he proclaimed a state of siege, and ejected the Liberal president and members of the Chamber. In 1856, having seen sixty years' service, he was made a field-marshal. At the age of eighty he commanded the Austro-Prussian army in the war with Denmark in 1864 with great ability but some barbarity. After the capture of Düppel he resigned the command, was created a count, and received other honours for his brilliant and rapid successes. In 1866 he assisted in the Bohemian campaign, but without a command on account of his great age. He took a keen interest in the war with France in 1870–71. He died at Berlin on 1st November 1877. (R. H. V.)

Wrangell, formerly Fort St Dionysius (1833), Fort Stickeen (1840), and Fort Wrangell (1867), a settlement at the north-west end of Wrangell Island, South-east Alaska, U.S.A., in 56° 28′ N. and 132° 23′ W., named after Baron Ferdinand von Wrangell, Russian governor and Polar explorer. The first settlement here was made by Zarembo in 1833, to repel anticipated trespass by the Hudson Bay Company, but later the whole region was leased for trading purposes by the Russian-American Company to the Hudson Bay Company. The British traders were attacked by the Indians in April 1842, and saved by the opportune arrival of Sir George Simpson with two armed vessels. Wrangell is the port of transhipment of goods for the interior of British Columbia (Cassiar district) from sea-going vessels to river steamers navigating the Stikine river. As such it enjoyed great prosperity in 1874–77 during the Cassiar gold excitement, when it had a population of 4000, and again in 1896–97, during the efforts to reach the Klondike by the so-called Edmonton trail. The failure of this project left the settlement in a torpid state. The first Presbyterian mission station in Alaska was established here in 1877 by Mrs M'Farland and Dr Sheldon Jackson. At present there is a custom-house, a mission home for native children, a settlement of Stikine Indians, and a small body of white settlers. Population in 1890 was 71 whites and 228 natives, exclusive of the mining population, which varies with the season of the year. In 1900 the total population was 868.

Wreck.—The present law of wreck found within the territorial waters of the United Kingdom is contained in the Merchant Shipping Act, 1894. "Wreck" was at common law applied only to wrecked property cast by the sea upon the land, but in the Act the term includes jetsam, flotsam, lagan, and derelict, found in or on the shores of the sea or any tidal water. It does not include a barge adrift in the Thames, nor a drifting raft of timber with no one in charge. Wreck must consist of the hull, cargo, or appurtenances of a ship or vessel.

The provisions of the Act dealing with wreck (ninth part) may be summarized as follows:—The Board of Trade (as the receiver-general of droits of Admiralty) has the general superintendence of wreck in the United Kingdom, and appoints receivers of wreck for the whole coast, who are paid by fees. Where a British or foreign vessel is wrecked, stranded, or in distress, at any place on or near the coasts or any tidal water within the limits of the kingdom, it is the duty of the receiver for the district to proceed there and give directions for preserving the ship, the lives on board her, and her cargo and apparel. He can require the assistance of any person, especially the master of any vessel, or the use of any waggons, carts, or horses, near at hand; and for this purpose any person may, unless there is a public road equally convenient, pass and repass with or without horses or carriages over any adjoining lands without the owner's or occupier's consent, doing as little damage as possible, and may also deposit there any things recovered from the ship; any damage so done is a charge on the ship, cargo, or articles, and is recoverable like salvage (*q.v.*). Penalties are imposed on any owner or occupier hindering the operations. The receiver has power to suppress any plundering or disorder, or any hindering of the preservation of the ship, persons, cargo, or apparel. Where any vessel, wrecked or in distress as above, is plundered, damaged, or destroyed, by any riotous or tumultuous assembly ashore or afloat, compensation must be made to her owner in England and Scotland by the same authority which would be liable to pay compensation in cases of riot (*q.v.*) and in Ireland in cases of malicious injuries to property. In the absence of the receiver, his powers may be exercised by the following officers or persons in successive order, viz., a chief officer of customs, principal officer of coast-guard, inland revenue officer, sheriff, justice of the peace, and naval or military officer on full pay. These persons act as the receiver's agent and put the salvage in his custody, but they are not entitled to any fees nor are they deprived of any right to salvage by so doing. An examination is also directed to be held, in cases of ships in distress on the coasts of the kingdom, by a wreck receiver, wreck commissioner, or his deputy, at the request of the Board of Trade or a justice of the peace, by evidence on oath as to the name and description of ship, name of master, shipowner, and owner of cargo, ports to and from which the ship was bound, the occasion of the ship's distress, the services rendered, and the like. The Act provides as follows for dealing with wreck:—Any one finding wreck, if he is the owner of it, must give notice of his having done so to the receiver of the district, and if he is not the owner he must deliver it to that officer as soon as possible. No articles belonging to a wrecked ship found at the time of the casualty must be taken or kept by any person, whether their owner or not, but must be handed over to the receiver. The receiver taking possession of any wreck must give notice of it, with a description, at the nearest custom-house; and if the wreck is in his opinion worth more than £20, also to Lloyds. The owner of any wreck in the hands of a receiver must establish his claim to it within a year, and on so doing, and paying all expenses, is entitled to have it restored to him. Where a foreign ship has been wrecked on or near the coast, and any articles forming part of her cargo are found on or near the coast, or are brought into any port, the consular officer of the foreign country to which the ship or cargo belongs is deemed to be the agent for the owner so far as the custody and disposal of the articles is concerned. The receiver may in certain cases, *e.g.*, where the value is small, sell the wreck and hold the proceeds till claimed. The right to unclaimed wreck belongs to the Crown, except in places where the Crown has granted that right to others. Persons so entitled, such as admirals, vice-admirals, lords of manors, and the like, are entitled, after giving the receiver notice and particulars of their title, to receive notice from the receiver of any wreck there found. Where wreck is not claimed by an owner within a year after it was found, and has been in the hands of a receiver, it can be claimed by the person entitled to wreck in the place where it was found, and he is entitled to have it after paying expenses and salvage connected with it; if no such person claims it, it is sold by the receiver, and the net proceeds are applied for the benefit of the Crown, either for the duchy of Lancaster or the duchy of Cornwall; if these do not claim it, it goes to the Crown. Where the title to unclaimed wreck is disputed, the dispute may be settled summarily, as in cases of salvage; either party, if dissatisfied, may within three months after a year since the wreck came into the hands of the receiver proceed in any competent court to establish his title. Delivery of unclaimed wreck by the receiver discharges him from liability, but does not prejudice the title thereto. The Board of Trade has power to purchase rights of wreck. No person exercising Admiralty jurisdiction as grantee of wreck may interfere with wreck otherwise than in accordance with the Act. Duties are payable on wrecked goods coming into the United Kingdom or Isle of Man as if they had been imported thither; and goods wrecked on their homeward voyage may be forwarded to their original destination, or, if wrecked on their outward voyage, to their port of shipment, on due security being taken for the protection of the revenue. Wreck commissioners may be appointed by the Lord Chancellor to hold investigations into shipping casualties, to act as judges of courts of survey, and to take examinations in respect of ships in distress (see above).

The owner of a wrecked ship, sunk by his negligence in a navigable highway, so as to be an obstruction to navigation, if he retains the ownership of her, is liable in damages to the owner of any other ship which without negligence runs into her. If, however, the owner has taken steps to indicate her position, or the harbour authority at his request has undertaken to do so, no action lies against him for negligence either *in rem* or *in personam.* He may, however (whether the sinking was due to his negligence or not), abandon the ship, and can thus free himself from any further liability in respect of her. If he abandons her to any other person—*e.g.*, an underwriter—who pays for her as for a total loss, that person does not become liable for her unless he takes possession or control in any way. Harbour authorities generally have by local statute, as they have by the general Harbours, Docks, and Piers Clauses Act, 1847 (if incorporated in their own Act), the power of removing the wreck in such a case, and recouping themselves for their expenses from its proceeds. The general Act also gives a personal right of action against the owner for any balance of expense over the value of the wreck; but if the owner has abandoned it, and no one else has taken it, neither he nor any one else is liable. A particular or local Act (as *e.g.*, one of the state of Victoria) may, however, fasten this liability on the person who is owner at the time when the ship is wrecked, and then he cannot free himself of it. A harbour authority is not obliged to remove a wreck because it has power to do so, unless it takes dues from vessels using the harbour where the wreck lies, or in some way warrants that the harbour is safe for navigation, in which case it is under an obligation to do so. Further statutory provision is now made in this respect by the Merchant Shipping Act, which empowers harbour authorities to raise, remove, or destroy (and meantime buoy or light), or to sell and reimburse themselves out of the proceeds of any vessel or part of a vessel, her tackle, cargo, equipment, and stores, sunk, stranded, or abandoned in any water under their control, or any approach thereto, which is an obstruction or danger to navigation or lifeboat service. They must first give due notice of such intention, and offer the wreck to the owner. The Act gives similar powers to lighthouse authorities, with a provision that any dispute between a harbour and lighthouse authority in this respect is to be determined finally by the Board of Trade.

The method of dealing with wreck outside territorial waters (which does not come within the scope of the Act) is governed by the previous general law relating to droits of Admiralty (see below). The Board of Trade, as receiver-general, in its instructions to receivers, directs that wreck picked up at sea out of the limits of the United Kingdom, or brought to it by British ships, is to be taken possession of by the receiver and held by him on behalf of the owners, or, if the owners do not claim it, on behalf of the Crown. Derelict ships picked up at sea outside territorial limits and brought into British ports must be delivered to the receiver and kept by him until the owner can be found (but not longer than a year and a day). Wreck picked up out of territorial limits by a foreign ship need not be interfered with by the receiver, unless upon application by a party interested. For the receiver's rights with respect to property in distress and its liability to salvage, see SALVAGE.

Legal provision for the protection of wreck is found in English law from very early times. At present, under the Merchant Shipping Act, it is a felony to take wreck in territorial limits to a foreign port, and it is punishable by fine to interfere with a wreck. The receiver has power, by means of a search warrant from a justice, to search for wreck which he has reason to believe is concealed. By the general criminal law in Scotland plundering wreck is punishable at common law; and in England and Ireland it is a felony to plunder or steal any wreck or part thereof, to destroy any wreck or part thereof, to prevent or impede any person on board a wreck from saving himself, and to exhibit any false signal with the intent of endangering any ship, or to do anything tending to the immediate loss or destruction of a ship for which no other punishment is provided.

Of old it seems to have been the general rule in the civilized maritime countries of Europe that the right to wreck belonged to the sovereign, and formed part of the royal revenue. This was so under the Roman law and the feudal law; and in England the common law set out in the statute *De prærogativa regis* (17 Edw. II., 1324), provided that the king has wreck of the sea, whales, and sturgeons taken in the sea and elsewhere within the kingdom, except in certain places privileged by the king. This right, which it is said had for its object the prevention of the practice of destroying the property of the shipwrecked, was, however, gradually relaxed; and the owner of wreck was allowed to recover it if he made claim to it, and gave proof of his ownership within a certain time—fixed at a year or a year and a day alike by a decree of Antonine the Great, the feudal law, the general maritime law, the law of France, and English law. Richard I. released his prerogative right to wreck to the extent of allowing children, or if there were none, brothers and sisters of a perishing owner, to have his goods; and Henry III., by a charter of 1236, allowed the owner of wrecked goods to have his property again if he claimed within three months, provided that any man or beast escaped from the ship. The statute of Westminster the First (1276, 3 Edw. I.), provided that where a man, a dog, or a cat, escape alive out of the ship, such ship or barge or anything in it shall not be adjudged wreck, but the goods shall be saved and kept by view of the sheriff, coroner, or the king's bailiff, and delivered into the hands of such as are of the town where the goods were found, so that if any one sue for those goods and prove that they were his, or perished within his keeping, within a year and a day, they shall be restored to him without delay, and if not they shall remain to the king or to such others to whom the wreck belonged. In 1277 the statute *De officio coronatoris* made provision for the safe custody of wreck; and one of 1353 provided for the delivery to the merchants of goods coming to land which may not be said to be wreck, on payment of salvage. In Scotland, a statute of Alexander II., similar to that of Westminster, declared that where any creature escapes alive from a wrecked vessel, the goods cast away are not accounted wreck, but are to be preserved by the sheriff for those who within a year shall prove their property therein; otherwise they shall escheat to the Crown. For a long time the view of English law was that the right to recover wrecked property depended on the fact of a live creature escaping, though in Hale's words, "because it was *lex odiosa* to add affliction to the afflicted, it was bound up with as many limits and circumstances, and restricted to as narrow a compass as might be"; and the Admiralty records illustrate the statement. Thus in 1382 the prior of Wymondham claimed as wreck a ship which came ashore with no one on board, the men having left her for fear of their lives because of an enemy ship which was about to capture her; but the King's Council, before whom it came, by certiorari from the admiral of the north, decided against the claim. In 1543, ships grounded on the Goodwins were held to be waif and wreck, although their crews to save their lives made their way to shore; and in 1637 a ship in the Cinque Ports was proceeded against in Admiralty and condemned, "no man or dog being on board, but only a dead man with his head shot off." Finally, in 1771 Lord Mansfield and the King's Bench held definitely that the property in wrecked goods is not divested out of the owner by the fact that no living thing escaped from the wreck, but the owner may prove his ownership in any other way; and the law in Scotland by a decision in 1725 had already, it seems, allowed prior owners to reclaim wrecked goods on proving their title and paying salvage, though no creature escaped alive, and notwithstanding the year had elapsed. The sovereign might grant the right of wreck in a particular place to a subject, who would then have the same rights in respect of it as the Crown. Hale says that "though wreck of the sea doth *de jure communi* belong to the king, yet it may belong to a subject by charter or by prescription. . . . Sometime wreck hath belonged to an honour by prescription, as in the honour of Arundel, sometimes to the owner of a county. The lords of all counties palatine regularly had *wreccum maris* within their counties palatine as part of their *jura regalia*, but yet inferior lords might prescribe for wreck belonging to their several manors within a county palatine. The Earl of Cornwall had *wreccum maris per totum comitatum Cornubiæ*; for though Cornwall was not a county palatine, it had many royalties belonging to it, viz., as against the king, though particular lords might prescribe for wreck against the earl" (*De Jure Maris*, i. vii.; Hargrave, 41). In the Isle of Man unreclaimed wreck, whether cast on shore or found in the sea, within the headlands of Man, belongs to the lord, now the Crown by purchase from the duke of Athol; in the Channel Islands all wreck cast on shore or within reach of a person standing on shore, except certain valuables which go to the Crown, belongs to the lord of the manor if not reclaimed within a year and a day; while in Wales the old law made everything thrown on shore belong to the king, for "the sea is a packhorse of the king" (*A. G.* v. *Jones*, 2 H. & C. 347). This royal franchise of wreck was probably granted out in nearly all manors in England by the end of the reign of Henry II. In Scotland the admiral is considered the king's donatory of wreck where no special right is shown in another; and so in England the lord high admiral's patents, from the time of Henry VI. onwards till the Crown took the office of Admiralty into its own hands, contain express grants of wreck, which were asserted against lords of manors and others, including the warden of the Cinque Ports. The dispute between the lord high admiral and the lord warden was settled in 1624 by Buckingham agreeing to rent the right of the lord warden to wreck and sea estrays within the Cinque Ports for a fixed sum of money.

From early times a distinction was made in English law between wreck cast ashore and floating wreck called droits of Admiralty (see ADMIRALTY). Wreck proper, or common law wreck, *ejectus navis*, is what is cast by the sea upon the shore; for "nothing shall be said to be *wreccum maris* but such goods as are cast or left upon the land" (*Sir H. Constable's Case*, 1599, 5 Rep. 106), and this belonged to the king *jure coronæ*, and was dealt with by the common law. Floating wreck belonged to the Crown as *inter regalia*, but was granted to the lord admiral *jure regis*. Even when the office of lord high admiral is in abeyance, and the duties performed by commissioners, as now, these rights which then belong to the Crown are distinguished from the other royal revenues as belonging to the Crown in its office of Admiralty. The admiral, however, tried to usurp, and there are several instances of his actually usurping jurisdiction over wreck proper; and in the reign of Richard II. special statutes (which were only declaratory of the common law) were passed for the purpose of confining the jurisdiction of the admiral to its proper limits. One of these (15 Ric. II.) declared that "of all manner of contracts, pleas, and quereles, and all other things arising within the bodies of the counties as well by land as by water and also of wreck of the sea, the Admiral's Court shall have no manner of cognizance, power, nor jurisdiction, but all such manner of contracts, pleas, and quereles, and all other things rising within the bodies of counties as well by land as by water as afore, and also wreck of the sea, shall be tried by the laws of the land and not before nor by the admiral nor his lieutenant in any wise." In spite of this statute, instances still occurred of the Admiralty Court exercising this jurisdiction, until by frequent prohibition by the common law courts, especially in the 17th century, and by the admission of the Admiralty judges themselves, it was recognized as beyond the scope of their authority. These Admiralty droits are classified as flotsam, jetsam, lagan, and derelict. In Lord Coke's words, flotsam is "when a ship sinks or otherwise perishes, and the goods float on the sea"; jetsam is "when goods are cast out of a ship to lighten her when in danger of sinking, and afterwards the ship perishes"; and ligan, or lagan, is "when heavy goods are, to lighten the ship, cast out and sunk in the sea tied to a buoy or cork, or something that will not sink, in order that they may be found again and recovered." Derelict is a ship or cargo, or part of it, abandoned by its master and crew *sine spe recuperandi et sine animo revertendi*. "None of these goods," adds Coke, "which are so called, are called wreck so long as they remain in or upon the sea; but if any of them by the sea be put upon the land then they shall be said to be wreck" (*Sir H. Constable's Case*, 1599, 5 Rep. 106; and 2 Inst. 167). Hale says "they are not wreck of the sea but of another nature, neither do they pass by *wreccum maris* as is recorded in Sir Henry Constable's case and the case of the 3 Edw. II., where they are styled *adventurae maris*. And as they are of another nature, so they are of another cognizance or jurisdiction, viz., the admiral jurisdiction. Flotsam, jetsam, and lagan, and other sea estrays, if they are taken up in the wide ocean, belong to the taker of them if the owner cannot be known. But if they be taken up within the narrow seas that do belong to the king, or in any haven, port, or creek or arm of the sea, they do *primâ facie* and of common right belong to the king, in case where the ship perisheth or the owner cannot be known. . . . But if the owner can be known he ought to have his goods again, for the casting them overboard is not a loss of his property. Although the right of these adventures of the sea within the king's seas belongs to him where the owner cannot be known, yet the king hath little advantage of it, for by the custom of the English seas the one moiety of what is gained belongs to him that saves it [this is not the present rule]. . . . A subject may be entitled to these as he may be entitled to wreck—(1) by charter; (2) by prescription" (*De Jure Maris;* Hargrave, 41, 42). The difference between these two kinds of wreck is clearly brought out in *R.* v. *49 Casks of Brandy* (1836, 3 Hagg. Ad. 257; and *R.* v. *2 Casks of Tallow*, *ibid.* 294)—a dispute between the Crown and a grantee of wreck, where it was decided that objects picked up below low-water mark, and within three miles of it, as also objects afloat between high and low water marks, never having touched the ground, are droits of the Crown, whereas objects picked up aground between high and low water marks, or though aground, yet covered by the waves, are wreck.

The distinction that Hale draws in the above passage between sea waifs or estrays taken on the high seas, and those taken in the seas of the realm, seems to be founded on the *occupatio* of the civil law; but although favoured by the similar rule existing in the case of royal fish, it has not been recognized by the courts, which have always held that in both cases they are droits of the Crown in its office of Admiralty, and, subject to the right of the salvor to reward and the right of the owner to reclaim them in a year and a day, go to the royal revenue (Lord Stowell, *The Aquila*, 1798, 1 C. Rob. 37). Lord Stowell bases this prerogative right "on the general rule of civilized countries that what is found derelict on the seas is acquired beneficially for the sovereign, if no owner shall appear." It seems that this was also Coke's view (2 Inst. 168).

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(G. G. P*.)

Wrexham, a municipal borough of North Wales, Denbighshire, 11 miles south-south-west of Chester, with a station on the Great Western Railway and another on the Great Central Railway. It is included in the Denbigh district of parliamentary boroughs. Population (1881), 10,978; (1901), 14,966.

Writing.—Very early in the history of mankind three needs become pressing. These are (*a*) to recall at a particular time something that has to be done; (*b*) to communicate with some other person who is not present, nor for the moment easily accessible; (*c*) to assert rights over tools, cattle, &c., by a distinctive mark, or by a similar mark to distinguish one's own production (*e.g.*, a special make of pottery) from that of others. The last-named use, out of which in time develops every kind of trade-mark, is itself a development of the earlier property mark. The right to property must be established before traffic, whether by way of barter or of sale, is possible.

Knot signs.

Every one is familiar with devices to achieve the first of these aims; one of the commonest is to tie a knot in a handkerchief. It is obvious that by multiplying the number of knots a number of points equal to the number of knots might in this way be referred to, though it is probable that the untrained memory would fail to recall the meaning attached to more than a very limited number of knots. The simplest application of these knots is in keeping a record of a number of days, as in the story related by Herodotus (iv. 98), to the effect that Darius, on crossing the Ister in his Scythian expedition, left with the Greeks appointed to guard the bridge a thong with a number of knots equal to the number of days that their watch over the bridge was to be continued. One knot was to be undone each day, and if the king had not returned by the time that all the knots were undone, the Greeks were to break down the bridge and go away. A development of this is found in the Peruvian *quipu*, which consists of a number of thongs or cords hanging from a top-band or cross-bar. In its simplified form, knots are merely tied upon the individual cords. In its more elaborate forms, one of which is figured in colours in Berger's *Histoire de l'Écriture dans l'Antiquité*, p. 6, the cords are of different colours, and are knotted together so as to form open loops of various shapes. In the *Antiguëdades Peruanas*,[1] we are told that the knots of the *quipu* in all probability indicated only numbers originally, but that as time went on the skill of the makers became so great that historical events, laws, and edicts could thus be communicated. In every place of any importance there was an official whose business it was to interpret *quipus* received from a distance, and to make *quipus* himself. If, however, the *quipu* which was received came from a distant province, it was not intelligible without an oral explanation. Unfortunately, the art of interpretation of *quipus* is lost, so that it is impossible to ascertain how far the knots were merely a mnemonic for the messenger, and how far they were intelligible without explanation to a stranger. Similar mnemonics are said to have been used in the remotest antiquity amongst the Chinese, the Tibetans, and other peoples of the Old World.[2]

Message sticks.

Similar in character to the *quipu* is the message-stick, which is still in use amongst the natives of Australia. A branch of a tree is taken and notches made upon it. These are now cut with a knife; in earlier times they were made with the edge of a mussel shell. The notches are made in the presence of the messenger, who receives his instructions while they are being made. The notches are thus merely aids to memory, and not self-explanatory, though if messages frequently passed between two persons, practice would in time help the person to whom the message was sent to guess at the meaning, even without a verbal explanation. The following was the method of the Wotjoballuk of the Wimmera river in Victoria.[3] "The messenger carried the message-stick in a net bag, and on arriving at the camp to which he was sent, he handed it to the headman at some place apart from the others, saying to him, 'So-and-so sent you this,' and he then gives his message, referring as he does so to the notches on the message-stick; and if his message requires it, also enumerates the days or stages, as the case may be," by a method of counting on different parts of the body.

Marked pebbles.

For the purposes of communication with absent persons, however, another method commended itself, which in time was adopted also for mnemonic purposes. This method was the beginning whence some forms at least of later writing have been derived. From the very earliest times to which the energy of man can be traced, date two kinds of writing: (*a*) engraving of a visible object on some hard substance, such as the flat surface of a bone; (*b*) drawing, painting, or engraving marks which could again be identified. Of the first kind are the engravings of reindeer, buffaloes, and other animals by the cave men of prehistoric times; of the second are a large number of pebbles discovered by M. Ed. Piette at Mas d'Azil, on the left bank of the Arize, an account of which is published by the discoverer in *L'Anthropologie*, vol. vii. (1896), pp. 384 ff. This layer of coloured pebbles is intercalated between the last layer of the Reindeer Age and the first of the Neolithic period. The layer is over 2 feet thick, of a reddish-black colour, and along with the pebbles are found cinders, peroxide of iron, teeth of deer perforated, probably in order to be strung like beads, harpoons of various kinds, and the bones of a large number of animals, some wheat, and, in the upper part of the layer, nuts, cherry-stones, and plums. The stones were coloured with peroxide of iron. The characters are of two kinds: (*a*) a series of strokes which possibly indicate numbers, (*b*) graphic symbols. The stones were scattered about without connexion or relation one with another. Whatever the meaning may be, it is clear that the markings are not accidental. It is noticeable, however, that none of them definitely represent any animal, though some of them bear a certain resemblance to caterpillars or serpents. Others look like rough attempts to represent trees and river plants. A great number closely resemble symbols of the alphabet, like **E**, **I**, **T**, **O**, **A**, **Σ**, **Φ**, **Π**, &c. The learned discoverer is inclined to see in these symbols the forerunners of the later syllabaries and alphabets of the East, nine of the symbols from Mas d'Azil agreeing with forms in the Cypriot syllabary, and eleven with those of the Phœnician alphabet. While any such theory is, to say the least, premature, the similarity of the forms is indubitable. A certain amount of likeness, however, could not well be avoided, for as soon as the artist advances beyond the single perpendicular or horizontal line he must, by crossing two lines, get forms which resemble alphabetical symbols, whether **Γ**, **T**, **+**, **X**, **L**, or others of the same kind, as **V**, &c. It might be therefore a safer conclusion to suppose that if they passed beyond magic symbols, to be buried like the Australian *churinga* (some of which, *e.g.*, No. 5 of Fig. 21 in Spencer and Gillen's *Native Tribes of Central Australia* are very similar, and deposits of which are kept in caves like the rock-shelter at Mas d'Azil), they were conventional marks understood by the members of the clan or tribe which frequented the caves of Mas d'Azil. Colonel Garrick Mallery, referring to an earlier discovery described by M. Cartailhac in *L'Anthropologie*, ii. p. 48, suggests that, like similar things among the American Indians, they were used in playing games or gambling.

A very large number of conventional marks, however, are demonstrably reductions from still older forms, conventional marks often developing out of pictographs. Pictography has, in fact, left its traces in all parts of the world. It has, however, been most widely developed in the New World as a system lasting down to modern times. The best and fullest account of the picture-writing of the American Indians has been given by Colonel Garrick

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[1] Quoted by Middendorf, *Das Runa Simi oder die Keshua Sprache* (Leipzig, 1890), p. 8.

[2] *Cf.* Andree, *Ethnologische Parallelen und Vergleiche*, i. p. 184 ff.

[3] A. W. Howitt in *Journal of the Anthropological Institute*, xviii. (1889), p. 318 ff.

Mallery in the Tenth Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution (1893). Although there are other forms of pictograph which are much older, it may be well to take those of the New World first, as they, unlike those of Egypt and China, have never shown any tendency to develop beyond the genuine picture stage towards a syllabary or an alphabet. The American Indians, besides picture-writing, used also (1) the simple mnemonic of a notched stick to record various incidents, such as the number of days spent on an expedition, the number of enemies slain, and the like; (2) wampum belts, consisting of strung beads, which could be utilized as a mnemonic, exactly like a rosary. Wampum belts, however, were employed in more intricate forms; white beads indicated peace, purple or violet meant war (Mallery, *Report*, p. 230). Sometimes a pattern was made in the belt with beads of a different colour, as in the belt presented to William Penn on the making of a treaty with the Leni-Lenape chiefs in 1682. Here, in the centre of the belt two figures, intended to represent Penn and an Indian, join hands, thus clearly indicating a treaty. Very simple pictures are drawn upon birch bark, indicating by their order the subjects in a series of song chants with sufficient precision to enable the singer to recall the theme of each in his recitation. An account can be kept of sales or purchases by representing in perpendicular strokes the number of items, and adding at the end of each series a picture of the animal or object to which the particular series refers. Thus three strokes followed by the picture of a deer indicate that the hunter has brought three deer for sale. A conventional symbol (a circle with a line across it) is used to indicate a dollar, a cross represents ten cents, and an upright stroke one cent, so that the price can be quite clearly set forth. This practice is followed in many other parts of the world. In clay tablets discovered by Mr Arthur Evans during his exploration of the great palace at Knossos, in Crete, a somewhat similar method of enumeration is followed; while at Athens conventional symbols were used to distinguish drachmæ and obols upon the revenue records, of which considerable fragments are still preserved.

American picture-writing, &c.

In comparatively recent times, according to Colonel Mallery, the Dakota Indians invented a chronological table, or winter count, wherein each year is recorded by a picture of some important event which befell during that year. In these pictures a considerable amount of symbolism was necessary. A black upright stroke indicates that a Dakota Indian was killed, a rough outline of the head and body spotted with blotches indicates that in the year thus indicated the tribe suffered from small-pox. Sometimes, in referring to persons, the symbol is of the nature of a rebus. Thus, Red Coat, an Indian chief, was killed in the winter of 1807-8; this fact is recorded by a picture of a red coat, with two arrows piercing it and blood dripping. There is, however, nothing of the nature of a play upon words intended, and even when General Many-adier is represented as a figure in European dress, with the heads of two deer behind his head and connected with his mouth, no rebus was intended (many a deer), but the Indians supposed that his name really meant this, like their own names Big Crow, Little Beaver, and so forth. Here the Mexicans proceeded a stage farther, as in the often quoted case of the name of Itz-coatl, literally knife-snake, which is ordinarily represented by a reptile (*coatl*) with a number of knives (*itz*) projecting from its back. It is, however, also found divided into three words, itz-co-atl—knife-pot-water—and represented by a different picture accordingly. The Mexicans, moreover, to indicate that the picture was a proper name, drew the upper part of the human figure below the symbol, and joined them by a line, a practice adopted also amongst their northern neighbours when, as in names like Little-Ring, the representation would hardly be sufficiently definite. Simple abstract notions could also be expressed in this picture-writing. Starvation or famine was graphically represented by a human figure with the ribs showing prominently. A noose amongst the Mexicans was the symbol for robbery, though more logically belonging to its punishment. In a Californian rock-painting reproduced by Mallery (p. 638), sorrow is represented by a figure from whose eyes drop tears. This could be abbreviated to an eye with tears falling from it, a form recorded by Schoolcraft as existing amongst the Ojibwa Indians. The symbol is so obvious that it is found with the same value among Egyptian hieroglyphics.

The civilization of the American Indians was nowhere very high, and for their simple needs this system, without further development, sufficed. It was different in the more elaborate civilizations which prevailed among the ancient peoples of the Old World, to whom with certainty the development of writing from pictography can be ascribed—the Assyrians, Egyptians, and Chinese. Here more complex notions had to be expressed. The development of the system can be traced through many centuries, and, as might be expected, this development shows a tendency to conventionalize the pictorial symbols employed. Out of conventionalized forms develop (*a*) syllabaries, (*b*) alphabets.

Chinese script.

In Chinese the development of the script from picture writing is certain, though no actual Chinese picture-writing exists as the earlier stage of the present script, which can be traced back to 1000 B.C. or 800 B.C. By that period the script was developed in the form in which it still exists. From the forms existing in the oldest Chinese dictionary, however, it is clear how it developed. For example, the symbol for brightness 明 goes back to two symbols, a circle for the sun, a crescent for the moon, which were so drawn as long as the writing was done on a hard substance with a hard point. When paper, silk, and other soft materials came into use, and the writing was done not with a hard point but with a brush, the symbols gradually passed into their present shapes. As yet the antiquities of Chinese script have not been adequately studied, and forgeries and sham antiques have long been provided by the Chinese for the curious. By the historical period other concrete forms have been developed into abstractions. Thus the form , which is so often cited as being the primitive Chinese picture for a tree, is not known to exist in any genuine ancient Chinese writing. Thus 木 is the historical form for a tree. Doubled it is a forest; tripled 森 it indicates the abstraction "darkness." The oldest form for the hand is said to be as representing the five fingers. It is not so found, the historical form being 手, but the symbol for friendship 友 goes back to the very natural picture of two hands . The form for mountain in the historical script is 山, which goes back to an existing form ; and this latter is obviously a picture, just as the symbol for mountain is in Egyptian also. The earliest recorded form for child is , which has now become 子, an obvious development when the whole symbol is in practice made without lifting the brush more than once.

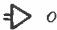
The language could have been represented only in the rudest way if the development of writing had stopped at this point. Concrete objects like house, child, horse, leg, eye, were easy enough to represent by a picture. Abstractions were much more difficult to express in such a way as to be generally intelligible. Moreover, even if Chinese had arrived at alphabetic writing, its difficulties would have been by no means over. As the language is monosyllabic, it must of necessity have a very large number of its words with the same combination of sounds. In the spoken language the different modulations or tones increase very considerably the distinctions possible between forms that would be spelt identically in an alphabet, and no doubt a method of indicating these tones could have been invented, as has been done in Greek and Vedic Sanskrit for the much less complicated systems of those languages, in distinguishing, as in Greek, acute, grave, and circumflex. Chinese, however, followed an entirely different path. The Peking dialect has only 420 vocables with differing sounds, while the words of the ordinary vocabulary are at least ten times as many. Instead of any attempt towards alphabetical development the Chinese fell upon the ingenious method of taking the symbol for some simple concrete idea and using it for other words which contained the same sounds, distinguishing which idea was intended by prefixing to the original symbol another which should be, as it were, a diacritical mark for the genus of the thing indicated. Thus the vocable *ting* has for one of its simplest meanings that of sting of a bee, &c., the symbol for which is 丁, the crossbar probably representing the termination of the body, the rest the sting with a barb at the end. From the shape of the symbol and the signification, transition to the idea of nail was easy. But there were many other meanings to the vocable *ting*. Thus it meant an ingot of metal, a boil or blain, to give orders, to settle by deliberation. To express an ingot the symbol for metal was prefixed—metal-nail (this form itself is now used for nail); to express a boil the symbol for disease is prefixed, *cp.* French *clou.* Verbal ideas are more difficult; *order*, however, is expressed by prefixing the symbol for mouth, *settle* by prefixing the symbol for words, which itself represents something like smoke proceeding from a mouth.[1] The Chinese is the hardest of all scripts to master, but this ingenious device ensures that once the simple forms have been learnt there shall be comparatively little ambiguity as to the meaning. Out of it the Japanese have developed a syllabary for the writing of their language, which is of an altogether different type, a proceeding which we shall see has parallels elsewhere.[2]

Egyptian.

The Egyptian system of writing is perhaps the oldest of known scripts and was carried on till the Ptolemaic period, when the more convenient Greek alphabet led to its gradual disuse. But, as in Chinese, the fact that it has been so long in use has led to the conventionalizing of the pictures and in many cases to a complete divorcement between the symbol and the sound represented, the original word having often become obsolete. In this case it is no longer possible to trace it. Attempts have been made to connect the three great pictographic systems of the Old World, some authorities holding that the Chinese migrated eastwards from Babylonia, while others contend that the civilization of Egypt sprang originally from the valley of the Euphrates, and that the ancient Egyptians were of the same stock as the Somali and were overlaid and permeated by a Semitic conquest and civilization. At many periods in their history Assyria and Egypt were in close political relations, but at present there is no clear evidence that the Egyptian system of writing was not a development in the Nile valley itself,[3] or that it was either the descendant or the parent of the pictographic system which developed into the cuneiform of Assyria and neighbouring lands.

Egyptian started from the same point as every other pictographic system—the representation of the object or the concrete expression of the idea. But like the Chinese, it took the further step, short of which the American pictographs stopped; it converted its pictures into a syllabary from which there was an imperfect development towards an alphabet. Egyptian, however, never became alphabetic in the sense in which the western languages of modern Europe are alphabetic. That this last step was never taken by Egyptian is attributed by Mr Griffith[4] to the natural conservatism of the people and the influence of the artist scribes, "who fully appreciated the effect of decorative writing; to have limited their choice of signs by alphabetic signs would have constituted a serious loss to that highly important body." The effect of this love for decorative effect, combined with a desire for precision, is shown by the repetition several times over in the symbols of the sounds contained in a word. The development of Egyptian was exactly parallel to Chinese. A combination of sounds, which was originally the name of an object, was represented by the picture of that object. This picture again, like Chinese and like the Indian name Little Ring, required at the end a determinative—a picture of the kind of object intended—in order to avoid ambiguity. As the alphabet represented only consonants and semi-consonants, and the Egyptian roots consisted mostly of only three letters, the parallelism with Chinese is remarkably close. (For the further history of this system, with its hieratic and demotic forms, see the articles EGYPTOLOGY and HIEROGLYPHICS.)

Cuneiform.

The explanation of the cuneiform writing of Asia has been entirely the work of the 19th century. In the same year (1802) Akerblad, a Swede, began the decipherment of Egyptian, and Grotefend published his first attempt to elucidate the Persian cuneiform inscriptions. As Champollion and Thomas Young developed, with the aid of the Rosetta stone, the study of Egyptian, so Grotefend and Sir Henry Rawlinson laid the foundations of cuneiform scholarship by elucidating the inscriptions set up by Darius Hystaspes in 516 B.C. Here the existing remains of the Persian sacred books—the Avesta—which are written in a dialect closely akin, afforded great assistance; and when once the Old Persian was deciphered, the interpretation of the parallel columns of Susan and Babylonian was only a question of time. Later discoveries of material in many parts of Asia Minor have vastly increased our knowledge of the cuneiform writing, and the history of the Euphrates valley has started into being from the clay tablets found on the sites of Nineveh and Babylon. The peculiar wedge shape of the cuneiform symbols arose from the use of clay as a writing material, for the papyrus plant, which furnished from its bark such an excellent substance for writing in Egypt, was not utilized for this purpose in Mesopotamia in very early ages, and in Syria, according to Pliny (*N. H.*, xiii. 73), was used only for ships' cordage in Antigonus's time.[5] On the soft clay before it was baked the scribe wrote with a square-ended stylus, which, when held at an angle, naturally made a deeper impression with its lowest corner, thus producing a wedge-shaped mark. The result in process of time was that, unlike Egyptian, the pictograph in Assyrian ceased altogether to be recognizable as such. The oldest symbols, however, are clear enough. The symbols for hand and arm are exactly like the crude attempts of children to represent the same objects. That the symbol should mean *heart*, the symbol  *ox* seems natural enough; both are obviously pictographs, the latter of the head of the animal only. A wavy line or set of wavy lines is an obvious pictograph for water; it is so employed in Chinese, Egyptian, and Babylonian. The secondary notion of verbal action, whereby a leg indicates *walk* or *stand*, is easily attained. Here again Egyptian is parallel, two legs turned towards the left indicating *go*, *walk*, *stand*, while one leg bent at the knee means *to run away*, and two legs moving towards the right *to retreat.* More complicated operations are expressed by combinations: eating and drinking are represented by putting the symbol for food or water inside the symbol for mouth; a tear is naturally represented by the combination of eye and water, just as it is in Egyptian, and as we have already seen *sorrow* was expressed by the American Indians. At least two hundred symbols, however, have no obvious explanation of this kind, and the attempt of Delitzsch[1] to account for them has met with severe criticism from some of the other experts in the study. He seems, however, to have proved that, by the addition of four parallel strokes to a simple symbol, a strengthening or modification of its meaning was brought about, and that a considerable number of symbols heretofore regarded as units could be resolved into still simpler elements.

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[1] For further details see H. A. Giles, *China and the Chinese*, Lecture I. (New York, 1902).

[2] *See* Taylor, *The Alphabet*, i. p. 34 ff.

[3] F. Ll. Griffith in *Journal of the Anthropological Institute*, xxx. (1900), p. 158.

[4] *Op. cit.*, p. 154.

[5] Papyrus now grows in the Anapus, near Syracuse, but not on the Egyptian Nile north of Fashoda, though it flourishes luxuriantly throughout tropical Africa, and is one of the chief components of the "sudd" which used to obstruct the navigation of the upper Nile.

The difficulties of the interpretation of the cuneiform inscriptions are considerably increased (1) by the fact that the system was not the invention of the Semitic-speaking people who employed it in Babylonia, but was borrowed by them from the Sumerian pre-Semitic inhabitants; (2) by the use of symbols, not merely as ideograms, but also as syllables, whether as in Cyprian (see below), consisting of a consonant followed by a vowel, or of two consonants separated by a vowel. Here, as in the American Indian's reckoning, in Chinese and in Egyptian it was necessary to employ *determinatives*. These in most cases were prefixed to the symbol which was actually pronounced, in order to show its exact value in the particular place. Another method was to add the *phonetic complement*: in other words, to give the final syllable of the word for which the symbol was intended. This method was particularly useful in the verb in order to indicate the proper tense forms.[2]

Hittite.

From Assyria and Babylonia this cuneiform writing spread to other lands and other peoples who spoke tongues that were in no way akin to those of either its inventors, the Sumerians, or their conquerors, the Semitic Babylonians. A widespread series of inscriptions, found in many parts of Asia and even in the islands of the Aegean, which are generally described as Hittite, are written in a script of pictographic origin, although probably independent of Babylonian in its development. Of these the decipherment, in spite of many attempts, is but beginning, and it is not possible to discuss those attempts here.[3] As we have already seen, it was from the Indo-European Old Persian that the decipherment of cuneiform first began.

Cyprian.

At a very early period a colony of Greeks from the Peloponnese, speaking a dialect closely akin to the Arcadian dialect (which is known to us only from a much later period), had settled in the island of Cyprus. Alone among the Greeks this colony did not write in an alphabet, but under some Asiatic influence adopted a syllabary. Even when the island came again closely in touch with their Greek kinsfolk, after the Persian wars, the Greek inhabitants continued to write in their syllabary. In the recent excavations made by the authorities of the British Museum an inscription of the 4th century B.C. was discovered, whereon a dedication to Demeter and Persephone was given first in Greek letters and repeated below in the syllabary, the Greek (as universally at so late a period) reading from left to right, the syllabary from right to left. This syllabary has five vowel symbols, but it could not distinguish between long and short vowels. In its consonant system it is unable to distinguish between breathed, voiced, and aspirated stops, thus having but one symbol to represent τε, δε, and θε. It is, of course, unable to represent a final consonant, but this is achieved by using the symbol for a syllable ending in *e* conventionally for the final consonant. Thus *ka-se* stands for κάς, the Cyprian equivalent of καί, "and." There are symbols for *ta*, for *te*, for *ti*, for *to*, for *tu*, though none for *t*, and similarly for most of the other consonants. There is, however, no symbol for *wu* (Fυ); *ya*, *ye*, *yi* occur, but no *yo* or *yu*. Δημήτρι is expressed by *ta-ma-ti-ri*, where *ti* stands for *t* alone; *sa-ta-sa-to-ro* stands for Στασάνδρω (genitive). Here it is to be observed (1) that ν preceding another consonant is omitted altogether, the vowel being probably nasalized as in French; (2) that, as in the previous word, there is a sort of vowel euphony whereby the unnecessary vowel accompanying *t* takes the colour of the succeeding vowel. In other cases, however, it follows the preceding vowel, as in *a-ri-si-to-pa-to-o-a-ri-si-ta-go-ra-u* = Ἀριστόφαντο(ς) ὁ Ἀρισταγόραν.

Origin of the alphabet.

The discussion of Cyprian brings us face to face with the question of the origin of the alphabet, which spread from Phœnicia and Greece first round the coasts of the Mediterranean, and gradually extended its sway till it conquered the world. Until the last few years the view of Vicomte Emmanuel de Rougé, first propounded to the Académie des Inscriptions in 1859, but unnoticed by the world at large till republished after de Rougé's death by his son in 1874, was generally accepted. According to this view, the alphabet was borrowed by the Phœnicians from the cursive form of Egyptian hieroglyphics. The resemblances in some cases are striking; in other cases the differences are equally remarkable. De Rougé's famous *Mémoire* was published just as the era of excavation in the eastern Mediterranean commenced. The discoveries of symbols like alphabetic characters in all quarters of the Mediterranean, and dating back to very remote ages, began to give scholars pause, and finally in the volume published by the Egyptian Exploration Fund in 1900, which contained the results of Professor Flinders Petrie's excavations at the Egyptian royal tombs at Abydos, it became clear that a system of signs closely resembling the symbols of the alphabet, and coexisting with hieroglyphics, preceded even the first dynasty of Egyptian kings known to history.[4] According to Professor Flinders Petrie, "the usage of such forms in the same country from about 6000 B.C. to 1200 B.C., or later, shows that we have to deal with a definite system. And it seems impossible to separate that in 1200 B.C. in

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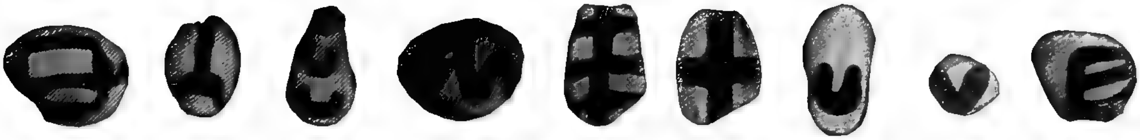
[1] *Die Entstehung des ältesten Schriftsystems oder der Ursprung der Keilschriftzeichen* (Leipzig, 1897). Delitzsch has replied to his critics in a *Nachwort* (Leipzig, 1898).

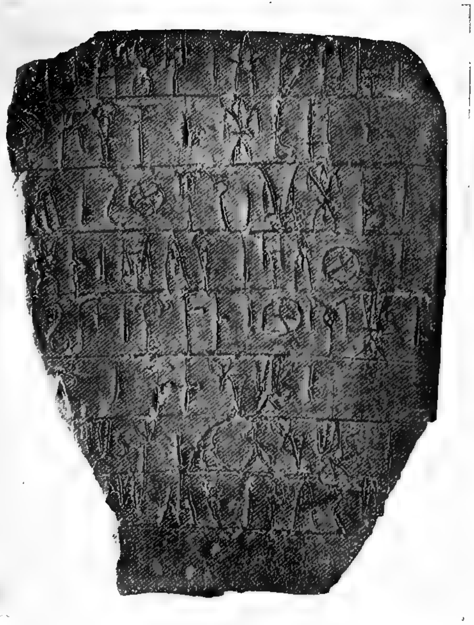
[2] See further L. W. King in *Encyclopædia Biblica*, i. p. 422 ff.

[3] P. Jensen, in his *Hittiter und Armenier* (Strasburg, 1898), contends that these so-called Hittites were the prehistoric ancestors of the Armenians. Professor Sayce made an attempt at decipherment in a paper read before the Society for Biblical Archæology in June 1902 (reported in *Athenæum* of 21st June, p. 788).

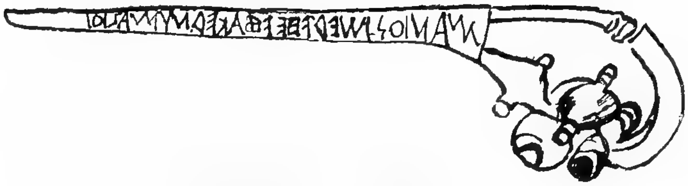
[4] See *op. cit.*, p. 31 ff., and vol. ii. (1901), p. 47, with plates LV. *a*, *b*, *c*, *d*.



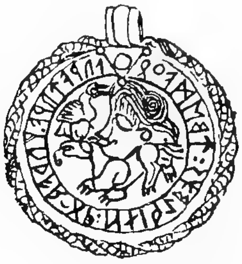
Inscribed Pebbles from Mas d'Azil.



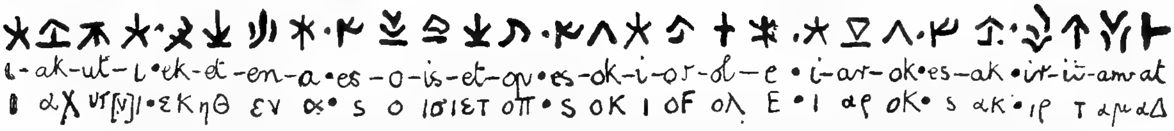
Prehistoric Linear Script from Crete.



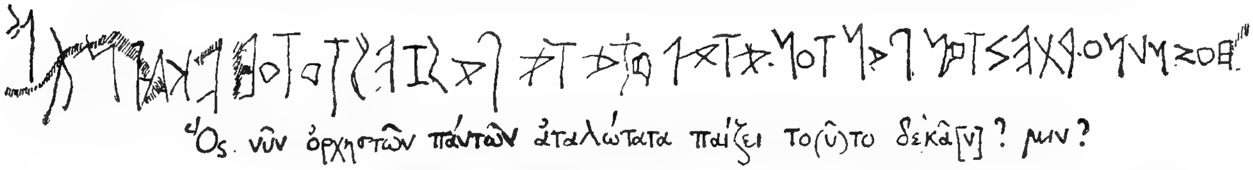
Gold Fibula from Præneste, with Early Latin Inscription. Right to left.



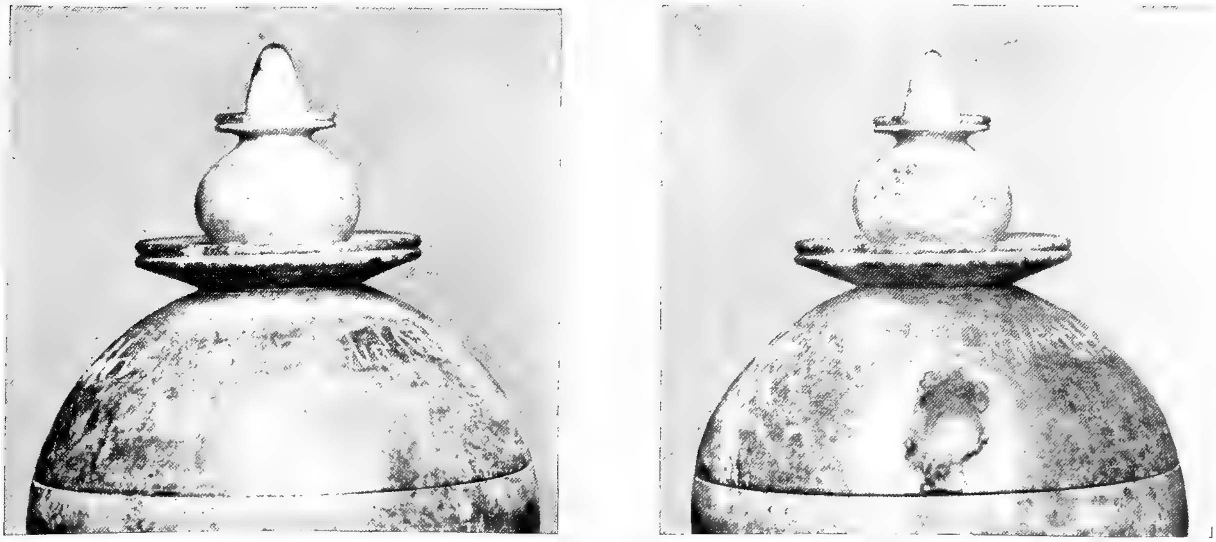
Vadstena Pendant, with Runic Alphabet; about A.D. 600.


i-ak-ut-i•ek-et-en-a•es-o-is-et-ap•es-ok-i-or-ol-e•i-ar-ok•es-ak•ir-ti-amrat
ι αχυτ[ν]ι•εκηθ εν α• ς ο ισιετ οπ•ς οκ ι οϝ ολ Ε•ι αρ οκ• ς ακ•ιρ ταμαδ

Cyprian Inscription (4th century B.C.) from Curium (*British Museum Excavations*, p. 64). Below are (1) the transliteration of the symbols, (2) the Greek words, both like the Cyprian reading from right to left.


Ὃς. νῦν ὀρχηστῶν πάντων ἀταλώτατα παίζει το(ῦ)το δεκᾶ[ν] ? μιν ?

Oldest Attic Inscription. From a Dipylon vase probably of 8th century B.C. Right to left.



Inscription on Buddha Vase, perhaps 4th century B.C.

Egypt from the similar forms found in other lands connected with Egypt from 800 B.C. down to later times; we may find many of these also in the Cretan inscriptions long before 800 B.C."[1] These dates put the old explanations of the alphabet as a development by the Phœnicians from the later Egyptian out of the question. But as yet it would be premature to form any further hypothesis. It is possible that the symbols were pictographic in origin. Unless there is extraordinary variety in representation they cannot be alphabetic, for their different forms can be counted by hundreds.

In Egypt and in Crete, where Mr Arthur Evans in his excavations at Knossos has discovered many hundreds of inscribed clay tablets, investigation into this problem is only beginning, and the next quarter of a century may see as surprising a development as has taken place in the period since 1875. The provisional accounts of the records found in Crete in the spring of 1900, which have been given by Mr Evans in the *Annual of the British School at Athens* and elsewhere,[2] show that in Crete two if not three systems of writing prevailed. The first of these is a pictographic script, the existence of which as a system was first proved to the world by the same discoverer in his articles in the *Journal of Hellenic Studies*[3] in 1894 and 1897. Before this time symbols had been observed in the engravings on Mycenæan objects, but no attempt had been made to collect them or to regard them as other than ornamental devices to fill vacant spaces. In the first of these articles Mr Evans showed conclusively that, whatever their meaning, the individual symbols were part of a system, and were not merely decorative. They were in fact hieroglyphics, but in no way identical with Egyptian hieroglyphics, though naturally the same themes, such as parts of the human body and figures of animals and birds, occur in this system as well as in Egyptian. Of eighty-two such pictographs six represent the human body and its parts, seventeen arms, implements, and instruments, eight parts of houses and household utensils, three marine subjects, seventeen animals and birds, eight vegetable forms, six heavenly bodies and derivatives, one a geographical or topographical sign, four geometrical figures, twelve uncertain symbols. Now that a large part of the ruins of the great palace at Knossos has been unearthed, it seems clear that this script belonged especially to the "præ-Mycenæan" population of the island.[4] We know from Homer (*Odyssey*, xix. 175 ff.), who belongs to a later epoch still than the Mycenæan supremacy, that the population of Crete was extremely mixed, and the fact that this script probably belonged to the Ἐτεόκρητες or True Cretans of Homer implies nothing whatever as to the comparative age of the pictographs and the linear writing. From the clay tablets containing accounts which Mr Evans has discovered, the conclusion seems probable that these earlier inhabitants were tributary to the Mycenæan invader. But the invader's system of writing is not less antique because he is a newcomer in the island. On the contrary, as the excavations at Abydos have shown, the Mycenæan script, which in many of its forms corresponds to the Egyptian pottery marks antedating even the First Dynasty, is as old as the hieroglyphic writing, if not older. Whether the forms of this script were syllabic or alphabetic, we do not yet know. The forms bear resemblances not only to the Egyptian pottery marks, but also to the forms of the Cyprian syllabary. Moreover, this script has many points of resemblance to that which is employed in Asia Minor for Carian and for Lycian, to that of the ancient Iberian inscriptions in Spain, and even to the modern Berber writing. Isolated resemblances are of course no proof of relationship. As has already been remarked, the possible permutations and combinations of a few straight or crooked strokes are very limited, and therefore in widely separated areas similar forms may arise accidentally. Here, however, the differences are too small, as compared with the resemblances, to admit of the possibility that the similarities are merely accidental. It is too early to dogmatize, but facts seem to favour Professor Flinders Petrie's view of the origin of the alphabet—that out of a large body of symbols in use from prehistoric times around the shores of the Mediterranean, the Phœnicians, to whom hitherto the development of the alphabet has been attributed, specialized as alphabetic signs those which they had utilized as numerals, and that this specialization was the starting-point of the alphabet as we know it. The use as numerals "would soon render these signs as invariable in order as our own numbers, and force the use of them on all countries with which the Phœnicians traded. Hence, before long these signs drove out of use all others, except in the less changed civilization of Asia Minor and Spain. This exactly explains the phenomena of the early Greek alphabets; many in variety, and so diverse that each has to be learned separately, and yet entirely uniform in order. Each tribe had its own signs for certain sounds, varying a good deal; yet all had to follow a fixed numerical system. Certainly all did not learn their forms from an independent Phœnician alphabet, unknown to them before it appeared as a whole. The history of the alphabet is as old as civilization."[5]

Cretan systems.

It is to be noticed, however, that even in ancient times there was a tradition that Crete acted as an intermediary for the spread of civilization in Caria and Lycia. According to Herodotus (i. 171), the Carians came into Asia from the islands; while the people of Caunus, whose language Herodotus regarded as very closely akin to the Carian, according to their own tradition (which he rejects) came from Crete (i. 172). He admits that the Lycians are of Cretan ancestry (i. 173); and, by his language regarding them, he seems to identify them with the Ἐτεόκρητες. The excavations at Knossos, however, seem to indicate a close relationship between Caria and the "Mycenæan" civilization there discovered. Carian and Lycian seem to be closely connected, but there is no satisfactory proof that the languages are of the Indo-European stock. On the other hand, the Phrygian inscriptions show a language which is certainly closely akin to Greek. In none of the three tongues do the inscriptions go back earlier than the 6th century B.C. Hence, although owing to the great difference in sounds between Greek and these languages of Asia Minor (especially Lycian), the alphabets show a considerable number of symbols different from any Greek alphabet, it has been customary to assume that their alphabets were derived from some Greek alphabet, the Dorian system of Rhodes being generally fixed upon as the ancestor. This view, however, is at once rendered doubtful by Mr Evans's discovery at Knossos of a third form far more closely resembling Greek writing than the linear script of the great mass of clay tablets discovered in 1900. "Out of twenty-one varieties ten are practically identical, both in shape and position, with later Greek alphabetic forms; while four more are the same, though in a different position. Thus we have—Δ, Λ, H, Ν, Ξ, Π, Þ, Y, +, and a form approaching the digamma, as well as Ǝ, ⅂, —, ⋖. Yet the Mycenæan date of these bone pieces is as well ascertained as anything found within the walls of the palace."[1]

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[1] *The Royal Tombs of the First Dynasty*, vol. i. (1900), p. 31.

[2] See *Annual of British School at Athens*, vi. (1899–1900), p. 55 ff., and for the later excavations, vii. (1900–1901), p. 10 and p. 100 ff.; and *Athenæum*, 5th July 1902, p. 36.

[3] "Primitive Pictographs and a præ-Phœnician Script from Crete and the Peloponnese," vol. xiv. pp. 270–372; "Further Discoveries of Cretan and Aegean Script, with Libyan and Proto-Egyptian Comparisons," vol. xvii. pp. 327–395. The two articles are also published together as a separate volume.

[4] Cp. *Journal of Hellenic Studies*, xiv. p. 362.

[5] *Royal Tombs*, i. p. 32.

Ownership marks.

At this point we seem to be driven to the conclusion that the symbols found upon Egyptian pottery, the varieties of which run into hundreds, may have arisen, not from pictographs, but from the third of the needs indicated at the beginning of this article. The sign scratched upon pottery indicates one of two things: (*a*) that it is the property of the man who made it, and that he wishes to be able to retain it by putting such a mark upon it; (*b*) that his work is recognized by his neighbours as of high quality. The mark, like its modern development, the trade mark, is at once a certificate of value and an advertisement of the maker. Such indications have existed at all periods in the world's history. They imply knowledge neither of literature nor of ability to write in the ordinary sense of the word. They are still in use among the Samoyedes and other peoples of the northern parts of the Russian empire, who at no period of their history are known to have been able to write. In the United Kingdom they are used to mark cattle and other animals which are sent to a distant market, or are liable to be confused with the property of other owners. Among the Swedish Lapps these marks present a considerable likeness to the old Norse runes. Still more remarkable is the resemblance which the property marks of the Cheremissian and Chuwash tribes of Russia present to the symbols found in Egypt and Crete.[2] Among them are the symbols H, X, Ч, Ψ, Ӿ, ⋈. Among the Samoyede signs are)–(, T, Ʌ, X̄, И, Ƶ, ≷. The *tamga* or brands used to mark their horses by the Circassians present other forms which resemble those of Egypt and Crete. Here, however, the forms are more complex. Writing, as generally understood, is altogether unknown among the Wotjaks, but each father of a family has his own distinctive mark, which passes to his son at his death, or if there are several sons, is divided amongst them. How the division is carried out our authorities unfortunately do not inform us.

Of the same nature are the masons' marks, which are found wherever in the Old World great building operations have been undertaken. They have in regions very distant from one another so close a resemblance that Brugsch[3] contends that the stones in the quarries were marked according to a definite system, and that the ancient gilds of stonecutters possessed an alphabet, possibly of a cryptic nature, which survived down to the 17th century. Among the sixteen forms which Brugsch gives appear T, +, Σ, Δ, A, O, ⊙, ♀.

As the Greek-looking signs on the Mycenæan bone pieces which were found by Mr Evans at Knossos were accompanied by upright strokes, which are obviously intended to indicate numbers, it seems safe to assume, provisionally at least, that the symbols were owners' marks. But any further research into this question is impossible until the signs and the various forms of script have been completely published. Table I. (p. 901) will illustrate the varieties of form of these symbols which have prevailed since the earliest times around the shores of the Mediterranean.[4] From the table it is clear enough that the early Phœnician alphabet, from which the earliest Greek alphabets in historical times are derived, is not independent of these symbols, however or wherever they may have originated.

Moabite stone.

The discovery of the famous Moabite stone in 1868 gave a new impulse to the study of the alphabet (see Table II., p. 902). It is to be remembered, however, that important as this monument is for the development of the alphabet, and because it can be dated with certainty as not much later than 895 B.C., the dialect and alphabet of Moab are not proof for the Phœnician forms which influenced the peoples of the Aegean and, through them, western Europe. The fragment of a bronze bowl discovered in Cyprus in 1876,[5] which bears round its edge an inscription dedicating it to Baal-Lebanon as a gift from a servant of Hiram, king of the Sidonians, is probably the oldest Phœnician document which we possess. This bowl, though perhaps a little earlier than the Moabite stone, in all probability is not more than a century older, while some think it is even later.

Relationship of Phœnician with Assyrian.

We have already seen that the symbols of the alphabet were in existence thousands of years before the date of the Moabite stone and the bowl of Baal-Lebanon, and that de Rougé's theory of the development of the Phœnician alphabet from Egyptian hieratic is destitute of foundation. The rival theory propounded by Deecke in 1877[6] never met with much acceptance. Deecke contended that the early Semitic alphabet was derived from the late Assyrian cursive cuneiform. He unduly magnified, however, the undoubted resemblances of some of the forms by taking similar ones from different geographical areas and different epochs and classing them all together as if they formed a uniform series. As we are still only on the threshold of investigation into the early history of the alphabet, it is possible that further discoveries may show that the Phœnicians owed more to Assyrian culture than is at present proved. Meanwhile there is no evidence whatever that the Phœnician alphabet was of Assyrian origin,[7] and such evidence, if discovered, must carry back the Phœnician alphabet thousands of years earlier than any date which can at present be established for its existence. Though we know of the existence of the symbols from an early date, we have at present no certain evidence of what the values of the symbols at this date were. Wherever the symbols originated, it was to the Phœnicians that the Western world owed its alphabet, as is clear (1) from the forms of the letters themselves; (2) from the names which the Greeks gave to them; (3) from the Greek tradition of such origin.

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[1] Evans, *Annual of British School at Athens*, vii. (1900–1901), p. 118. The bone pieces referred to were shaped like fishes. "On their under sides were engraved a series of signs accompanied by various scores in the shape of perpendicular lines, like those which on the clay tablets with the linear script indicate units."

[2] These Russian marks are most accessible in Andree's *Ethnographische Parallelen und Vergleiche* (Neue Folge, Leipzig, 1889). Schiefner called attention to the Samoyede marks in the *Bulletin Historico-philologique de l'Académie de St Pétersbourg* for 1855, 301 ff. Homeyer's *Die Haus- und Hofmarken*, 1870 (reprinted with appendix, 1890), contains the fullest treatment of the subject.

[3] *Reise nach Persien*, ii. p. 61. The marks from the Servian Wall at Rome are collected by Bruzza (*Annali del Instituto di Corrispondenza Archeologica*, xlviii. (1876), p. 72 ff.). To this collection some additions are made by Professor E. C. Clark in *Proceedings of the Society of Antiquaries* for 1901, p. 392 ff.

[4] The forms in this table are drawn from Petrie, *Royal Tombs*, p. 31; Evans, *Journ. Hell. Soc.*, xvii. p. 386; Sayce (for Carian), *Transactions of the Society of Biblical Archæology*, ix. p. 138; Kretschmer, *Einleitung in die Geschichte der griechischen Sprache*, p. 367 ff.; Kalinka (for Lycian), *Tituli Asiae Minoris*, vol. i.; Hübner (for Ancient Iberian), in *Monumenta Linguæ Ibericæ;* Maciver and Wilkin (for Libyan and Tifinagh), in *Libyan Notes* (1901).

[5] This is figured in Berger's *Histoire de l'Écriture*, p. 123, and on a larger scale in plate iv. to vol. i. of the *Corpus Inscriptionum Semiticarum*.

[6] *Der Ursprung des alt-semitischen Alphabets aus der neuassyrischen Keilschrift* (Zeitschrift der deutschen morgenländischen Gesellschaft, xxxi. p. 102 ff.). A still more sweeping theory of the same nature is propounded by the Rev. C. J. Ball in the *Proceedings of the Society of Biblical Archæology*, xv. (1893), p. 392 ff.

[7] One point of connexion has, however, been established by Zimmern (*Zeitsch. deutsch. morg. Gesell.*, vol. l. (1896), p. 668). Assyrian signs as well as Phœnician letters are used for numbers. The numbers indicated in the two cases are different, and Assyrian begins with *m*, not *a*. The symbols corresponding in name to the Phœnician Mem, Nun, 'Ajin, Pe, Resh, indicate numbers which, though not consecutive, increase from first to last. The same is true of those corresponding to Aleph, Beth, Daleth (*gamalla*, which corresponds to Gimel, is a borrowed word in Assyrian).

Relationship of Greek to Phœnician.

The discovery of a large number of very archaic inscriptions in the island of Thera which was made by Freiherr Hiller von Gärtringen in 1896, has shown that the earliest Greek alphabet was even more like the Phœnician than had been heretofore believed. The symbol for β in Thera (ᘐ) is nearer than any previously known to the Semitic letter (𐤁), though, as not infrequently happens in the transference of a symbol from one people to another, its position is inverted—a fate which in this alphabet has befallen also λ (Semitic 𐤋, Thera ⅂), and possibly σ (Semitic W, Thera M). The era of excavation initiated by Dr Schliemann on the grand scale has increased our knowledge of Greek inscriptions beyond anything that was earlier dreamt of. Besides the excavation of Athens, Delos, Epidaurus, and Delphi, the results of which are most important for the 5th century B.C. and later, the exploration of the sites of Olympia, of the Heræum near Argos, of Naucratis in Egypt, and of various Cretan towns (above all the ancient Gortyn), has revolutionized our knowledge of the archaic alphabets of Greece. We can now see how long and laborious was the process by which the Greeks attained to uniformity in writing and in numeration. In no field, perhaps, was the centrifugal tendency of the Greeks more persistent than in such matters. In numeration, indeed, uniformity was not attained till at least the 2nd century of the Christian era. The differentiation of the local alphabets is found from the very beginning of our records. Unfortunately, as yet no record is preserved which can with any probability be dated earlier than the 7th century B.C., and the Phœnician influence had by then nearly ceased. How long this influence lasted we cannot tell. If in Crete a system of writing of an entirely different nature had been developed seven or eight centuries before, there must have been some very important reason for the entire abandonment of the old method and the adoption of a new. In Crete, at least, the excavations show that the old civilization must have ended in a social and political cataclysm. The magnificent palace of Minos—there seems no reason to withhold from it the name of the great prince whom Thucydides recognized as the first to hold the empire of the sea—perished by the flames, and it evidently had been plundered beforehand of everything that a conqueror would regard as valuable. The only force in Greek history which we know that could have produced this change was that of the Dorian conquest. As everywhere in the Peloponnese, except at Argos, there seems to have been a sudden break with the earlier civilization, which can have been occasioned only by the semi-barbarous Dorian tribes, so the same result seems to have followed from the same cause in Thera. The Dorians apparently were without an alphabet, and consequently when Phœnician traders and pirates occupied the place left vacant by the downfall of Minos's empire, the people of the islands, and of the sea coasts generally, adopted from them the Phœnician alphabet. That the alphabet was borrowed and adapted independently by different places not widely separated, and that the earliest Greek alphabets did not spread from one or a few centres in Greek lands, seems clear (*a*) from the different Greek sounds for which the Phœnician symbols were utilized; (*b*) from the different symbols which were employed to represent sounds which the Phœnicians did not possess, and for which, therefore, they had no symbols. The Phœnician alphabet was an alphabet of consonants only, but all Greek alphabets as yet known agree in employing **A, E, I, O, Y** as vowels. On the other hand, a table of Greek alphabets[1] will show how widely different the symbols for the same sound were. Except for a single Attic inscription (see Plate), the alphabets of Thera and of Corinth are the oldest Greek alphabets which we possess. Yet at Corinth alongside Ɛ Ǝ, which is found for the so-called spurious diphthong ει (*i.e.*, the Attic ει, which does not represent an Indo-European ει, but arises by contraction, as in φιλεῖτε, or through the lengthening of the vowel sound as the result of the loss of a consonant, as in εἰρημένος for ϝεϝρημένος) the short ε sound is represented by **B**; ι is found at Corinth in its oldest form ≷, and also as **Σ**, while in Thera it is ϟ. In Thera the *w* sound of digamma (ϝ) was entirely lost, and therefore is not represented. Both Thera and Corinth employ in the earliest inscriptions 𐤆 for ζ, not ξ, though in both alphabets the ordinary use as ξ is adopted, no doubt through the influence of trade with other states. On the other hand, at Cleonæ, which is distant not more than 8 or 9 miles from Corinth, an ancient inscription written βουστροφηδὸν has recently been discovered, which shows that though Cleonæ for B wrote ᑯ, like the Corinthian ᒍ, and, as at Corinth, wrote **B** for a vowel sound, the vowel thus represented was not short and long *e* (ε and η) as at Corinth, but η only, as in **ΧΡΒΜΑ, ΜΒ** (χρῆμα, μή). Here Ǝ represents ε, and the spurious diphthong is represented by ει, as in ИƎΜΙƎ (εἶμεν, Doric infinitive = εἶναι), a form which shows that ι has at Cleonæ the more modern form **I** as distinguished from the Corinthian ≶.[2]

Regarding three other questions controversy still rages. These are: (*a*) how Greek utilized the four sibilants (Shin, Samech, Zain, and Tsade) which it took over from the Phœnician; (*b*) what was the history of development in the symbols for φ, χ, ψ, ω (the history of ξ belongs to both heads); (*c*) the history of the symbol for the digamma ϝ.

Greek use of Phœnician sibilants.

In the Phœnician alphabet Zain was the seventh letter, occupying the same position and having the same form approximately (𐤆) as the early Greek Z, while in pronunciation it was a voiced *s*-sound; Samech (𐤎) followed the symbol for *n* and was the ordinary *s*-sound, though, as we have seen, it is in different Greek states at the earliest period ζ as well as ξ; after the symbol for *p* came Sade (𐤑), which was a strong palatal *s*, though in name it corresponds to the Greek ζῆτα; while lastly Shin (**W**) follows the symbol for *r*, and was an *sh*-sound. The Greek name for the sibilant (σίγμα) may simply mean the hissing letter and be a derivative from σίζω; many authorities, however, hold that it is a corruption of the Phœnician Samech. Unfortunately, it is not clear how many sibilants were distinguished in Greek pronunciation, nor over what areas a particular pronunciation extended. There is, however, considerable evidence in support of the view that Greek σσ representing the sound arising from κy, χy, τy, θy, was pronounced as *sh* (ṣ), while ζ representing *gy*, *dy* was pronounced in some districts *zh* (ẓ).[3]

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[1] See, for example, the tables at the end of Roberts's *Introduction to Greek Epigraphy* (1887); or Kirchhoff's *Studien zur Geschichte des griechischen Alphabets* (ed. 4, 1887); or Larfeld's *Griechische Epigraphik* in Iwan von Müller's *Handbuch der klassischen Alterthumswissenschaft*, vol. i. (1892).

[2] Cp. Fränkel, *Corpus Inscriptionum Græcarum Peloponnesi*, i., No. 1607.

[3] See Witton, in *American Journal of Philology*, xix. p. 420 ff., and Lagerkrantz, *Zur griechischen Lautgeschichte* (Upsala, 1898).

On an inscription of Halicarnassus, a town which stood in ancient Carian territory, the sound of σσ in Ἁλικαρνασσέων is represented by Ͳ, as it is also in the Carian name Panyassis (ΠανυάͲιος, genitive), though the ordinary ΣΣ is also found in the same inscription. The same variation occurs at the neighbouring Teos, while the coins of Mesembria in Thrace show regularly ΜΕͲΑ and ΜΕͲΑΜΒΡΙΑΝΩΝ, where Ͳ represents the sound which resulted from the fusion of *θy*, and which appears in Homer as σσ in μέσσος, while in later Greek it becomes μέσος. This symbol Ͳ is in all probability the early form of the letter which was known to the Greeks as San (σάν) and at a later time as Sampi, and which is utilized as the numeral for 900 in the shape ϡ. According to Herodotus (i. 139), San was only the Dorian name for the letter which the Ionians called Sigma. This would bring it into connexion with the Phœnician W (Shin), which, turned through a right angle, is possibly the Greek Σ, though some forms of Sade on old Hebrew coins and gems (⋧ Σ) equally resemble the Greek letter. From other forms of Sade, however, the other early form of σ, viz., Μ, is probably derived. The confusion is thus extreme: the name Sade assimilated in Greek to the names ἦτα and θῆτα becomes ζῆτα, though the form is that of Zain; the name of Samech is possibly the origin of Sigma, while the form of Samech is that of Ξ which has not taken over a Phœnician name. It is probable that the form Ч is an abbreviation in writing from right to left of the earlier Μ, and ϟ of the four stroke Σ. That the confusion of the sibilants was not confined to the Greeks only, but that pronunciation varied within a small area even among the Semitic stock, is shown by the difficulty which the Ephraimites found in pronouncing "shibboleth" (Judges, xii. 6).

History of the digamma.

For the history of the additional symbols which are not Phœnician we must begin with Υ. There is no Greek alphabet in which the symbol is not represented. But the Phœnician form corresponding to it is the consonant *w*, and occupies the position of the Greek digamma as sixth in the series. Whence did the Greeks obtain the digamma? The point is not clear, but probably the Greeks acted here as they did in the case of the vowel *i* and the consonant *y*, adopting the consonant symbol for the vowel sound. As, however, except in Cyprus, Pamphylia, and Argos, the only *y* sound which survived in Greek—the glide between ι and another vowel as in διά = *diya*—is never represented, there was no occasion to use the Phœnician Jod in a double function. With Vau it was different; the *u*-sound existed in some form in all dialects, the *w*-sound survived in many far into historical times. The Phœnician symbol having been adopted for the vowel sound, whence came the new symbol Ϝ or [for the digamma? Hitherto there have been two views. Most authorities have held that the new form was derived from Ε by dropping the lowermost crossbar; some have held that it developed out of the old Vau, a view which is not impossible in itself and has the similar development in Aramæic (Tema) in its favour. But as Mr Evans has found a form like the digamma among his most recent types of symbols, and as we have no intermediate forms which will prove the development of Ϝ from Υ, though the form found at Oaxos in Crete, viz., Ν, shows a form sufficiently unlike Ϝ, it is necessary to suspend judgment.

Greek aspirates, &c.

The Greek aspirates were not the sounds which we represent by *ph*, *th*, *ch* (Scotch), but corresponded rather to the sound of the final consonants in such words as *lip*, *bit*, *lick*, the breath being audible after the formation of the consonant. It is not clear that Greek took over Θ with this value, for in one Theran inscription Θ ⊟ are found combined as equivalent to Τ—Η, while the regular representation of φ and χ is Π ⊟ and Κ ⊟, or Ϙ (koppa) ⊟ respectively. In the great Gortyn inscription from Crete and occasionally in Thera, Π (in Crete in the form C) and Κ are used alone for φ and χ, just as conversely even in the 5th century the name of Themistocles has been found upon an *ostrakon* spelt Θεμισθοκλῆς. Such confusions show that even to Greek ears the distinction between the sounds was very small. To have recorded it in writing at all shows considerable progress in the observation of sounds. Such progress is more easily indicated by changes in the symbols among a people whose acquaintance with the art is not of long standing nor very familiar. English, though possessing sounds comparable to the Greek θ, φ, χ, has never made any attempt to represent them in writing. On the other hand, no doubt Athens in 403 B.C. officially adopted the Ionic alphabet and gave up the old Attic alphabet. The political situation in Athens, however, at this time was as exceptional as the French Revolution, and offered an opportunity not likely to recur for the adoption of a system in widely extended use which private individuals had been employing for a long time.

The history of the symbols φ and χ is altogether unknown. The very numerous theories on the subject have generally been founded on a principle which itself is in need of proof, viz., that these symbols must have arisen by differentiation from others already existing in the alphabet. The explanation is possible, but it is not easy to see why, for example, the symbol ϙ or Ϙ = Koppa, the Latin Q should have been utilized for a sound so different as *p-h*; nor, again, why the symbol for θ (⊕) by losing its cross stroke should become φ, seeing that the sounds of θ and φ outside Aeolic (a dialect which is not here in question) are never confused. On the other hand, if we remember the large number of symbols belonging to the prehistoric script, it will seem at least as easy to believe that the persons who, by adding new letters to the Phœnician alphabet, attempted to bring the symbols more into accordance with the sounds of the Greek language, may have borrowed from this older script. It is now generally admitted that the improvements of the alphabet were made by traders in the interests of commerce, and that these improvements began from the great Greek emporia of Asia Minor, above all from Miletus. Symbols exactly like φ, χ, and ψ (Φ, Χ, Ψ) are found in the Carian alphabet, and transliterated by Professor Sayce[1] as *v* (and *ü*), *h*, and *kh* respectively. If the Carian alphabet goes back to the prehistoric script, why should not Miletus have borrowed them from it? We have already seen that, in the earliest alphabets of Thera and Corinth, the ordinary symbol for ξ in the Ionic alphabet was used for ζ. This usage brought in its train another—the use of Ψ, not for ψ as in Ionic, but for ξ in the name ΑΛΕΨΑ | CΟRΑ = Ἀλεξαγόρα, and similarly in Melos, . ΡΑΨ | ΙΚVΔ | ΕCΜ = Πραξικύδεος.[2] This experiment, for it was no more, belongs apparently to the latter part of the 6th century, and was soon given up. As the Ionians kept the form Ξ, which the people of Thera used for ζ, in the same position in their alphabet as Samech occupied in the Phœnician alphabet, there can be no doubt as to its origin. The symbol + which the Chalcidian Greeks used in the 6th century B.C. for ξ may be derived, according to the most widely accepted theory, from a primitive form of Samech ⊞, which is recorded only in the *abecedaria* of the Chalcidian colonies in Italy. In this case the borrowing of the Greek alphabet must long precede any Phœnician record we possess. But it is not probable that the Ionic and Phœnician ǂ developed independently from the closed form. Kretschmer, however, in several publications[1] takes a different view. He thinks that the guttural element in ξ was a spirant, and therefore different from χ, which is an aspirate. He points out that in Naxos, in a 6th-century inscription,[2] ξ in Ναξίον, ἔξοχος, and Φράξον is represented by □Σ, the first element in which he regards as a form of ⊟ = *h*. As χ is found in the same inscription (in the form X), the guttural element must have been different, else ξ would have been spelt XΣ. Attica and most of the Cyclades kept X for the guttural element in ξ (written Xϟ or +ϟ) and for χ as well. On the west of the Aegean a new symbol Ψ was invented for the aspirate value, and this spread over the mainland and was carried by emigrants to Rhodes, Sicily, and Italy. The sign X was kept in the western group for the guttural spirant in ξ, which was written XΣ; but, as this spirant occurred nowhere else, the combination was often abbreviated, and X was used for XΣ precisely as in the Italic alphabets we shall find that F = *f* develops out of a combination FH.

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[1] See especially *Proceedings of the Society of Biblical Archæology* for 1895, p. 40; *cf.* also Kalinka, *Neue Jahrbücher für Philologie*, iii. (1899), p. 683.

[2] *Inscriptiones Gr. Insularum Maris Aegaei*, Nos. 811, 1149.

The development of symbols for the long vowels η and ω was also the work of the Ionians. The *h*-sound ceased at a very early period to exist in Ionic, and by 800 B.C. was ignored in writing. The symbol ⊟ or H was then employed for the long open *ē*-sound, a use suggested by the name of the letter, which, by the loss of the aspirate, had passed from Heta to Eta. About the same period, and probably as a sequel to this change, the Greeks of Miletus developed Ω for the long open *ō*-sound, a form which in all probability is differentiated out of O. Centuries passed, however, before this symbol was generally adopted, Athens using only O for ο, ω, and ου, the spurious diphthong, until the adoption of the whole Ionic alphabet in 403 B.C.

Latin alphabet.

The discoveries of the last quarter of the 19th century carried back our knowledge of the Latin alphabet by at least two centuries, although the monuments of an early age which have been discovered are only three. (*a*) In 1880 was discovered between the Quirinal and Viminal hills a little earthenware pot of a curious shape, being, as it were, three vessels radiating from a centre, each with a separate mouth at the top.[3] Round the sides of the triangle formed by the three vessels and under the mouths runs an inscription of considerable length. The use for which the pot was intended and the purport of the inscription have been much disputed, there being at least as many interpretations as there are words in the inscription. The date is probably the early part of the 4th century B.C. Though found in Rome, the vessel is small enough to be easily portable, and might therefore have been brought from elsewhere in Italy.

The Dvenos inscription.

It is equally possible that the potter who inscribed the words upon it was not a native of Rome. One or two points in the inscription make it doubtful whether the Latin upon it is really the Latin of Rome. It is generally known as the Dvenos inscription, from the name of the maker who wrote on the vessel from right to left the inscription, part of which is DVENOS MED FECED (= *fecit*). (*b*) The second of these early records is the inscription on a gold fibula found at Præneste and published in 1887. The inscription runs from right to left, and is in letters which show more clearly than ever that the Roman alphabet is borrowed from the alphabets of the Chalcidian Greek colonies in Italy. Its date cannot be later than the 5th and is possibly as early as the 6th century B.C. The words are MANIOS MED FHEFHAKED NVMASIOI, "Manius made me for Numasius."

The Præneste fibula.

The symbol for M has still five strokes, *s* has the angular form ϟ, ϟ. The inscription is earlier than the Latin change of *s* between vowels into *r*, for *Numasioi* is the dative of the older form which corresponds to the later *Numerius*. The verb form is remarkable. In the Dvenos inscription the perfect of *facio* is *feced;* here it is a reduplicated form with the same vowel as the present. The spelling also is interesting. The symbol K is still in ordinary use, and not merely used for abbreviations as in the classical age. But most remarkable is the representation of Latin F by FH. The reason for this is clear. The value of F in the Greek alphabet is *w* and not *f* as in Latin. Greek had no sound corresponding to Latin F, consequently an attempt is made by combining F and H to indicate the difference of sound. Etruscan uses FH in the same way. As Latin, however, made the symbol V indicate not only the vowel sound *u*, but also the consonant sound *v* (*i.e.*, English *w*), the sign for the digamma F was left unemployed, and as FH was a cumbrous method of representing a sound which did not exist in Greek, the second element came to be left out in writing. Thus F came to be the representative of the unvoiced labiodental spirant instead of that for the bilabial voiced spirant. Whether the form *fefaked* was ever good Latin in Rome may be doubted, for the Romans, in spite of the few miles that separate Præneste from Rome, were inclined to sneer at the pronunciation and idiom of the Prænestines (*cf.* Plautus, *Trin.* 609, *Truc.* 691; Quintilian, i. 5, 56). (*c*) The last, and in some respects the most important of these records, was found in 1899 under an ancient pavement in the *Comitium* at the north-west corner of the Roman Forum. It is engraved upon the four sides and one bevelled edge of a pillar, the top of which has been broken off.

Forum inscription.

As the writing is βουστροφηδόν, beginning at the bottom of the pillar and running upwards and down again, no single line of the inscription is complete. Probably more than half the pillar is lost, so that it is not possible to make out the sense with certainty. The inscription is probably not older than that on the fibula from Præneste, but has the additional interest of being undoubtedly couched in the Latin of Rome. The surviving portion of the inscription contains examples of all the letters of the early alphabet, though the forms of F and B are fragmentary and doubtful. As in the Prænestine inscription, the alphabet is still the western (Chalcidian) alphabet. K is still in use as an ordinary consonant, and not limited to a symbol for abbreviations as in the classical period. The rounded form of γ is found with the value of G in RECEI, which is probably the dative of *rex*. H has still the closed form ⊟, M has the five-stroke form, S is the three-stroke Σ, tending to become rounded. R appears in the Greek form without a tail, and V and Y are both found for the same sound. The manner of writing up and down instead of backwards and forwards across the stone is obviously appropriate to a surface which is of considerable length, but comparatively narrow, a connected sense being thus much easier to observe than in writing across a narrow surface where, as in the gravestones of Melos, three lines are required for a single word. The form of the monument corresponds to that which we are told was given to the revolving wooden pillars on which the laws of Solon were painted. That the writing of Solon's laws, which was βουστροφηδόν, was also vertical is rendered probable by the phrase ὁ κάτωθεν νόμος in Demosthenes's speech *Against Aristocrates*, § 28, for which Harpocration is unable to supply a satisfactory explanation.

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[1] See especially *Athenische Mittheilungen*, xxi. p. 426.

[2] Figured in Roberts's *Introduction to Greek Epigraphy*, p. 65.

[3] It is figured most accessibly in Egbert's *Introduction to the Study of Latin Inscriptions*, p. 16.

Differentiation of Roman from Greek alphabet.

The differentiation of the Roman alphabet from the Greek is brought about (*a*) by utilizing the digamma for the unvoiced labiodental spirant F; (*b*) by dropping out the aspirates *θ*, *φ*, *χ* (Ψ in the Chalcidian alphabet, whence the Roman is derived) from the alphabet proper and employing them only as numerals, *θ* (⊙) being gradually modified till it was identified with C as though the initial of *centum*, 100. Similarly Φ became in time identified with M as though the initial of *mille*, 1000, and the side strokes of *χ* in the above form were flattened out till it became ⊥, and ultimately L, 50. (*c*) After 350 B.C., at latest, there was in Latin no sound corresponding to Z, which was therefore dropped. In the Chalcidian alphabet the symbol for *x* was placed after the symbols common to all Greek alphabets, a position which X retains in the Latin (and also in the Faliscan) alphabet. K in time passed out of use except as an abbreviation, its place being taken by C, which, as we have seen, is in the earliest inscription still *g*. Three points here require explanation: (1) Why K fell into disuse; (2) why C took the place of K; (3) why the new symbol G was put in the place of the lost Z. It is clear that C must have become an equivalent of K before the latter fell out of use. There is some evidence which seems to point to a pronunciation of the voiced mutes which, like the South German pronunciation of *g*, *d*, *b*, but slightly differentiated them from the unvoiced mutes, so that confusion might easily arise. The Etruscans, who were separated from the Romans only by the Tiber, had lost all the voiced mutes. But another cause was perhaps more potent. C and IC, as *k* was frequently written, would easily be confused in writing, and Professor Hempl (*Transactions of the American Philological Association* for 1899, p. 24 ff.) shows that the Chalcidian form of *ζ*—I developed into shapes which might have partaken of the confusion. Owing to this confusion, the new symbol G, differentiated from C, took the place of the useless I. In abbreviations, however, C remained as before in the value of G, as in the names Gaius and Gnaeus. Y and Z were added in the last century of the republic for use in transliterating Greek words containing *υ* and *ζ*.

The dialect which was most closely akin to Latin was Faliscan. The men of Falerii, however, regularly took the side of the Etruscans in wars with Rome, and it is clear that the civilization of the old Falerii, destroyed for its rebellion in 241 B.C., was Etruscan and not Roman in character. Peculiar to this alphabet is the form for *t*—↑. Much more important than the scanty remains of Faliscan is the Oscan alphabet. The history of this alphabet is different from that of Rome. It is certain from the symbols which they develop or drop that the people of Campania and Samnium borrowed their alphabet from the Etruscans, who held dominion in Campania from the 8th to the 5th century B.C. Previous to the Punic wars Campania had reached a higher stage of civilization than Rome. Unfortunately, the remains of that civilization are very scanty, and our knowledge of the official alphabet outside Capua, and at a later period Pompeii, is practically confined to two important inscriptions, the tabula Agnonensis, now in the British Museum, and the Cippus Abellanus, which is now kept in the Episcopal Seminary at Nola. Of Etruscan origin also is the Umbrian alphabet, represented first and foremost in the bronze tablets from Gubbio (the ancient Iguvium). The Etruscan alphabet, like the Latin, was of Chalcidian origin. That it was borrowed at an early date is shown by the fact that most of its numerous inscriptions run from right to left, though some are written *βουστροφηδόν*. That it took over the whole Chalcidian alphabet is rendered probable by the survival in Umbrian and Oscan, its daughter alphabets, of forms which are not found in Etruscan itself. This mysterious language, despite the existence of more than 6000 inscriptions, and the publication in 1892 of a book written in the language and handed down to us by the accident of its use to pack an Egyptian mummy, remains as obscure as ever, but apparently it underwent very great phonetic changes at an early period, so that the voiced mutes B, D, G disappeared. Of the existence of the vowel O there is no evidence. If it ever existed in Etruscan, it had been lost before the Oscans and Umbrians borrowed their alphabets. On the other hand, both of their alphabets preserve B and Umbrian G in the form >. Etruscan also retained this symbol in the form), and utilized it exactly as Latin did to replace ꓘ. Oscan, in order to represent D, introduced later a form q, thus creating confusion between the symbols for *d* and for *r*. This form was adopted for *d* because O had already been borrowed from Etruscan as the symbol for *r*, although q is also found on Etruscan inscriptions. For the Greek digamma Etruscan used both ɔ and ꟻ, but the former only was borrowed by the other languages. Etruscan, like Latin, used ⊟ ꟻ (from right to left) to represent the sound of Latin F, but, unlike Latin, adopted ⊟ not ꟻ as the single symbol. This form it then wrote as two lozenges 8, whence developed a later sign, 8, which is used also in Umbrian and Oscan. As the old digamma was kept, this new sign was placed after those borrowed from the Chalcidian alphabet. Similarly it used ǂ and I for the Chalcidian *ζ*; Umbrian borrowed the first, Oscan the second form. The form for *h* was still closed ⊟, which Etruscan passed on to Oscan, while Umbrian modified it to ⊘. The form for *m* has five strokes; from a later form ꟿ the Oscan form was borrowed. Of the two sibilants, M and ϟ or ƨ, Oscan adopted only ϟ, Umbrian both M and the rounded form ƨ. ϙ is found on Etruscan inscriptions, but not in the alphabet series preserved; neither Umbrian nor Oscan has this form. T appears in Etruscan as Y, ×, and X; of these Umbrian borrows the first two, while Oscan has a form T like Latin. Etruscan took over the three Greek aspirates, *θ*, *φ*, *χ*, in their Chalcidian forms; *θ* survives in Umbrian as ⊙, the others naturally disappear. Both Umbrian and Oscan devised two new symbols. Umbrian took over from Etruscan perhaps the sign q, but gave it the new value of a spirant which developed out of an earlier *d*-sound, but which is written in the Latin alphabet with *rs*. The second Umbrian symbol was d, which was the representative of an *s*-sound developed by palatalizing an earlier *k*. In Oscan, which had an *o*-sound but no symbol for it, a new sign was invented by placing a dot between the legs of the symbol for *u*—V. This, however, is found only in the best-written documents, and on some materials the dot cannot be distinguished. The symbol ⱶ was invented for the open *ĭ*-sound and close *ē*-sound.[1] At a much later epoch it was introduced into the Latin alphabet by the Emperor Claudius to represent *y*, and the sound which was written as *i* or *u* in *maximus*, *maxumus*, &c.

Besides the Italic alphabets already mentioned, which are all derived from the alphabet of the Chalcidian Greek colonists in Italy, there were at least four other alphabets in use in different parts of Italy: (1) the Messapian of the south-east part of the peninsula, in which the inscriptions of the Illyrian dialect in use there were written, an alphabet which, according to Pauli (*Alt-italische Forschungen*, iii. chap. ii.) was borrowed from the Locrian alphabet; (2) the Sabellic alphabet, derived from that of Corinth and Corcyra, and found in a few inscriptions of eastern-central Italy; (3) the alphabet of the Veneti of north-east Italy derived from the Elean; (4) the alphabet of Sondrio (between Lakes Como and Garda), which Pauli, on the insufficient ground that it possesses no symbols corresponding to *φ* and *χ*, derives from a source at the same stage of development as the oldest alphabets of Thera, Melos, and Crete.

From the fact that upon the Galassi vase (unearthed at Cervetri, but probably a product of Caere), which is now in the Gregorian Museum of the Vatican, a syllabary is found along with one of the most archaic Greek alphabets, and that a similar combination was found upon the wall of a tomb at Colle, near Siena, it has been argued that syllabic preceded alphabetic writing in Italy. But a syllabary where each syllable is made by the combination of a symbol for a consonant with that for a vowel can furnish no proof of the existence of a syllabary in the strict sense, where each symbol represents a syllable; it is rather evidence against the existence of such writing. The syllabary upon the Galassi vase indicates in all probability that the vase, which resembles an ink-bottle, belonged to a child, for whose edification the syllables *pa*, *pi*, *pe*, *pu*, and the rest, were intended. The evidence adduced from the Latin grammarians, and from abbreviations on Latin inscriptions like *lubs* for *lubens*, is not sufficient to establish the theory.

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[1] For further details of these alphabets, see Conway, *The Italic Dialects*, ii. p. 458 ff.

Teutonic runes.

It has been argued that the runes of the Teutonic peoples have been derived from a form of the Etruscan alphabet, inscriptions in which are spread over a great part of northern Italy, but of which the most characteristic are found in the neighbourhood of Lugano, and in Tirol near Innsbruck, Botzen, and Trent. The Danish scholar L. F. A. Wimmer, in his great work *Die Runenschrift* (Berlin, 1887), contends that the resemblance, though striking, is superficial. Wimmer's own view is that the runes were developed from the Latin alphabet in use at the end of the 2nd century A.D. Wimmer supports his thesis with great learning and ingenuity, and when allowance is made for the fact that a script to be written upon wood, as the runes were, of necessity avoids horizontal lines which run along the fibres of the wood, and would therefore be indistinct, most of the runic signs thus receive a plausible explanation. The strongest argument for the derivation from the Latin alphabet is undoubtedly the value of *f* attaching to ᚠ; for, as we have seen, the Greek value of this symbol is *w*, and its value as *f* arises only by abbreviation from FH. On the other hand, several of Wimmer's equations are undoubtedly forced. Even if we grant that the Latin symbols were inverted or set at an angle (a proceeding which is paralleled by the treatment of the Phœnician signs in Greek hands), so that ᚢ represents Latin V, ᛖ Latin E, ᛚ Latin L, and ᚦ Latin D; whilet hes ymbol for the voiced spirant ȣ is ᚦ doubled, ᛞ, ᛞ, it is difficult to believe that the symbol for the spirant *g*, viz., X, represents a Latin K (which was of rare occurrence), or again ᚾ, ᚾ a Latin N, or that the symbol for *ng*, ᛜ, represents < = *c* doubled. Moreover, the date of the borrowing seems too late. The runes are found in all Teutonic countries, and the Romans were in close contact with the Germans on the Rhine before the beginning of the Christian era. We hear of correspondence between the Romans and German chieftains in the early days of the empire. It is strange, therefore, if the Roman alphabet, which formed the model for the runes, was that of two whole centuries later, and even then the formal alphabet of inscriptions. By that time the Teutons were likely to have more convenient materials than wood whereon to write, so that the adaptation of the forms would not have been necessary. That the Germans were familiar with some sort of marks on wood at a much earlier period is shown by Tacitus's *Germania*, chap. x. There we are told that for purposes of divination certain signs were scratched on slips of wood from a fruit-bearing tree (including, no doubt, the beech; cp. *book*, German *buch* and *buchstabe*, a letter of the alphabet); the slips were thrown down promiscuously on a white cloth, whence the expert picked them up at random and by them interpreted fate. In these slips we have the origin of the Norse *kefli*, the Scots *kaivel*, which were and are still used as lots. The fishermen of north-east Scotland, when they return after a successful haul, divide the spoil into as many shares as there are men in the boat, with one share more for the boat. Each man then procures a piece of wood or stone, on which he puts a private mark. These lots are put in a heap, and an outsider is called in who throws one lot or kaivel upon each heap of fish. Each fisherman then finds his kaivel, and the heap on which it lies is his. This system of "casting kaivels,"[1] as it is called, is certainly of great antiquity. But its existence will not help to prove an early knowledge of reading or writing, for in order that everything may be fair, it is clear that the umpire should not be able to identify the lot as belonging to a particular individual. It has, however, been contended that a system of primitive runes existed whence some at least of the later runes were borrowed, and the ownership marks of the Lapps, who have no knowledge of reading and writing, have been regarded as borrowed from these early Teutonic runes.[2] Be this as it may, the resemblances between the runic and the Mediterranean alphabets are too great to admit of denial that it is from a Greek alphabet, whether directly or indirectly, that the runes are derived. That Wimmer postdates the introduction of the runic alphabet seems clear from the archaic forms and method of writing. It is very unlikely that a people borrowing an alphabet which was uniformly written from left to right should have used it in order to write from right to left, or *βουστροφηδόν*. Hence Hempl contends[3] that Wimmer's view must be discarded, and that the runes were derived about 600 B.C. from a western Greek alphabet which closely resembled the Formello alphabet (one of the ancient Chalcidian *abecedaria*) and the Sabellic and North Etruscan alphabets. He thus fixes the date at the same period as Isaac Taylor had done in his *Greeks and Goths* and *The Alphabet*. Taylor, however, derived the runes from the alphabet of a Greek colony on the Black Sea. Hempl's initiative was followed by Professor Gundermann of Giessen, who announced in November 1897[4] that he had discovered the source of the runic alphabet, the introduction of which he declares preceded the first of the phonetic changes known as the "Teutonic sound-shifting," since < = *g* is used for *k*, X = χ for *g*, a Theta-like symbol for *d*, while *zd* is used for *st*. If this view (which is identical with Taylor's) be true, we have a parallel in the Armenian alphabet, which is similarly used for a new value of the sounds. Hempl, on the other hand, contends that the sound-shifting had already taken place, and, arguing that several of the symbols have changed places (*e.g.*, ᚠ *f* and ᚨ *a*, ᚢ *u* and ᛒ *b*, because at this time *b* was a bilabial spirant and not a stop), ultimately obtains an order—a b d e f z *kgw* h i j ƕ p r s t u l m n ȣ o. As neither Gundermann nor Hempl has published the full evidence for his view, no definite conclusion at the moment is possible.

Ogam writing.

In one of the earliest runic records which we possess, the pendant found at Vadstena in Sweden in 1774, and dating from about A.D. 600 (see Plate), the signs are divided up into three series of eight (the twenty-fourth, ᛞ, being omitted for want of room). Upon the basis of this division a system of cryptography (in the sense that the symbols are unintelligible without knowledge of the runic alphabet) was developed, wherein the series, and the position within the series of the letter indicated, were each represented by straight strokes, the strokes for the series being shorter than those for the runes, or the series being represented by strokes to the left, the runes by strokes to the right, of a medial line.[5] From this system probably developed the ogam writing employed among the Celtic peoples of Britain and Ireland. The ogam inscriptions in Wales are frequently accompanied by Latin legends, and they date probably as far back as the 5th and 6th centuries A.D. Hence the connexion between Celt and Teuton as regards writing must go back to a period preceding the Viking inroads of the 8th century. Taylor, however, conjectures (*The Alphabet*, ii. p. 227) that the ogams originated in Pembroke, "where there was a very ancient Teutonic settlement, possibly of Jutes, who, as is indicated by the evidence of runic inscriptions found in Kent, seem to have been the only Teutonic people of southern Britain who were acquainted with the Gothic Futhorc." However this may be, the ogam alphabet shows some knowledge of phonetics and some attempt to classify the sounds accordingly. The symbols are as follows:[2]—

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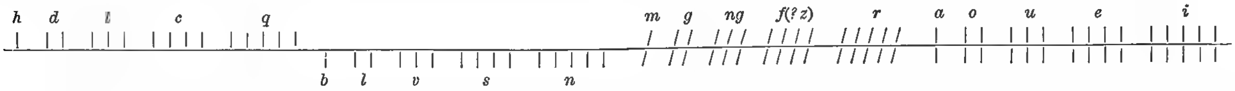
[1] This phrase, which is well known in north-east Scotland, seems to have escaped both the *New English Dictionary* and the *Dialect Dictionary*.

[2] R. M. Meyer, *Paul Braune und Sievers' Beiträge*, xxi. (1896), p. 162 ff.

[3] In a paper published in the volume of *Philologische Studien*, presented as a "Festgabe" to Professor Sievers in 1896, and in a second paper in the *Journal of Germanic Philology*, ii. (1899), p. 370 ff.

[4] See *Literaturblatt für germanische und romanische Philologie* for 1897, col. 429 f.

[5] A species of cryptography exactly like this, based upon the "abjad" order of the Arabic letters, is still in use among the Eastern Persians (E. G. Browne, *A Year Amongst the Persians*, p. 391 f.).



The form of the ogam alphabet made it easy to carve hastily; hence in the old sagas, when a hero is killed we find the common formula, "His grave was dug and his stone was raised, and his name was written in ogam." According to Sophus Müller (*Nordische Altertumskunde*, ii. p. 264), it was from Britain that the use of runes upon gravestones was derived, a use which, to judge from the number of bilingual inscriptions in Britain, the Celts derived from the Romans.

While the Carian and Lycian were, as we have seen, probably independent of the Greek in origin, so, too, at the opposite end of the Mediterranean was the Iberian (see Table I.). On the other hand, the Phrygian was very closely akin to the Greek in alphabet as well as in linguistic character. **Phrygian.** The Greek alphabet, with which it was most closely connected, was the Western, for the evidence is strongly in favour of the form Ψ having the value of χ, not ψ, in Phrygian, as it certainly has in the Etruscan inscription found on Lemnos in 1886, which is in an alphabet practically identical.

To a much later era belongs the Armenian alphabet, which, according to tradition, was revealed to Bishop Mesrob in a dream. **Armenian.** The land might have been Grecized had it not, about A.D. 387, been divided between Persia and Byzantium, the greater part falling to the former, who discouraged Greek and favoured Syriac, which the Christian Armenians did not understand. As those within Persian territory were forbidden to learn Greek, an Armenian Christian literature became a necessity. Taylor contends that the alphabet is Iranian in origin, but the circumstances justify Gardthausen and Hübschmann in claiming it for Greek. That some symbols are like Persian only shows that Mesrob was not able to rid himself of the influences under which he lived.

Of the later development of Phœnician amongst Phœnician people little need be said here. It can be traced in the *graffiti* of the mercenaries of Psammetichus at Abu Simbel in Upper Egypt, where Greeks, Carians, and Phœnicians all cut their names upon the legs of the colossal statues. Still later it is found on the stele of Byblos, and on the sarcophagus of Eshmunazar (about 300 B.C.). The most numerous inscriptions come from the excavations in Carthage, the ancient colony of Sidon. One general feature characterizes them all, though they differ somewhat in detail. The symbols become longer and thinner; in fact, cease to be the script of monuments and become the script of a busy trading people. While the Phœnician alphabet was thus fertile in developing daughter alphabets in the West, the progress of writing was no less great in the East, first among the Semitic peoples, and through them among other peoples still more remote. The carrying of the alphabet to the Greeks by the Phœnicians at an early period affords no clue to the period when Semitic ingenuity constructed an alphabet out of a heterogeneous multitude of signs. If it be possible to assign to some of the monuments discovered in Arabia by Glaser a date not later than 1500 B.C., the origin of the alphabet and its dissemination are carried back to a much earlier period than had hitherto been supposed. Next in date amongst Semitic records of the Phœnician type to the bowl of Baal-Lebanon and the Moabite stone comes the Hebrew inscription found in the tunnel at the Pool of Siloam in 1881, which possibly dates back to the reign of Hezekiah (700 B.C.). The only other early records are seals with Hebrew inscriptions and potters' marks upon clay vessels found in Lachish and other towns.[1] Like the Phœnician, these Hebrew signs are distinctly cursive in character, but, as the legend on the coins of the Maccabees shows, became stereotyped for monumental use, while the Jews after the exile gradually adopted the Aramaic writing, whence the square Hebrew script is descended. The Samaritans alone stuck fast to the old Hebrew as part of their contention that they, and not the Jews, were the true Hebrews.

The oldest records in Aramaic were found at Sindjirli, in the north of Syria, in 1890, and date to about 800 B.C. At this epoch the Aramaic alphabet, or at any rate the alphabet of these records, is but little different from that shown upon the Moabite stone. Either two sounds are confused under one symbol, or these records represent a dialect which, like Hebrew and Assyrian, shows *sh*, *z*, and *ç*, where the ordinary Aramaic representation is *t*, *d*, and *ṭ*, the Arabic *th*, *dh*, and *ṭh*. **Aramaic.** The Aramaic became in time by far the most important of the northern Semitic alphabets. Even while long and important documents in Assyria were still written on clay tablets, in cuneiform, a docket or *précis* of the contents was made upon the side in Aramaic, which thus became the alphabet of cursive writing—a fact which explains its later development. Two changes, the inception of which is early, but the completion of which belongs to the Persian period, gave the impulse which Aramaic obeyed in all its later developments. These were (*a*) the opening of the heads of letters, so that *beth* 𐤁, *daleth* 𐤃, and *resh* 𐤓 become respectively 𐡁, 𐡃, and 𐡓, while O becomes first U and ultimately V. In the later development the heads tend to be reduced in size, and finally to disappear. (*b*) As was natural in cursive writing, angles tend to become rounded, and the tails of the letters, which in Phœnician are very long, are curved round in the middle of words so as to join on to the succeeding letter. These characteristics were naturally emphasized in the Aramaic writing on papyrus which, beginning about 500 B.C., during the Persian sovereignty in Egypt, lasted on there till about 200 B.C. The gradual development of this script into the square Hebrew, and the more ornamental writing of Palmyra, may be traced in the works of Berger and Lidzbarski.[3]

In the land of the Nabatæans, a people of Arabian origin, the Aramaic alphabet was employed in a form which ultimately developed into the modern Arabic alphabet. Probably the earliest example of the Aramaic script in Arabia is the **Arabic.** stele of Tema, in north-western Arabia, whereon is commemorated the establishment of a worship of an Aramaic divinity. This monument, now in the Louvre, is not later than the 5th century B.C. In it the writing preserves its ancient form, the heads of the closed letters being only very slightly opened. The Nabatæan inscriptions belong to a different epoch and a different style. They were first discovered by Charles Doughty in 1876–77, who was followed between 1880 and 1884 by Hüber and Euting, to whom a complete collection of these records is due. The records are fortunately dated, and belong to the period from 9 B.C. to A.D. 75. A further development can be traced in the *graffiti* with which pilgrims adorned the rocks of Mount Sinai down to the 2nd or 3rd century A.D. By the help of these inscriptions it is possible to trace the development of the modern Arabic where so many of the forms of the letters have become similar that diacritic points are essential to distinguish them, the original causes of confusion being the continuous development of cursive writing and the adoption of ligatures. Arabic writing, as known to us from documents of the early Mahommedan period, exhibits two principal types which are known respectively as the Cufic and the *nashki*. The former soon fell into disuse for ordinary purposes and was retained only for inscriptions, coins, &c.; the latter, which is more cursive in character, is the parent of the Arabic writing of the present day. Another form of the Aramaic alphabet, namely, the so-called Estrangela writing which was in use amongst the Christians of northern Syria, was carried by Nestorian missionaries into Central Asia and became the ancestor of a multitude of alphabets spreading through the Turkomans as far east as Manchuria.

There still remains a branch of the Semitic languages which, except for one or two of the languages belonging to it, was practically unknown till recent years. This is the South Semitic. Till the 19th century the earliest form known of this alphabet was the Ethiopian or Geez, in which Christian documents have been preserved from the early centuries of our era, and which is still used by the Abyssinians for liturgical purposes.

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[1] These are figured most accessibly in Lidzbarski's article on the alphabet in the *Jewish Encyclopædia*, vol. i. (1901).

[2] *Cf.* Rhŷs, *Outlines of Manx Phonology*, p. 73 (Publications of the Manx Society, vol. xxxiii.); Rhŷs and Brynmor Jones, *The Welsh People*, pp. 3, 502. An interpretation of the oldest ogam inscriptions is given by Whitley Stokes in *Bezzenberger's Beiträge*, xi. (1886), p. 143 ff. Besides the collections of ogams by Brash (1879) and Ferguson (1887), a new collection by Mr R. A. S. Macalister is in course of publication (*Studies in Irish Epigraphy*, 1897, 1902). Professor Rhŷs, who at one time considered runes and ogam to be connected, now thinks that ogam was the invention of a grammarian in South Wales who was familiar with Latin letters.

[3] See Berger's *Histoire de l'Écriture dans l'Antiquité*, p. 252 ff.; Lidzbarski, *Nordsemitische Epigraphik*, p. 186 ff., from whom this summary is taken. Lidzbarski's second volume contains the most convenient collection of Northern Semitic inscriptions for the student's purposes.

South Semitic.

The travels of two English naval officers, Wellsted and Cruttenden, through Yemen in southern Arabia in 1835, first called attention to the earlier monuments of Arabia. Fulgence Fresnel first established the importance of the inscriptions discovered by these Englishmen, and in 1843, when French consul at Jeddah, obtained through a French traveller, François Arnaud, information about other monuments of the same kind. In 1869 Joseph Halévy brought back nearly seven hundred inscriptions from Yemen, and this number has been increased from other quarters by several thousands, through the energy of several adventurous scholars, but chiefly by Eduard Glaser's repeated journeys. The south Arabian inscriptions to which the terms Himyaritic and Sabæan are applied fall into two groups, the Sabæan proper and the Minæan. These are distinguished by differences in grammar and phraseology rather than in alphabet. The relative age of the Minæan and Sabæan monuments is a matter of dispute amongst Semitic scholars. Inscriptions in a kindred dialect were brought from El-Ola, in the north of the Hedjaz, by Professor Euting. To these D. H. Müller[1] gave the title of Lihyanite, from the name of the tribe (Liḥjân) to which they belong. Their date is supposed to be earlier than that of the Sabæan and Minæan. Minæan inscriptions were found at the same place, the Minæans having had a trading station there. In 1893 J. Theodore Bent copied carefully at Yeha in Abyssinia a few inscriptions, some of which had been already copied in 1814 by the English traveller Salt. These inscriptions are of the greatest importance, because they demonstrate, according to D. H. Müller,[2] that the Sabæans had colonized Abyssinia as early as 1000 B.C. Other inscriptions copied by Bent at Aksum belong to the 4th century A.D. and later. Two of the earliest are written in Sabæan characters, but in the language which is known as Geez or Ethiopic. From about A.D. 500 Ethiopic was written in an alphabet which according to Müller was no gradual growth but an ingenious device of a Greek scholar of this period at the court of Abyssinia. The Sabæan, like other Semitic, inscriptions are generally written from right to left, but a few are βουστροφηδόν; the Ethiopic is written from left to right, and makes a marked advance upon the ordinary Semitic manner of writing by indicating the vowels. This is done by varying the form of the consonant according to the vowel which follows it. The Ethiopic system is thus rather a syllabary than an alphabet. It is noticeable that the changes thus established were made upon the basis of the old Sabæan script, which in its oldest form is evidently closely related to the old Phœnician, though it would be premature to say that the Sabæan alphabet is derived from the Phœnician. It is as likely, considering the date of both, that they are equally descendants from an older source. The characteristics of the Sabæan are great squareness and boldness in outline. It has twenty-nine symbols, whereby it is enabled to differentiate certain sounds which are not distinguished from one another in the writing of the Northern Semites. As we have seen, it is a tendency in Northern Semitic to open the heads of letters, and therefore it is possible that the Sabæan form for Jod ♀ may be older than the Phœnician ⺄. Similarly if *Pē* means *mouth*, Hommel is right in contending that the Sabæan ◇ is more like the object than the Phœnician ↄ, if we suppose the form, like ⋝ or the Phœnician ⩗ and ⋚ for the Phœnician ʳ /, turned through an angle of 90°. So also if Kaf corresponds to the Babylonian *Kappu*, "hollow-hand," the Sabæan form ⋂ which Hommel[3] interprets as the outline of the hand with the fingers turned in and the thumb raised is a better pictograph than the various meaningless forms of *k* (⋎, &c.).

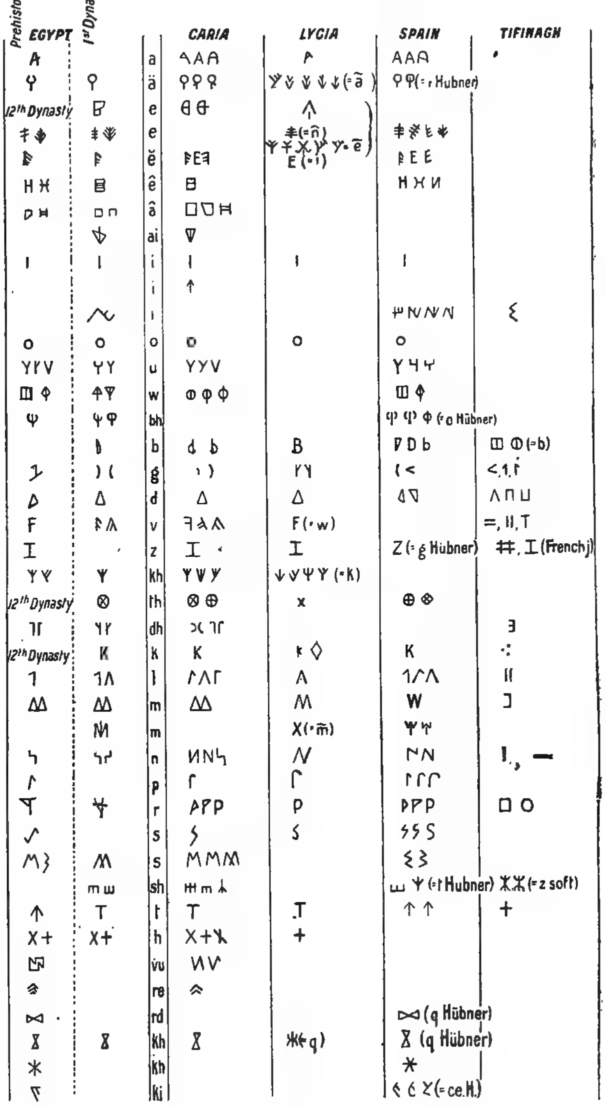
The rock inscriptions in the wild district of Safah near Damascus which have been collected by Halévy are also written in an Arabic dialect, but, owing chiefly to their careless execution, they are to a large extent unintelligible. The character appears to be akin to the Sabæan. It has been suggested that they were the work of Arabs who had wandered thus far from the south.

There still remain for discussion the alphabets of the Indo-European peoples of Persia and India from which the other alphabets of the Farther East are descended. We have already seen that when Darius in 516 B.C. caused the great Behistun inscription to be engraved, it was the cuneiform writing that was adopted for this purpose. We have also seen that at Babylon itself the Aramaic language and character were well known. It is probable therefore, *à priori*, that from the Aramaic alphabet the later writing of Persia should be developed. The conclusion is confirmed by the coins, the only records with Iranian script which go back so far; but the special form of Aramaic from which the Iranian alphabet is derived must at present be left undecided. The later developments of the Iranian alphabet are the Pahlavi and the Zend, in which the MSS. of the Avesta are written. Of these manuscripts none is older than the 13th century A.D. The Pahlavi is properly the alphabet of the Sassanid kings who ruled in Persia from A.D. 226 till the Arab conquest in the 7th century A.D. Under the Sassanids the old Persian worship, which had fallen with the Achæmenid dynasty in Alexander's time, and had been neglected by the subsequent Arsacid line, was revived and the remains of its liturgical literature collected. The name is, however, also applied to the alphabet on the coins of the Parthian or Arsacid dynasty, which in its beginnings was clearly under Greek influence; while later, when a knowledge of Greek had disappeared, the attempts to imitate the old legends are as grotesque as those in western Europe to copy the inscriptions on Roman coins. The relationship between the Pahlavi and the Aramaic is clearest in the records written in the "Chaldæo-Pahlavi" characters; the most important of these documents is the liturgical inscription of Hadji-abad where the Arsacid and Sassanian alphabets are found side by side. Taylor (*The Alphabet*, ii. p. 248 f.) regards the former as probably derived from the "ancient alphabet of Eastern Iran, a sister alphabet of the Aramæan of the satrapies," while the Sassanian belongs to a later stage of Aramaic.

Persia.

The alphabets of India all spring from two sources: (*a*) the Kharoṣṭhī, (*b*) the Brāhmī alphabet. The history of the former is fairly clear. It was always a local alphabet, and never attained

TABLE 1. EARLIEST MEDITERRANEAN SYMBOLS


Prehistoric
1st Dynasty
EGYPT
CARIA
LYCIA
SPAIN
TIFINAGH
a
ä
e
e
ĕ
ê
â
ai
i
i
i
o
u
w
bh
b
g
d
v
z
kh
th
dh
k
l
m
m
n
p
r
s
s
sh
t
h
vu
re
rd
kh
kh
ki
12th Dynasty
12th Dynasty
12th Dynasty
(= r Hübner)
(= o Hübner)
(= b)
(= w)
(= g Hübner)
(French)
(= K)
(= m̃)
(= t Hübner)
(= z soft)
(q Hübner)
(q Hübner)
(= ce.H.)

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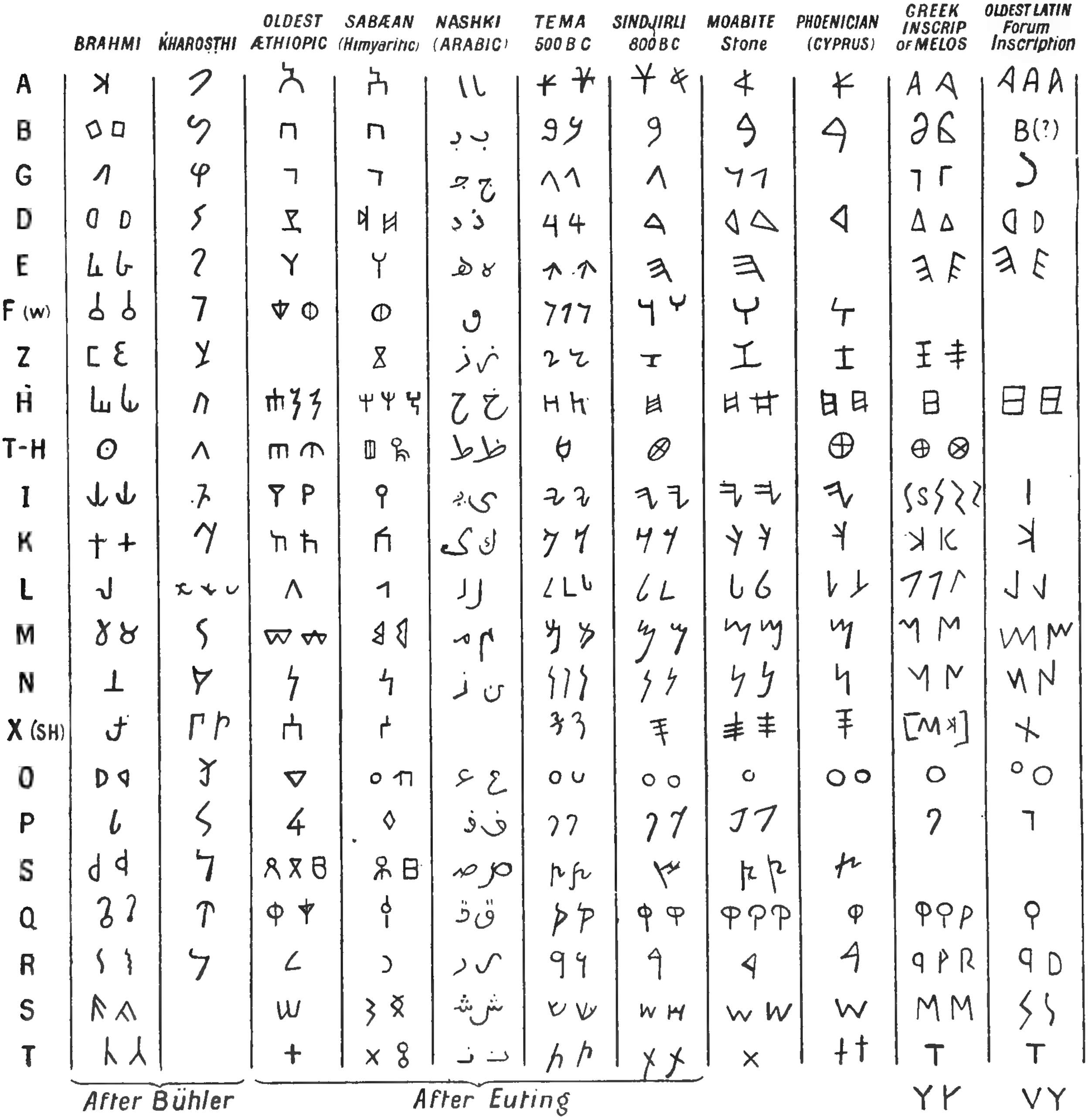
[1] Müller, *Epigraphische Denkmäler aus Arabien* (Vienna, 1889).
[2] *Epigraphische Denkmäler aus Abessinien* (Vienna, 1894).
[3] Hommel, *Süd-arabische Chrestomathie* (Munich, 1893), p. 5.

the importance of its rival. **India.** According to Bühler,[1] its range lay between 69° and 73° 30′ E. and 33° to 35° N., a conclusion which is not invalidated by the fact that some important modifications are found beyond this area, nor by Dr Stein's discovery of a great mass of documents in this alphabet at Khotan in Turkestan, for, according to tradition, the ancient inhabitants of Khotan were emigrants banished in the time of King Açoka from the area to which Bühler assigns this alphabet (see Stein's *Preliminary Report*, 1901, p. 51). Rapson[2] has pointed out that both Kharoṣṭhī and Brāhmī letters are found upon Persian silver *sigloi*, which were coined in the Punjab and belong to the period of the Achæmenid kings of Persia. As Bühler shows in detail, the Kharoṣṭhī alphabet is derived from the alphabet of the Aramaic inscriptions which date from the earlier part of the Achæmenid period. The Aramaic alphabet passed into India with the staff of subordinate officials by whom Darius organized his conquests there. The people of India already possessed their Brāhmī alphabet, but had this other alphabet forced upon them in their dealings with their rulers. The Kharoṣṭhī is then the gradual development under local conditions of the Aramaic alphabet of the Persian period. As Stein's explorations show, both alphabets may be found on opposite sides of the same piece of wood.

TABLE II.—*Development of the Semitic Alphabet.*


BRAHMI
KHAROSṬHI
OLDEST ÆTHIOPIC
SABÆAN (Himyaritic)
NASHKI (ARABIC)
TEMA 500 B C
SINDJIRLI 800 B C
MOABITE Stone
PHOENICIAN (CYPRUS)
GREEK INSCRIP OF MELOS
OLDEST LATIN Forum Inscription
A
B
G
D
E
F (W)
Z
Ḣ
T-H
I
K
L
M
N
X (SH)
O
P
S
Q
R
S
T
B(?)
After Bühler
After Euting

The history of the Brāhmī alphabet is more difficult. In its later forms it is so unlike other alphabets that many scholars have regarded it as an invention within India itself. The discovery of earlier inscriptions than were hitherto known has, however, caused this view to be discarded, and the problem is to decide from which form of the Semitic alphabet it is derived. Taylor (*The Alphabet*, ii. p. 314 ff.), following Weber, argues that it comes from the Sabæans who were carrying on trade with India as early as 1000 B.C. Even if the alphabet had not reached India till the 6th century B.C., there would be time, he contends, for the peculiarities of the Indian form of it to develop before the period when records begin. The alphabet, according to Taylor, shows no resemblance to any Northern Semitic script, while its stiff, straight lines and its forms seem like the Sabæan. Bühler, on the other hand, shows from literary evidence that writing was in common use in India in the 5th, possibly in the 6th, century B.C. The oldest alphabet must have been the *Brāhmī lipi*, which is found all over India. But he rejects Taylor's derivation of this alphabet from the Sabæan script, and contends that it is borrowed from the North Semitic. To the pedantry of the Hindu he attributes its main characteristics, viz.: (*a*) letters made as upright as possible, and with few exceptions equal in height; (*b*) the majority of the letters constructed of vertical lines, with appendages attached mostly at the foot, occasionally at the foot and at the top, or (rarely) in the middle, but never at the top alone; (*c*) at the tops of the characters the ends of vertical lines, less frequently straight horizontal lines, still more rarely curves or the points of angles opening downwards, and quite exceptionally, in the symbol *ma*, two lines rising upwards. A remarkable feature of the alphabet is that the letters are hung from and do not stand upon a line, a characteristic which, as Bühler notes (*Indian Studies*, iii. p. 57 *n.*), belongs even to the most ancient MSS., and to the Açoka inscriptions of the 3rd century B.C. When these specially Indian features have been allowed for, Bühler contends that the symbols borrowed from the Semitic alphabet can be carried back to the forms of the Phœnician and Moabite alphabets. The proof deals with each symbol separately; as might be expected of its author, it is both scholarly and ingenious, but, it must be admitted, not very convincing. Further evidence as to the early history of this alphabet must be discovered before we can definitely decide what its origin may be. That such evidence will be forthcoming there is little doubt. Even since Bühler wrote, the vase, the top of which is reproduced (see Plate), has been discovered on the borders of Nepal in a stupa where some of the relics of Buddha were kept. The inscription is of the same type as the Açoka inscriptions, but, in Bühler's opinion (*Journal of the Royal Asiatic Society*, xxx., 1898, p. 389), is older than Açoka's time. It reads as follows: *iyaṃ salilanidhane Budhasa bhagavate sakiyanaṃ sukitibhatinaṃ sabhaginikanaṃ saputadalanaṃ.* "This casket of relics of the blessed Buddha is the pious foundation (so Pischel, no doubt rightly, *Zeitsch. deutsch. morg. Gesell.*, vol. lvi. p. 158) of the Çākyas, their brothers and their sisters, together with children and wives."

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[1] Bühler, *Indian Studies*, iii. (2nd edition, 1898), p. 93. The account of these alphabets is drawn from this work and from the same author's *Indische Palæographie* in the *Grundriss der indo-arischen Philologie*, to which is attached an atlas of plates (Strasburg, 1896), and in which a full bibliography is given.

[2] For a coin and a gild token with inscriptions see Rapson's *Indian Coins* (in *Grundriss d. ind-ar. Phil.*), plate i.

How this alphabet was modified locally, and how it spread to other Eastern lands, must be sought in the specialist works to which reference has already been made.

AUTHORITIES.—Since the article on Alphabet in the ninth edition of this Encyclopædia in 1875, the only general works that have been produced are *The Alphabet* (2 vols.), by Canon Isaac Taylor (1883), reprinted from the stereotyped plates with small necessary corrections (1899); and *Histoire de l'Écriture dans l'Antiquité*, par M. Philippe Berger (Paris 1891, 2nd edition 1892). The literature of separate departments has been indicated in the notes. The writer is indebted to Mr A. J. Evans for the photograph of a Cretan tablet and for information regarding the excavations in Crete, and to Professors H. A. Giles and Bevan of Cambridge and Mr F. W. Thomas, sub-librarian of the India Office, for help in their respective departments of Chinese, Semitic, and Indian languages.

(P. GL.)

Wuchang, the capital of the combined provinces of Hupeh and Hunan, China, situated on the right bank of the river Yangtse, almost directly opposite the foreign settlement of Hankow. It is the seat of the provincial government of the two Hu or Hukwang, as these provinces are collectively termed, at the head of which is a governor-general or viceroy. Next to Nanking and Canton, it is one of the most important vice-royalties in the empire, disposing of large revenues, and employing a considerable military force, which is partially foreign drilled and armed. It possesses an arsenal, and a mint for the coinage of silver dollars and copper cash. The provincial government has also at great cost established iron-works for the manufacture of rails and other railway material. As the works did not pay under official management, they have been transferred to the director-general of railways. Wuchang is not open to foreign trade and residence, but a considerable number of missionaries, both Catholic and Protestant, live within the walls and carry on their work without molestation. The native population is estimated at 800,000, including cities on both banks.

Wuchow, a treaty port in the province of Kwangsi, China, situated on the left bank of the Si-kiang (West river), at its junction with the Fuho. It is 220 miles above Canton, with which it is in navigable connexion for vessels drawing up to eight feet of water. It is a large commercial centre for local distribution of goods. The country round about is rich and in a high state of cultivation. In 1900 the value of the trade passing through the maritime customs amounted to H. taels 6,552,590 (£1,017,000), representing, however, only a portion of the trade. Of this total, two-thirds were for imports, consisting principally of cotton and cotton goods, kerosene oil, woollens, &c. Sugar, various oils, hides, and aniseed were the chief exports. The native population is estimated at about 50,000. The scenery on the Si-kiang, as Wuchow is approached, is very fine. At Shuihing the river cuts transversely a ridge of hills, and flows for five miles through a deep gorge bordered by limestone cliffs 2000 feet in height. Farther up the river threads its way through a series of rocky defiles, forming at intervals what seems an inland lake with no apparent outlet. During summer floods the water thus pent up by the gorges rises at Wuchow 50 or 60 feet.

Wun, a town and district of India, in Berar or the Haidarabad Assigned Districts. Population of the town (1881), 4207; (1891), 4856. There is no municipality. An important cattle fair is held annually. The district of WUN has an area of 3911 square miles; population (1881), 392,102; (1891), 471,613; (1901), 466,811. The land revenue and rates are Rs.6,63,458; cultivated area (1897–98), 1,178,219 acres; number of police, 440; boys at school (1896–97), 4775; death-rate (1897), 41·6 per 1000. The principal crops are millet, cotton, pulse, oilseeds, and wheat. The chief centre of trade is Yeotmal (population, 6464), where cotton is ginned and pressed, and exported by road to the railway in the neighbouring district of Amraoti. Coal has been found, but is no longer worked; and iron ore abounds.

Wundt, Wilhelm Max (1832–——), German physiologist and philosopher, was born 16th August 1832 at Neckarau, in Baden. He studied medicine at Tübingen, Heidelberg, and Berlin, and in 1857 began to lecture at Heidelberg on medical subjects. In 1864 he became assistant professor there, and in 1866 was chosen to represent Heidelberg in the Baden Chamber, but he soon resigned this office. In 1874 he was elected regular professor of philosophy at Zürich, and in the following year was called to the corresponding chair at Leipzig. The list of Professor Wundt's works is a long and comprehensive one, for it includes physiology, psychology, logic, and ethics. His earlier works deal chiefly with physiology, though often in close connexion with psychology, as in the *Vorlesungen über die Menschen- und Tier-seele* (1863), *Lehrbuch der Physiologie des Menschen* (1865), and *Grundzüge der physiologischen Psychologie* (1874). He published an important work on *Logik* (1880–83), and this was followed in 1886 by his *Ethik*. According to Wundt, the straight road to ethics lies through ethnic psychology, whose especial business it is to consider the history of custom and of ethical ideas from the psychological standpoint. We must look for ethics to supply the corner-stone of metaphysics, and psychology is a necessary propædeutic. The *System der Philosophie* (1899) contains the results of all Wundt's past work, both in the domain of science and in the more strictly philosophic field. The metaphysical or ontological part of psychology is in Wundt's view the actual part, and with this the science of nature as well as the science of mind are to be brought into relation, and thus constituted as far as possible philosophical sciences. In 1892 Wundt published a volume on *Hypnotismus und Suggestion.* The *Philosophische Studien*, published at Leipzig, contains articles by Wundt and his pupils, dealing chiefly with experimental psychology. (See also METAPHYSICS.)

Wurnu. See NIGERIA.

Würtemberg, a kingdom of Germany, with an area of 7528 square miles, and population (1885), 1,995,185; (1895), 2,081,151; (1901), 2,169,434. The density is thus 288 inhabitants to the square mile. The population of the four circles into which the kingdom is divided is shown in the following table :—

Circle.	Area in sq. miles.	Population, 1895.	Population, 1900.	Density per sq. mile, 1900.
Neckar . .	1284	697,373	745,675	581
Black Forest .	1842	488,431	509,258	276
Jagst . .	1984	398,887	400,005	201
Danube . .	2418	496,460	514,496	213
Total .	7528	2,081,151	2,169,434	288

Between 1885 and 1895 the population thus increased at the rate of 4·3 per cent., and between 1895 and 1900 at the rate of 4·2 per cent. In the last-mentioned year the urban population numbered 35 per cent. of the whole, and the rural population 65 per cent. There were 1,052,716 males and 1,116,718 females, or 1060 females for every 1000 males. Classified according to religion, 1,497,349, or 69 per cent., were Evangelical Protestants in 1900, and 649,876, or 30 per cent., Roman Catholics; Jews numbered 11,859; "others," 10,350. The marriage-rate was 7·8 per 1000 inhabitants, the birth-rate 35·4, the death-rate 22·1. The illegitimate births were just under 10 per cent. of the total births. Würtemberg takes the very highest rank in respect of educational efficiency, a result largely due to the energy and talent of the late Dr von Sarwey. There is not an individual in the kingdom, above ten years of age, who cannot both read and write. In 1900 there were 2340 elementary public schools, 174 modern and classical schools, and 6 lyceums. The higher branches of learning are provided in the University of Tübingen (1489 students and 102 professors in 1901), in the technical high school, with academic rank since 1900, of Stuttgart (627 students in 1900), and at various special schools, *e.g.*, the royal building trades school (over 800 pupils), the veterinary high school at Stuttgart, the commercial college at Stuttgart, and two commercial improvement schools, one at Stuttgart, the other at Heilbronn. There are, further, seven spinning, weaving, and knitting schools, and a mechanicians' technical school. Stuttgart is famous for its conservatory of music, and has a good school of art. In 1899 there were twelve girls' higher schools, the Olga Institute and the Catherine Institute (two colleges for girls), and the girls' gymnasium (founded in 1899). The agricultural college of Hohenheim (usually about 100 students) is one of the best equipped institutions of the kind in Europe. In addition there are three farming schools and nearly a dozen winter agricultural schools. There is a school of viticulture at Weinsberg. The emigration steadily decreased from 6445 in 1888 to 1151 in 1898, but was 1250 in 1899 and 1160 in 1900.

Agriculture.—Of the entire area, 64 per cent. is under cultivation, mostly by peasant proprietors. In 1895 the total number of farms was 306,643, and of these 106,846, or 34·8 per cent., were each less than 2½ acres; 173,422, or 56·6 per cent., were each between 2½ and 25 acres; 26,219 between 25 and 250 acres; and 156 exceeded 250 acres. Some 1,080,000 persons, or half of the entire population, are supported by agriculture. In 1900 vineyards covered 41,740 acres, and yielded 9,637,000 gallons of wine, valued at close upon one million sterling; and 11,640 acres were planted with hops. The fruit crop, chiefly of cherries and apples (which are made into cider), averages some £400,000 annually. In 1900 the live stock comprised 1,017,683 cattle, 512,485 pigs, 315,965 sheep, and 112,129 horses. The kingdom has over 400 co-operative dairies.

Mining and Industry.—Salt-works produced 280,870 tons of salt, valued at £103,900, in 1900. The produce of the iron foundries and furnaces amounted to 48,920 tons, and was valued at £565,400. The sugar factories turned out 14,410 tons of sugar; the breweries, 85,286,300 gallons of beer; and the distilleries, 862,970 gallons of pure alcohol. The manufacturing industries developed at a rapid rate during the last years of the 19th century. For example, the number of workpeople employed in the fifteen leading industries increased nearly 50 per cent. in the years 1894–99. As in other parts of Germany, the chemical and electrical industries made remarkable progress. Amongst other interesting developments is the manufacture of liquid carbonic acid gas procured from natural gas springs beside the Eyach, a tributary of the Neckar.

Communications.—In 1900 the railways had a total length of 1193 miles, of which 1141 miles belonged to the state.

Finances.—The state revenue for 1902–03 was estimated at £4,557,415, and the public expenditure at £4,427,800. The revenue is principally derived from the railways and forests, and direct taxation. The public debt in 1902 amounted to £24,758,400, of which over 90 per cent. was incurred for railway construction. Nearly 16 per cent. of the total national annual expenditure is spent upon "worship and education," principally the latter, or say some £650,000 out of a total of 4½ millions sterling. The quota which Würtemberg contributed to the imperial treasury in 1901 amounted to £1,092,500.

Army.—The forces forming the 13th corps of the imperial German army had on a peace footing 24,106 men in 1901.

Würzburg, a city and episcopal see of Bavaria, Germany, capital of the district of Lower Franconia, 63 miles north-west of Nuremberg by the railway to Frankfort, and on the river Main. The exterior of the cathedral was restored in 1882–83. Amongst the most notable additions to the town buildings are the law courts (1892–1895), two fountains—the Kilian (1895) and the Luitpold (1893), and two bridges across the Main—the Luitpold (1887) and the Ludwig (1894). In the castle are preserved a picture gallery and the collections of the Historical Society. The university was attended by 1108 students in 1901, and had 91 professors. Its institutions embrace a library of over 250,000 volumes, and laboratories and collections in all departments, especially medical and physical. There are many other educational establishments; *e.g.*, a botanical garden, art museum, picture and sculpture galleries, cabinet of coins, astronomical observatory, antiquarian museum, schools of agriculture, viticulture, and horticulture, theological and pedagogic seminaries, a music school, polytechnic schools, weaving school, deaf and dumb and blind asylums. It is a centre of the German wine trade. Population (1885), 55,010; (1895), 68,747; (1900), 75,497.

Wurzen, a town of Germany, on the Mulde, here crossed by two bridges, 15½ miles by rail east by north of the city and in the circle of Leipzig, kingdom of Saxony. It has an old cathedral, a castle, a higher-grade girls' school, and an agricultural school. The industries comprise iron-founding and the making of machinery. There are also important mills, with a large biscuit factory. Population (1890), 14,635; (1900), 16,614.

Wyandotte, a city of Wayne county, Michigan, U.S.A., on the Detroit river, and the Michigan Central, the Detroit and Lima Northern, and the Lake Shore and Michigan Southern railways, in the south-east part of the lower peninsula. Population (1890), 3817; (1900), 5183, of whom 1267 were foreign-born.

Wyoming, a north-western state of the United States, admitted to the Union on 10th July 1890. The increase in population has been continuous though not rapid. The leading industries—stock-raising, coal-mining, and irrigated agriculture—are not calculated to secure a rapid growth. In 1880 the population was 20,789; in 1890, 60,705; and in 1900, 92,531. Cheyenne, the state capital, is the largest city. Its population in 1890 was 11,760, and in 1900 it was 14,087. Of the total population in 1900, 58,184 were males and 34,347 were females; 75,116 were native-born and 17,415 (18·8 per cent.) foreign-born. There were 940 negroes, 461 Chinese, 393 Japanese, and 1686 Indians. Out of 37,898 adult males, 1636 were illiterate (unable to write), of whom 979 were foreign-born, 348 were Indians, and 102 were negroes. The lack of railway centres and of manufacturing districts has thus far operated against the growth of towns. The principal increase in population since 1890 has been in the irrigated districts and mining camps, but there are indications that manufacturing will in the near future assume greater importance.

Agriculture and Stock-Raising.—The free pasturage afforded by the large areas of public land covered with scanty but nutritious grass has made the pioneer industry of stock-raising a lucrative, if somewhat hazardous, business. Formerly all kinds of stock were left on the open range all the year round, but winter feeding on the irrigated farms has greatly increased, to the advantage of both the farmer and the stock-raiser. The significant feature of the range stock business in recent years has been the decrease in cattle and the increase in sheep. Between 1889 and 1899 the number of cattle declined from 623,283 to 311,629, and their value from $7,014,661 to $5,412,792; while the number of sheep rose from 459,991 to 2,164,701 and their value from $794,557 to $4,380,681. In 1899 there were 82,446 horses valued at $1,336,490, and 3192 swine valued at $13,754. The total value of all live stock was $11,143,717.

Finances.—The total valuation of state property in 1889 was $31,431,495; in 1894 it had fallen to $29,198,041, and in 1899 it had risen again to $35,578,806. State taxes, excepting the support of state educational and charitable institutions and interest on the public debt, are limited to four mills on the dollar of assessed valuation, and county taxes to twelve mills on the dollar of assessed valuation. The state has no floating debt. Its total bonded debt is $320,000, incurred for building the capitol, the university, the insane asylum, and other public buildings. The rate of interest on the debt is 6 per cent. In 1899 the state levied taxes for state, county, general schools, special schools, interest on bonds and other purposes, to the amount of $813,535, not including the school poll-tax. Of the 63 million acres of the state's area, less than 10 per cent., or 6,192,233 acres, is taxed, the average assessed value being a little over $1 per acre. Three-fourths of this is, or was, a part of the Union Pacific land-grant. A surprisingly small percentage of the public lands has been disposed of under the public land laws. There are in all in the state thirteen national banks, nine state banks, and nine private banks, with a capital in 1900 of $1,168,867 and deposits of $5,572,549.

Irrigation.—About one million acres of land are irrigated, the water being diverted in between 6000 and 7000 ditches from over 600 natural streams. The following table summarizes the grants of titles to water for the land proved to be irrigated between the organization of the state in 1890 and the end of 1898:—

Year.	Streams.	Certificates of Appropriation.	Volume cubic feet per second.	Acres Irrigated.
1891 . .	35	993	3,074·05	203,658
1893 . .	50	548	902·48	55,442·36
1895 . .	60	1010	2,262·14	113,270·41
1897 . .	153	947	1,678·81	108,986·71
Total .	298	3498	7,917·48	481,357·48

To this are to be added decrees for water to irrigate 100,000 acres, issued between 1888 and the time of Wyoming's admission as a state, and for nearly half a million acres now being irrigated, for which proof has not as yet been submitted.

Mining and Manufacturing.—Although some of the richest mines of silver and gold in the country are within fifty miles of each of the four borders of the state, there is not a single paying silver mine within them, and the profitable gold-mines can be counted on the fingers of one hand. Coal is the chief mineral product. It is found in every county in the state, and is mined commercially in all but two. In 1890 the output was 1,870,366 tons, and by 1901 it had steadily risen to more than double this, or 4,392,497 tons, valued at $7,686,869, the estimated value at the mine being $1.75 per ton. Coal oil is produced, but the product is heavy, being better suited for lubricating than for illuminating. A small refinery at Casper produces machine oils, axle grease, and paraffin products. Copper has been discovered in paying quantities. There are two deposits of hæmatite ore of known excellence. The deposit at Hartville, Laramie county, covers an area of several square miles and extends to an unknown depth. It assays over 60 per cent. iron, and is one of the greatest deposits of Bessemer ore in the world. It can be mined and loaded wholly by machinery. Two railways have been built to this place. The other deposit at Seminoe, in Carbon county, is also a Bessemer ore of excellent quality. Its extent is as yet unknown. The opening up of the iron-mines and oil-fields promises the beginning of an era of manufacturing and a more diversified industrial life. Better transportation will make available soda, building stone, and a long list of minerals of less commercial importance. The manufacturing establishments, which are confined mostly to products for local consumption, numbered 196 in 1900 (excluding those classified as hand trades, and others with a product of less than $500). They had a total capital of $2,242,840, an average number of 1963 wage-earners, and products valued at $3,493,306.

Railways and Telegraphs.—In 1900 there were 1180 miles of railways, assessed at a value of $7,118,902, and 1017 miles of telegraph lines, assessed at $103,364. Almost half of this was constructed after 1890; and by the end of 1900 about 200 miles of railway was added. The leading lines are the Union Pacific with its tributaries (534 miles), Grand Island and North Wyoming (237 miles), Burlington and Missouri (about 200 miles), Cheyenne and Northern (154 miles), and Wyoming Central (130 miles).

Education.—For the school year closing in September 1901 there were enrolled 15,764 pupils, who were taught in 620 common schools by 563 teachers. School attendance is compulsory. Text-books are free, being furnished by the state. The funds for the support of both primary and higher education are derived in part from taxation and in part from the rentals of school lands, of which the state owns about 4,000,000 acres. As the lands may not be sold for less than $10 an acre, or more than ten times their market value, only a few hundred acres adjoining town sites have been sold. To support the schools $191,773 was collected by taxes, $25,607 was received from the common school land income fund, and $7575 received mainly from interest on the proceeds of land sales. The State University at Laramie is an institution for higher education, the state agricultural college being combined with it. The buildings completed, or now in process of completion, represent a total expenditure of over $150,000. The attendance for 1899 was 142, 76 of whom were males and 66 females. The total number of instructors is 13. In addition to the funds provided by the state, the agricultural college and experiment station receives $40,000 a year from the National Government.

Religion and Charities. — Large sections of Wyoming are so sparsely and so recently settled that many districts are not able to support church organizations; and although their inhabitants may be church members, it is difficult to secure accurate statistics regarding them. The three largest denominations are the Roman Catholics, with about one-tenth of the population of the state, the Latter Day Saints or Mormons, whose membership is unknown, and the Methodists.

The state insane asylum at Evanston, the miners' hospital at Rock Springs, the two penitentiaries at Laramie and Rawlins, are all commodious and well equipped. There is also a state soldiers' home at Cheyenne, and a state poor farm at Lander.

Legislation and Politics.—The constitution and laws under which the state was admitted to the Union contain few special features. All state officers, except judges of the Supreme Court, are elected for a term of four years; the latter for eight years. The sessions of the legislature are limited to forty days. Two features of the constitution were departures from existing instruments at the time of its adoption in 1890. The first was the giving of equal suffrage and equal political rights to both sexes. The second was the result of the realization of the fact that the social and industrial problems of arid lands are largely problems of water. The constitution makes the water of all natural streams, springs, lakes, and other collections of still water the property of the state, providing for its use under state control. Both innovations have justified the claims of their supporters. State control of streams has relieved the irrigators of Wyoming from the controversies over water rights which have proved so burdensome in some other states.

Wyoming, unlike most or all of the surrounding states, voted for the maintenance of the gold standard at the Presidential elections of 1892 and 1896. The difference was probably due to the absence of silver-mines and to the general prosperity which prevailed. In the Presidential election of 1900, out of a total vote of 20,863, the Republicans polled 10,072 and the Democrats 10,655. (E. M*.)

Xanthi (or in Turkish, *Eskidja*), a town in the sanjak of Gumuldjina, vilayet of Adrianople, Turkey in Europe, situated at the foot of the slopes of Mount Rhodope, and on the Salonica–Dedeaghatch–Constantinople railway, 29 miles west of Gumuldjina. There are remains of the ancient stronghold of the Middle Ages, and on the plain the ruins of an ancient Greek town. The town, which is built in the form of an amphitheatre, possesses six mosques, five Orthodox churches, three monasteries, a theatre with public garden, and a municipal garden. Among other schools is a preparatory one for boys and girls founded and endowed by Mazzini. There is a considerable general trade, but the town is chiefly notable for the famous De Yémidjé tobacco. The population is estimated at 14,000, of whom the bulk are Turks and Greeks in about equal proportions, and the remainder (about 4000) Armenians, Catholics, or Jews.

Xenia, a city of Ohio, U.S.A., capital of Greene county, in the Miami valley, on the Cincinnati, Hamilton, and Dayton, and the Pittsburg, Cincinnati, Chicago, and St Louis railways, in the south-western part of the state, at an altitude of 910 feet. It is regularly laid out, with broad streets, and is divided into seven wards. It is surrounded by a rich farming region, for which it serves as a market-place. It has varied manufactures. Population (1890), 7301; (1900), 8696, of whom 410 were foreign-born and 1988 negroes.

Xingú. See Amazon.

Yachting.—It is both natural and desirable that one of the leading pastimes of a maritime nation should be yachting, while, in addition to the health and pleasure to be derived from its pursuit, there are few other sports in which the individual interested can equally employ his intellectual powers. Almost every known mechanical principle, and some as yet not fully understood, find a place in the designing of a modern racing yacht. For several centuries British sovereigns, as well as a few of their subjects, owned yachts, while in 1720 and 1775 respectively the Cork Water Club and the Cumberland Fleet, upon the Thames, were formed to encourage the sport. Still, it was not until the early part of the 19th century that yachting became even in a measure popular, while it may be said that the vessels built then were either examples of artisans' skill working on traditional lines, or, and more rarely, the result of blind experiments. Now, however, the designer works with a knowledge of the principles involved, for the effect of every curve in the vessel is calculated before her keel is laid, and the desired result in a great measure arrived at. Still, it must be remembered that the axioms of one generation are frequently disproved by the next. Like any other sailing vessel, a yacht is essentially a compromise between many opposing forces, for the quality that renders her safe and stable may make her slow, that which tends to speed may reduce her internal accommodation, and the power of beating to windward unduly increase her draught. Thus few advantages are secured without sacrificing others. Racing is the dominating influence in yachting, for even vessels built entirely for cruising generally follow the type of racing craft more or less. Therefore the history of yachting is bound up with that of yacht-racing and its measurement rules.

Racing yachts may be divided into three classes, mentioned inversely to their order of importance. (1) There is what may be called the free handicap class, *i.e.*, vessels built for cruising or obsolete racers. These are generally handicapped on their supposed merits, instead of on a definite scale, and though this rarely affords universal satisfaction, such races are fairly numerous. The system of starting a race and allowing for handicap may be briefly explained. Yachts are now almost invariably started level. An imaginary line is taken between two anchored vessels, a pier and a buoy, or other convenient marks, and the competing yachts get under way when it suits their owners. Fifteen minutes exactly before the starting-time a flag is hoisted denoting the race. Ten minutes later this flag comes down, a gun is fired and the blue peter hoisted, while the yachts manœuvre for the best position near the line. Then, at the exact moment, a second gun is fired, the blue peter run down, and the helmsman endeavours to take his craft across the line almost simultaneously. Should any spar, however, cross it a moment too soon, the boat is recalled, and must keep clear of the others while regaining a position to start again. Then, as the yachts eventually pass the finishing marks, their times are carefully taken, and the number of minutes each has to allow deducted; while it occasionally happens that the last boat wins because the leaders have not arrived sufficiently long before her. The foregoing also applies to vessels handicapped on the Yacht Racing Association scale of rating.

(2) Probably with a desire to prevent other competitors from being crushed out by owners of superior wealth (for, as will be shown, the production of the fastest boat is to a great extent a question of the heaviest investment), what are called one-design, or restricted, classes have latterly become popular, especially in case of the smaller craft. Various yacht clubs adopt a definite model to which their racers must be built, sometimes also fixing the exact cost, or draw up a rigid specification allowing only small differences in construction and rig. There is no time allowance in the case of such boats, and the first to pass the finishing mark is the winner. Thus excessive expenditure may be checked, and prize-winning becomes a question of superior seamanship; but the system has disadvantages, because it curtails the scope of invention for the designer or owner.

(3) The third and principal class is that in which time is allowed in accordance with a standard scale (generally abbreviated to Y.R.A. rating), appointed since 1875 by the Yacht Racing Association, while the successive rules for its calculation have had a marked effect upon the form of the racing yacht. Their aim has been to encourage a fast, safe, and seaworthy vessel, though they may have occasionally failed in this to some extent.

At the beginning of the 19th century yachts were built upon the lines of successful smugglers or revenue cutters, full in the bows and broad, generally three or four beams to length, with sharp under-water sterns, on the then generally accepted theory that to sail fast a vessel must have a cod's broad head and a mackerel's slender tail. In the case of some floating bodies the rule still holds good, for large pine logs are usually towed with the thicker end first. The yachts were held upright against the heeling effort of their canvas by an inside load of stones or ore, and as there was no time allowance, the largest boat generally won, so that size largely increased: the *Alarm*, 193 tons, and the *Louisa*, 180 tons, both rigged as cutters, were the racers of the 'fifties. This result naturally suggested the necessity for some handicapping scale, and the first adopted was based on the 1794 merchant tonnage law, length of keel and breadth alone being effectively taxed for time allowance. This did not at first lead to a change in type, for designers worked chiefly by tradition then, but they eventually began to realize that as breadth increased the number of minutes each boat had to allow it might with advantage be reduced. Now, any sailing vessel is enabled to withstand the overturning effort of the wind by two principal factors—the resistance of the water, which increases as her breadth, and the weight of cargo or ballast below her water-line. The latter must be lifted through an arc before she can be capsized, and it is evident that the lower this weight is placed and the heavier it is so the power of the righting lever is increased. Therefore, as breadth diminished, constructors sought for means to increase the righting lever or artificial stability, and naturally found it in lead. Nevertheless, mathematics counting little then against precedent, such an innovation was condemned, and it was only by degrees that a little lead inside gave place to the heaviest possible load placed as low as possible, *i.e.*, on the vessel's keel, because each inch gained below the water-line increased its effective power. Thus, slowly at first, more rapidly later, yacht-builders grasped the fact that, however narrow a vessel became, she would stand upright if sufficient lead were hung on her, while, depth not being taxed in the formula, the direct result was that between about 1875 and 1886 yachts grew narrower and narrower, until they had diminished from three to six beams to length. Minor rules were adopted earlier by the Royal London and New Thames Yacht Clubs, which, in order to invalidate various devices for evading the taxed length, decreed that the latter should be measured on deck; and the so-called Thames measurement is still the yachting standard—except for racing.

The advent of the United States schooner *America* in 1851 (when she won the famous Cup in a race round the Isle of Wight) with a long hollow bow and flat-cut sails, exploded the British cod's-head theory, and led to most new vessels being built with lean hollow bows, and many older ones altered to that model. What Scott Russell's wave theory, propounded earlier, had failed to do, ocular demonstration accomplished. In 1875 the Yacht Racing Association was founded, and one of its first rules decreed that length should be measured on the load water-line (l.w.l.). Still, it was only slowly that designers discarded the old straight stem and adopted the overhanging bow, thus getting a longer boat than they were handicapped for. In 1881 a measurement formula was also introduced which appeared likely to encourage the building of broader vessels, but failed to do so, until in 1886 the racing yacht resembled a long-drawn-out wedge, and a change became imperative. Therefore a new Y.R.A. rule was passed, taking only length and sail area into account, thus leaving it open to increase the beam, and permitting the use of a centre-board. This was a simple formula: length (on the water-line) multiplied by sail area and divided by 6000 gave the Y.R.A. rating, for every foot of which so many seconds' time had to be allowed. Nevertheless, it was not till 1893 that large racing vessels exhibited much increase of beam, when *Satanita*, *Britannia*, *Calluna*, *Valkyrie*, about four beams to length, were the leading yachts.

Approximately, the narrow and deep craft may be contrasted with the broad and shallow one as follows:—The former, depending on her weight of lead for stability, is more costly, but she will sail to windward, especially through broken water, faster than the other, for the long lean hull with the momentum of its heavy load shears more readily through the seas that meet it diagonally. Lacking this weight and displacement, and consequent "power," the shallower boat will not do so equally well; but with a fair wind may outsail the former, while as she depends partly on breadth for stability, she is, other things being equal, cheaper to construct.

In 1895 the Y.R.A. rule which taxes breadth and depth by making girth a factor was formulated. It has been shown how yachts diminished from three beams in length to six, and then broadened again to much the original beam; but meanwhile, with the measuring of length on the water-line, another change began. The older vessels had straight keels, with stem and sternpost nearly vertical, which made them slow to answer the helm; but it became apparent that by raking, or slanting, stem and sternpost a vessel could be built much longer on the deck than on the water-line, and yet not be handicapped accordingly. Thus the present overhangs were initiated. Their advantage is chiefly that when the vessel is heeled by the wind they become immersed, and consequently increase her water-line length. This, however, would not alone account for the modern racing yacht's profile, and it must be explained that, besides helping to keep the ballast low, a yacht's depth serves her by presenting a large area of immersed surface to the water, which prevents her from being pushed away sideways by the wind when sailing close-hauled, for which purpose the centre-board, or sliding keel, is used in shallow craft. There are also two factors which check a vessel's speed—wave-making, or the pushing aside and piling up of water, and, what is sometimes more important, skin-friction, *i.e.*, the drag of water along her bottom. The importance of the latter was long under-rated, and builders believed that a large area of deadwood formed by an approximately right-angled junction of stem and keel was necessary for lateral resistance, or power of holding on to windward. The famous yawl *Jullanar*, 126 tons, with one or two other vessels built about 1875, with this area of forefoot completely cut away, thus saving a large amount of skin-friction, disproved the theory. Little by little the modern under-water profile was reached, which roughly resembles an isosceles triangle, though two lines are more or less curved. The deck forms one side, the other long one is the sweep from head of stem along the keel to the apex at its junction with the sternpost, and the third, and shortest, side the line from the foot of the latter to the deck again. This reduces skin-friction and renders the craft quick upon her helm, although it is sometimes overdone and too little surface left for lateral resistance. In 1901 another new rating rule, which aims at encouraging a vessel of fuller body, came into force for seven years. It takes the difference between the actual midship section of the yacht and a line drawn straight from her keel to water-line into special account, and thus should prevent undue hollowness of section; but it is premature to anticipate its exact effect.

The last great change has been in the direction of lightness of construction, for whereas the earlier yachts were heavily built, the modern ones are the thinnest shell, though the Y.R.A. now propose to introduce a scantling rule. The reason is simply that all weight above the water-line tends to capsize a vessel, while that beneath it tends to hold her upright. Thus, as the hull will only float a certain weight, it is important to place as much as possible upon her keel. Therefore the weight of hull is pared down to the uttermost, and some small vessels have to be braced inside like a lattice-girder to preserve their shape, while in the case of the America Cup challenger of 1901, *Shamrock*, which had a draught of nearly 20 feet, the lead keel weighed approximately 90 tons. To save weight her submerged portion was plated with manganese bronze, which is half the weight of steel, while for that above water even this was not light enough, so an aluminium alloy one-third the weight of the other was used. The cost of such construction, necessitating not only first-class material but the highest workman's skill, is enormous.

Thus the modern racer has been evolved. Her chief characteristics are—the lightest possible hull, the heaviest possible keel, long overhangs, a cut-away under-body sufficient for lateral resistance with minimum surface for skin-friction, a hollow steel mast, and sails of the lightest and closest material. She is also almost universally rigged as a cutter, for though schooners, ketches, and yawls can be handled more comfortably by a smaller crew, the cutter can readily beat them to windward, and this in spite of the fact that the Y.R.A. allow a reduction in the rating of the former craft. So each successive rule has had its influence, but whether the most satisfactory type has been produced is a question which has always been fiercely debated. At present the racing vessel of a given size increases in cost year by year, while there are not wanting those who predict that plating of aluminium and keels of platinum may eventually become a necessity unless some effort is made to check the excessive expenditure. (H. Bs.)

Yakoba. See NIGERIA.

Yakub Khan (1849- ——), ex-Amir of Afghanistan, son of the Amir Sher Ali, was born in 1849. He showed great ability at an early age, and was made governor of Herat by his father, but broke into open rebellion against him in 1870, and was imprisoned in 1874 in Kabul. However, when Sher Ali in 1878 fled before the British, he handed over the government to Yakub, who, on his father's death in the following February, was proclaimed Amir, and signed a treaty of peace with the British at Gandamak. He agreed to receive a British Resident, and was in turn to receive a subsidy and support against foreign attack. But in September of the same year his revolted troops attacked the British Residency, and the Resident, Sir Louis Cavagnari, and his staff and suite were cut to pieces. This outrage was instantly avenged, for in October Earl (then Sir Frederick) Roberts with a large force defeated the Afghans on the 6th and took possession of Kabul on the 12th. Yakub Khan thereupon abdicated, and took refuge in the British camp, and was sent to India on the 13th of December, to remain in safe custody as a deposed sovereign.

Yaku-shima, an island belonging to Japan, lying to the south of Kiushiu, in 30° 30′ N. and 130° 30′ E. It is shaped like an irregular pentagon, and measures 14 miles in width and the same in length. It is separated from Tanega-shima by the Yaku-kaikyô (Vincennes Strait), 12¼ miles wide, and its surface is broken by lofty mountains, of which Yaye-dake rises to a height of 6515 feet, and Eboshi-dake to a height of 4840 feet. It is covered with dense forest, in which are some of the finest cryptomeria in Japan, known as *Yaku-sugi*.

Yakutsk, an extensive province of Asiatic Russia, eastern Siberia, covering nearly one-fifth of the Russian Empire, bounded on the N. by the Arctic Ocean, on the W. by Yeniseisk, on the S. by Irkutsk, Transbaikalia, and Amur, and on the E. separated from the Pacific Ocean by a narrow strip only belonging to the Maritime Province (*Primorskaya Oblast*). The Yakutsk expedition has carried out much valuable exploring work, and made important researches into the ethnography and demography of the province. Only incomplete accounts of the expedition have yet appeared. The province has an area of 1,533,400 square miles, but its population in 1897 was only 261,731 (domiciled only), of whom 125,670 were women, and 9019 lived in towns. The bulk of the inhabitants (213,800) are Yakuts; Russians number 18,360, of whom 6370 are exiles; Tungus, 10,050; Tatars, 1350; Lamuts, 2840; Chukchi, 1600. The province is divided into five districts, the chief towns of which are Yakutsk, Olekminsk (1178), Sredne-Kolymsk (538), Verkhoyansk (356), and Viluisk (609). The standard of education is low, and in 1898 there were only 75 primary schools attended by 1100 boys and 225 girls. Though the production of gold dust from gold washings has been on the decrease, 9097 kilogrammes were still obtained in 1898, and over 15,000 workers are employed in the Olekma and Vitim system of gold-mines. Though it has been proved by the exiles that barley could be grown much more widely than it is at the present time, immense tracts are quite unsuitable for agriculture, and only 43,000 acres are under crops, chiefly barley. Most of the inhabitants are engaged in cattle-breeding, and it is estimated that there are in the province 117,000 horses, 213,000 horned cattle, about 20,000 reindeer, and 1700 sledge-dogs. Fish is an important article of food, especially in the Kolyma region, where the supply for the year has to be obtained during the six or seven weeks that the rivers are free from ice. There is a great dearth of salt, and the fish have to be frozen as they are for future use. In the northern districts hunting remains important; it was estimated in 1898 that it employed nearly 15,000 men, who obtained from 100,000 to 175,000 squirrels, about 11,000 ermines, 237,000 hares, from 3000 to 3700 foxes, from 3000 to 4000 Arctic foxes, but only from 100 to 150 sables, some 50 beavers, and about 150 bears. These estimates, however, seem to be too small.

See W. L. SIEROSZEWSKI. *The Yakuts*, vol. i. St Petersburg, 1896.—V. G. BOGORAZ. *Materials for the Study of the Chukchi Language and Folk-lore*, vol. i. Published by the St Petersburg Academy of Sciences, 1900.—*Bulletin* of the East-Siberian Geographical Society. (P. A. K.)

Yakutsk, capital of the above province, situated in 62° 2′ N. and 129° 44′ E., on a left-bank branch of the Lena, 1800 miles north-east of Irkutsk. It consists of a small number of wooden houses, most of which have their windows made of mica (this is replaced by ice in winter), and of many Yakut tents built amidst the houses. It has one *real*-school, a theological seminary, a high school for girls, and three primary schools, and carries on an active trade with the rest of the province. Population (1897), 6534.

Yale University.—Yale College, which received its charter in October 1701, and took its name in 1718 from its early benefactor, Governor Elihu Yale of England, became legally Yale University in 1887. At first instruction was given in various towns in Connecticut, but in 1717 the commencement exercises were held at New Haven, Conn., where the institution has since remained. At the end of the administration of the first rector, Abraham Pierson, in 1707, there were 19 students and 2 members of the faculty. The record at the close of certain subsequent administrations was as follows: Thomas Clap, 1766—116 students, 5 members of faculty; Timothy Dwight, 1817—325 students, 14 members of faculty; Theodore Dwight Woolsey, 1871—755 students, 65 members of faculty; Timothy Dwight, 1899—2511 students, 260 members of faculty. Arthur Twining Hadley was inaugurated President, 18th October 1899. The main groups of buildings occupy the larger part of four adjoining squares, extending over half a mile in length, in the centre of the city of New Haven. The oldest, South Middle, built in 1750, has been preserved. Eighteen buildings, or nearly half of the accommodation of the University in 1900, were erected during the administration of the second Timothy Dwight, between 1885 and 1899.

The different libraries of the University contain over 300,000 volumes. The value of the land and buildings is estimated at $7,000,000. In 1901 the permanent funds were $6,234,026. This included about $760,000 of bicentennial and other special building funds. By July 1902 about $2,000,000 had been given for buildings commemorative of the bicentennial celebration, and for other purposes in connexion with that event. Nearly all the acquisitions of property and money since 1850 have been by private gifts.

The curriculum of the college proper, or academic department, is in the freshman year nearly all prescribed work. In the sophomore year the student may choose six out of twelve courses offered, but must indicate his general line for the rest of the course. The last two years are entirely elective, but subject to this general choice, and also to the requirements of consistency and symmetry. The first considerable introduction of the elective system in the college was made in 1885, when the last two years were made four-fifths elective, the first two remaining nearly all prescribed work. The other changes were introduced in 1900 and 1901. The purpose of the latter changes was to allow the student to group his studies earlier in some general direction, while he is still required to take nearly the same amount of elementary study as a foundation. The academic department numbered 1240 students in 1901. The other undergraduate department, the Sheffield Scientific School, has maintained its system of group electives, which was fixed early in its history at a time when the modern system of electives was unknown. It allows the student to choose the goal of his studies, while the faculty fixes the means by which this may best be reached. In the freshman year there is the same work for all, with a general scientific basis of physics, chemistry, and mathematics, accompanied by the study of English and modern languages. The system is one of general studies, scientific, literary, and linguistic, and the underlying principle is preparation rather than technical equipment. The course is three years, and the requirements for a baccalaureate degree have been much increased by raising the standard of admission. The school numbered 675 students in 1901.

The rapid development of the University life has been evidenced by the establishment of an excellent department of music in 1894, the first distinct school of music granting degrees in the United States; by the foundation of a School of Forestry in 1900; by a very large increase in the amount of instruction in the Graduate School; by the increased attention paid in new University courses and lectureships to the problems of democratic government and the duties of American citizenship, and by closer cooperation under the administration of President Hadley among all departments.

Among the professional schools, the most conspicuous events have been the increase of the Medical School course of study in 1895 from three to four years, and of the Law School course in 1897 from two years to three. Individual instruction has become the distinguishing feature of the Medical School instruction. The school was founded in 1810, and in 1901 enrolled 147 students. The Law School has developed a character as a school of direct instruction, and is drawing largely for its faculty on men on the bench or in active practice. The school was founded in 1843, and its students in 1901 numbered 249. The chair of divinity, first established in 1755, developed into a distinct theological class in 1822. The Yale Theological School in the last quarter of the 19th century kept itself well abreast of the most enlightened scholarship of the new school of theology. It enrolled 100 students in the year 1901. The Yale School of Fine Arts was established in 1864, and enrolled 166 students in 1901, although its connexion with the University enables it to give instruction to nearly 300 students annually. The government of the University is vested first in the corporation, comprised of the president of the University, the governor and lieutenant-governor of Connecticut; ten Congregational ministers of Connecticut, who elect their own successors, and six graduates of the University, chosen by vote of the graduates. The University council, composed of representatives of the several departments is advisory in character. The different faculties care for practically all matters of their respective departments.

From the first, Yale College, or the academic department, has required daily attendance on religious services, which were formerly conducted by the president, always a minister of the Gospel until President Hadley's election and, since his accession, by members of the faculty. The active religious life of the college is contained in the students' voluntary association known as the Yale Young Men's Christian Association. It enrolls more than half of the men of the University, making a larger number than any other similar organization in the world, and conducts a great variety of religious services and philanthropic and missionary enterprises. The attendance at Yale remains conspicuously national in its character. Nearly two-thirds of the students of the academic department reside in college dormitories in and about the old college square.

Among the graduates of Yale, well known in recent times, may be named the late Theodore Dwight Woolsey, the scholar and educator; the late James Dwight Dana, the geologist; the late Hubert A. Newton, the mathematician; the late Elias Loomis, the mathematician; the late Henry Barnard, the educator; the late Horace Bushnell, the theologian; President Daniel C. Gilman of Johns Hopkins University; Justices George Shiras, David J. Brewer, and Henry B. Brown, of the United States Supreme Court; the Hon. Andrew D. White, the educator and diplomat; the Hon. Simeon E. Baldwin, the jurist; Professor Josiah Willard Gibbs, the mathematician; the late Professor Othniel Charles Marsh, the palæontologist; the late William D. Whitney; the Hon. William H. Taft, governor-general of the Philippine Islands. (L. S. W.)

Yalta, a district town and seaport of Russia, in the government of Taurida, on the south coast of Crimea, at the foot of the Yaila mountains, 57 miles south of Simpheropol. It is the *Galita* or *Jalita* of the Arab geographers. Its roadstead is open, but it enjoys a very temperate climate, and has some reputation as a winter resort. Population (1897), 13,269.

Yambol, or YAMBOLI, JAMBOL, or IAMBOL, a town in the Slivno department of eastern Rumelia, Bulgaria, on the Tunja, an affluent of the Maritza, 49 miles west of Burgas by rail. It has a large agricultural trade, being situated in the centre of one of the chief corn districts of eastern Rumelia. A large number of mulberry trees have been planted on the banks of the Tunja. The river is crossed by two wooden bridges resting on stone pillars. There are the remains of the old fortifications, and the ruins of a fine old mosque. The *bezetlan*, or old market-house, is entire, but is now used as a military magazine. An ancient Macedonian town lay some 4 miles to the north, but Yambol is first mentioned in the 11th century, when it was known by the Byzantines as Dampolis or Hyampolis. During the wars between the Byzantines and Bulgarians it was an important frontier fortress. Under the Turks it was the favourite residence of the Sultan Mahommed IV. Population (1893), 13,588, of whom about three-fourths are Bulgarians.

Yamèthin, a district in the Meiktila division of Upper Burma, lying between the Shan States and the Meiktila Magwe and Toungoo districts. Area, 4258 square miles. Population (1891), 206,557. There were 1098 villages in 1898–99, paying a revenue of Rs.4,37,826. The population was made up in 1891 of 195,880 Buddhists and Jains, 2247 Hindus, 7119 Mahommedans, 679 Christians, 488 of whom were natives, mostly Karens, and 632 others, mostly Shans and Karens.

The northern part of the district is a plain, sloping up to the Shan hills on one side and to the Pegu Yomas on the other, and mostly under rice cultivation. The southern portion, the former district of Pyinmana, is covered with dense forests to the south, and produces some of the best teak in Burma. Of a total area of 2,724,965 acres, there were 180,350 cultivated in 1898–99; current fallow covered, 11,375 acres; and the amount remaining available for cultivation was 566,840 acres; 629,120 acres were under forests, and the uncultivable area covered 1,337,280 acres. The total rainfall taken at Yamèthin was 41·14 inches, but in the south of the district there was probably one-half more. The thermometer frequently rises over 100° F. in the hot weather, and the mean minimum reading in the cold weather is about 59°. The headquarters of the district are at Yamèthin, which had a population, according to the census of 1891, of 6584. There are large railway works on the Mandalay-Rangoon section. Pyinmana, the southern sub-divisional town, had in 1891 a population of 12,926. It is a considerable trading town, and is a station on the railway, as is also Pyaw-bwè, a thriving township to the north of Yamèthin, which is visited by many caravans from the southern Shan States.

Yangtse-kiang, the name by which the great river and commercial highway of China is known to the world. It takes its rise in the high table-lands of central Asia, as do all the great rivers of the eastern continent. It derives its origin from the junction of a series of small streams draining the eastern slopes of the Tibetan plateau, and for the first third of its course flows almost parallel with two other large rivers of eastern Asia, which have had a similar origin, viz., the Mekong and the Salween, each, however, separated from the other by intervening ridges of great height. The total length of the Yangtse has not been ascertained with precision, but is calculated to be not less than 3000 miles. Although the term Yangtse is applied by Europeans to the whole course of the river, in China itself the name is employed to indicate only the last three or four hundred miles, where it flows through a division of the empire which in ancient time was known as "Yang"—a name which also survives in the city of Yang Chow in the province of Kiangsu. The ordinary official name for the whole river is Ch'ang Kiang (pronounced in the north, Chiang) or Ta Chiang, meaning the "long river" or the "great river." Popularly in the upper reaches every short section has its own local name. As it emerges from Tibet into China it is known as the Kinsha Kiang or river of Golden Sand, and farther down as the Pai-shui Kiang. In Szechuen, after its junction with the large tributary known as the Min, it is for some distance called the Min-kiang, the people being of opinion that the Min branch is in fact the main river. The fall in the upper reaches is very rapid. At the junction of the two main affluents in Upper Tibet, where the river is already a formidable torrent barely fordable at low water, the altitude is estimated at 13,000 feet. From Bathang (8540 feet) to Wa-Wu in Szechuen (1900 feet) the fall is about eight feet per mile, thence to Huang-kuo-shu (1200 feet) about six feet per mile, and farther down to Pingshan (1039 feet) the fall is about three feet per mile. At Pingshan, in the province of Szechuen, the river first becomes navigable, and the fall decreases to about six inches per mile down to Chungking (630 feet). From Chungking through the gorges to Ichang (130 feet), a distance of nearly 400 miles, the fall again increases to about fourteen inches per mile, but from Ichang down to the sea, a distance of 1000 miles, the fall is exceedingly small, being as far as Hankow at the rate of two and a half inches, and from Hankow to the mouth at the rate of little more than one inch per mile. The last 200 miles are in fact practically a dead level, for at low-water season there is a rise of tide enough to swing ships as far up as Wuhu, 200 miles from the mouth.

The principal tributaries, counting from the sea upwards, are (1) the outlet from Poyang Lake, draining the province of Kiangsi; (2) the Han river, entering on the left bank at Hankow; (3) the outlet from Tungting Lake on the right bank, draining the province of Hunan; (4) the three great rivers of Szechuen, the Kialing, the To Kiang, and the Min, all entering on the left bank; and (5) the Yalung, draining a vast area on the border-land between Szechuen and Tibet. The whole drainage area is about 650,000 square miles, of which more than four-fifths lie above Hankow. The period of low water is from December to March. The melting of the snows on the Tibetan highlands combined with the summer rainfall causes an annual rise in the river of from 70 to 90 feet at Chungking and from 40 to 50 at Hankow and Kiukiang. The mean volume of water discharged into the sea is estimated at 770,000 cubic feet per second. The quantity of sediment carried in solution and deposited at the mouth is similarly estimated at 6428 million cubic feet per annum, representing a subaerial denudation of the whole drainage area at the rate of one foot in 3707 years. (See *Journal* of the China Branch of the Royal Asiatic Society, vol. xvi., Dr. Guppy.)

Commercially speaking, the Yangtse-kiang forms a highway of first-class importance. As the rise in the river is only about 130 feet for the first 1000 miles, it resembles a huge canal expressly formed for steam navigation. Except at winter low water, steamers of five or six thousand tons can reach Hankow with ease. Between Hankow and Ichang, especially above the outlet from Tungting Lake, the volume of water diminishes very much, and as the channel is continually shifting with the shifting sand-banks, navigation is more difficult. Above Ichang, where the river flows between rocky gorges, and where a series of rapids are encountered, navigation is still more difficult, and the problem of how best to introduce steam towage is not yet solved. But taking the Yangtse as a whole, with its numerous subsidiary streams, canals, and lakes, it forms a highway of communication unrivalled in any other country in the world. About half the sea-borne commerce of all China is further distributed by means of the Yangtse and its connexions, not to mention the interchange of native produce between province and province, which is carried by native sailing craft numbered by thousands.

The Yangtse valley as a political term indicates the sphere of influence or development which by international agreement has been assigned to Great Britain. This was first acquired in a somewhat negative manner by the Chinese Government giving an undertaking, which they did in 1898, not to alienate any part of the Yangtse valley to any other Power. A more formal recognition of the British claim was embodied in the agreement between the British and Russian Governments in 1899 for the delimitation of their respective railway interests in China, Russia agreeing not to interfere with British projects in the basin of the Yangtse, and Great Britain agreeing not to interfere with Russian projects north of the Great Wall (Manchuria). The basin or valley of the Yangtse was defined to comprise all the provinces bordering on the Yangtse river, together with the provinces of Honan and Chekiang. This agreement was communicated to the Chinese Government, and has been generally acknowledged. Germany has similarly claimed the province of Shantung as her special field of enterprise. The only object of these negotiations was to guard against conflict of railway interests; in all other respects the policy known as that of the "open door" was advocated by Great Britain and the chief commercial states. This policy was more fully declared by mutual engagements entered into in 1900 by the Great Powers on the initiative of the United States, whereby each undertook to guarantee equality of treatment to the commerce of all nations within its own sphere. (G. T.)

Yanina. See JANINA.

Yankton, a city of South Dakota, U.S.A., capital of Yankton county, on the northern bank of the Missouri river, at the mouth of the James, in the south-eastern part of the state, at an altitude of 1200 feet. It is entered by the Chicago and North-Western, the Chicago, Milwaukee, and St Paul, and the Great Northern railways, which, with boats on the river, give it a large trade, and make it a market-place for a large area of the fertile wheat-producing plains which surround it. It is the seat of Yankton College, a Congregational institution opened in 1882. This had in 1899 a faculty of 14 and an attendance of 185 students, of whom 79 were women. Population (1890), 3670; (1900), 4125, of whom 850 were foreign-born.

Yap. See MICRONESIA.

Yapura. See AMAZON.

Yaritagua, a town in Venezuela, capital of Yaritagua district. It is 18 miles from Barquisimeto, in a beautiful and extensive valley 1037 feet above the sea, with a population of 12,000. It is an industrial and commercial centre. Coffee, sugar-cane, cacao, and, above all, tobacco of an excellent quality are cultivated.

Yarmouth, a seaport town and port of entry, Yarmouth county, Nova Scotia, on the Dominion and Atlantic Railway, 71 miles south of Digby. It contains many fine public buildings, good schools, important manufactories, two banks and one bank agency, is lighted by electric light and gas, and has an electric street railway. Shipbuilding is important. In 1900 197 vessels, net tonnage 25,084, were registered in this port. In 1901 the exports were $1,309,462, and imports $590,968. Population (1891), 6089; (1901), 6430

Yarmouth, Great, a municipal, county, and parliamentary borough of England, also an important watering-place and fishing station, and a seaport, mostly in Norfolk, though partly in Suffolk, 122 miles north-east of London by rail. In 1890 the area of the municipal borough was extended by the inclusion of Gorleston with Southtown, so that it is now coincident with the area of the parliamentary borough, namely, 3567 acres. But for ecclesiastical purposes Gorleston with Southtown is still regarded as belonging to Suffolk. The town has a sea frontage of about 1½ miles. The parish church of St Nicholas has been restored and enlarged since 1883, and also St John's and St George's chapel. The toll-house was adapted for the free library in 1885. The other new buildings and institutions include a museum, a theatre, the Royal Aquarium Theatre, the Yarmouth hospital, the isolation hospital, the Gorleston cottage hospital, and the shipwrecked mariners' refuge at Gorleston (1892). There are two new lighthouses at the mouth of the Yare. In 1895 the North Sea Church Mission was established here. The recent educational institutions include the borough of Great Yarmouth technical school and the corporation technical schools. Public recreation grounds were laid out about 1890. Since 1896 the principal streets and the quays have been lighted by electricity. For certain purposes Yarmouth was in 1888 declared a county borough. It returns one member to the House of Commons. The average annual value of the imports for the ten years ending 1895 was £204,900; of the exports, £16,830; the respective figures in 1900 were £350,532 and £210,043. In 1900 the port was entered by 317 vessels of 70,881 tons engaged in foreign trade, and by 1205 vessels of 148,940 tons engaged in the coasting trade. The registered fleet of the port amounted in 1900 to 314 vessels of 15,194 tons. There is a fishing fleet of nearly 500 vessels of some 20,000 tons, manned by about 3000 men and boys. Population (1891), 49,334; (1901), 51,250. Birth-rate, 27·6; death-rate, 21·5.

Yaroslavl, a government of Central Russia, on the upper Volga, with an area of 13,751 square miles. Its population, which is thoroughly Russian, decreased from 1,118,130 in 1883, to 1,072,478 (domiciled only) in 1897, but, as large numbers of men leave their homes in winter (when the 1897 census was taken) to go and work in the capitals, the population is really more than this latter figure would indicate. In 1897 612,245 were women, and 142,441 lived in towns. It is divided into ten districts, the chief towns of which are Yaroslavl, Daniloff (4288), Lyubim (3002), Mologa (4206), Myshkin (2238), Poshekhoniye (4036), Romanoff-Borisoglyebsk (6518), Rostoff (13,016), Rybinsk (25,223), and Uglich (9698). Several industrial villages are more important than most of these towns. The standard of education is relatively high, and in 1897 there were 1033 primary schools attended by 36,750 boys and 11,420 girls. Yaroslavl belongs to the manufacturing region of Central Russia, but agriculture is still carried on everywhere, even in the manufacturing villages, the domestic character of many industries permitting the inhabitants both to cultivate their fields and to work in small factories. The peasants and peasant communities hold 5,050,000 acres, or about 57 per cent. of the total area, of which they have acquired nearly 1,000,000 acres by purchase since their emancipation; 30 per cent. is held by private persons, and 7 per cent. by the Crown. The forests still cover 39 per cent. of the aggregate area, namely, 44,439,400 acres. There were in 1900 1,169,000 acres under cereal crops, and the average yield in 1895–99 was: rye, 4,531,000 cwt.; wheat, 161,500 cwt.; oats, 3,070,000 cwt.; and barley, 244,000 cwt.; also potatoes, 7,142,000 cwt. Flax is widely cultivated both for linseed (70,000 qrs.) and fibre (200,000 cwt.). Kitchen gardening is pursued on a large scale, and both fresh and dried vegetables are widely exported; Rostoff enjoys a great reputation as the centre of the trade. Cattle-breeding is of only less importance than agriculture, and the export of poultry is growing rapidly. Large numbers of the inhabitants find employment in a great variety of domestic trades (the making of hardware, locks, felt boots, &c.). The weaving of linen has declined as a domestic industry, and though nearly 6000 persons are still engaged in it, the yearly returns only amount to £11,000. Factories, however, have considerably developed, and their annual turnover is about 28,000,000 roubles. The principal establishments are cotton, flax, and woollen mills, flour-mills, tobacco works, distilleries, breweries, chicory works, tanneries, candle works, naphtha refineries, chemical works and match works. The three great centres of trade are Yaroslavl, Rybinsk, and Rostoff, where fairs are held every year.

Yaroslavl, capital of the above government, situated on the upper Volga, 173 miles by rail north-east of Moscow, and connected also with Vologda and Archangel by a railway which has added considerably to its importance. Its educational institutions are above the average, and include a high school with a faculty of law. It has cotton-mills, flour-mills, tobacco factories, &c., with an annual turnover of nearly 15,000,000 roubles, and as the chief intermediary in the trade of Moscow with northern Russia, it is of very considerable commercial importance. Population (1897), 70,610.

Yasin. See GILGIT.

Yassy. See JASSY.

Yates, Edmund Hodgson (1831–1894), English journalist and author, son of the actor Frederick Henry Yates (1797–1842), was born at Edinburgh, 3rd July 1831. He was educated at Highgate, and in 1847 was given a clerkship in the General Post Office, with which he continued to be connected up to 1872, becoming in 1862 head of the missing letter department. He married in 1853, and soon began to write for the press, his father's friends being very useful in giving him a start in that direction. Charles Dickens helped him by making him dramatic critic to the *Daily News* and a contributor to *Household Words;* and he wrote several farces which were acted between 1857 and 1860. In 1855 he had begun writing a column for the *Illustrated Times* (under Henry Vizetelly), headed "The Lounger at the Clubs": this was the first attempt at combining "smart" personal paragraphs with the better class of journalism; and in 1858 Yates was made editor of a new paper called *Town Talk*, which carried the innovation a step forward. His first number contained a laudatory article on Dickens, and the second a disparaging one on Thackeray, containing various personal references to private matters. Thackeray, regarding this as a serious affront, brought the article before the committee of the Garrick Club, of which he contended that Yates had made improper use, and the result was that Yates was expelled. Besides editing *Temple Bar* and *Tinsley's Magazine*, Yates during the 'sixties took to lecturing on social topics, and published several books, including his best novel, *Black Sheep* (1867); and under the heading of "Le Flâneur" he continued in the *Morning Star* the sort of "personal column" which he had inaugurated in the *Illustrated Times.* On his retirement from the Post Office in 1872 he went to America on a lecturing tour, and afterwards, as a special correspondent for the *New York Herald*, travelled through Europe. But in 1874, with the help of E. C. Grenville Murray (1819–1881), who was living in Paris, he established a new London weekly, *The World*, "a journal for men and women," which he edited himself, and with which his memory is now chiefly connected. The paper at once became a success, and Yates bought out Grenville Murray and became sole proprietor. *The World* was the first of the new type of "Society papers," abounding in personal criticism and gossip: one of its features was the employment of the first person singular in its columns, a device by which the personal element in this form of journalism was emphasized. After *Truth* was started in 1877 by Mr Henry Labouchere (who was one of Yates's earliest contributors), the rivalry between the two weeklies was amusingly pointed by references in *The World* to what "Henry" said, and in *Truth* to the mistakes made by "Edmund." In 1885 Yates, having been convicted of a libel in 1884 on Lord Lonsdale, had the unpleasant experience of being sent to prison at Holloway for seven weeks. In the same year he published his *Recollections and Experiences* in two volumes. He continued to edit *The World*, but his health gradually gave way, and on 20th May 1894 he died. He had been the typical *flâneur* in the literary world of the period, an entertaining writer and talker, with a talent for publicity of the modern type—developed, no doubt, from his theatrical parentage—which, through his imitators, was destined to have considerable influence on journalism.

Yatsauk, called by the Shans LAWKSAWK, a state in the central division of the southern Shan States of Burma. It is bounded on the north by the state of Thibaw, on the east by the states of Laihka, Möng Küng, and Möng Nai; on the south by the Yawnghwe and the Myelat states of Pangtara and Maw Sön; and on the west by the district of Kyauksè, by Ye-ngan and Maw states. Area, 2196 square miles, with 285 villages. As a whole it is mountainous, with ranges running north and south. The main range has a general height of 5000 feet, with peaks, such as Loi Sampa, rising to 7846 feet. The middle and southern portions, however, consist of open rolling country, with an average height of 3500 feet. To the north the country falls away to the Nam Tu (Myitngè), where there are fine teak forests as well as here and there along the Nam Lang and Nam Et, which with the Zawgyi form the chief rivers of the state. Most of them disappear underground at intervals, which makes the extraction of timber impossible except for local use.

The population is estimated at no more than 15,000. The tribute paid by the sawbwa in 1890 was Rs.12,000, which was only half the sum paid to the kings of Burma. The inhabitants of the state are Shans, Danus, Taungthus, Taungyos, and Palaungs. The Shans form one-half of the entire population, and the Danus three-quarters of the remainder. Cotton blankets of a particular pattern, pottery, coarse paper and lacquer ware, are the chief industries and exports. Lawksawk, the capital, in 21° 15′ N. and 96° 55′ E., stands in bare undulating country, on the north bank of the Zawgyi, on a small weedy lake. The old brick walls and the moat are falling into decay. The position was formerly a very strong one. The chief at the time of the annexation had been at war with the Burmese, but refused to submit to the British, and fled to Kēng Hūng, where he died some years afterwards. The sawbwa chosen in 1887 belonged to another Shan ruling house. He died in 1900, and was succeeded by his son.

Yauco, a small city in the western part of the province of Ponce, Porto Rico. It is the centre of an extensive coffee-producing district, and is connected by rail with Ponce. Population (1899), 6108.

Yazd, or YEZD, a province of Persia, bounded on the S. by Kerman, on the W. by Fars and Isfahan, and on the N. and E. by the central Persian deserts. It contains an area of about 20,000 square miles, but its population barely exceeds 100,000, of whom about half inhabit the capital of the province. Its subdivisions are: (1) the city of Yazd and immediate environs; (2) Ardakán; (3) Bafk; (4) Taft; (5) Kúhistan (Písh Kúh, Mían Kúh, Pusht Kúh, on the slopes and in the valleys of the Shír Kúh, a part of the great Central Range of Persia west of the city of Yazd, and rising to an elevation of 11,000 feet); and (6) Shahr i Bábek. The last is situated far south near Kerman, and sometimes is regarded as part of that province. The revenues of Yazd, including customs (470,000 krans), amount to 2,850,000 krans, or £57,000 a year.

Yazd, or YEZD, a town in Persia, capital of the above province, at an elevation of 4370 feet. Its population is 45,000 to 50,000, including 1300 Zoroastrians and 2000 Jews. About 5000 Zoroastrians live in twenty-two villages a few miles to the west, and have a number of fire-temples. Four fire-temples are kept up in the city. In 1879 the Zoroastrian community of Yazd, city and villages, numbered 6480 souls, but as many subsequently emigrated, it was computed in 1901 that the number in the district was about the same, or a little less. The grain produced in the district sufficing for only two or three months' consumption, supplies have to be obtained from elsewhere, mostly from Khorasan, and wheat and barley are in consequence generally dearer than at other places in Persia. About 1000 looms manufacture nearly 2,000,000 yards of silk stuffs yearly. Much silk was grown in the district, but 84,500 ℔ of raw silk were imported from Gílán. Great quantities of felts (*nimads*), yellow cotton stuffs (a kind of nankeen), are also manufactured, and much opium for home consumption and export is produced. The people of Yazd and surrounding districts are exempted from military service. A branch of the Imperial Bank of Persia was established there in 1891.

Yecla, a town of Spain, province of Murcia, on the railway to Villena. It is in a mountainous, well-watered district, which produces much wheat, wine, oil, esparto grass, and fruit. The parish church is a large structure of Corinthian style. The square where the town hall stands has arcades all round. The streets are clean and regular, though it is an old town with many ruins. Population (1887), 17,706; (1897), 17,085.

Yedo. See Tôkyô.

Yeisk, a district town of Russia, northern Caucasia, in Yeisk Bay, in the north-east of the Sea of Azov, province of Kubañ, 140 miles north-west of Ekaterinodar. Owing to its situation in a fertile region, its exports of corn, wool, and linseed are of some importance. Population (1897), 20,706.

Yellow Fever.—In the course of these volumes it has been shown that several of the most dreaded and destructive diseases have been elucidated and to a large extent brought under control by modern science. (See Cholera, Malaria, Plague, Tuberculosis, Typhoid Fever.) The latest to be added to the list is yellow fever. Recent evidence leaves no doubt that its efficient cause has been discovered, and that prevention is practicable.

This disease is of strictly limited geographical distribution, but of great importance within the area of incidence, and, consequently, to maritime Powers whose vessels frequent ports within that area. It is more or less endemic in the tropical and subtropical regions of Central and South America, in the West Indies, and in tropical West Africa. It is not endemic in the Southern states of North America; but it appears there in epidemic form, and occasionally it has extended its range farther to the north and the south. Great Britain and the United States, therefore, are both concerned in its prevention. The first step towards this was taken in 1881, when Dr Charles Finlay, of Havana, propounded the theory that mosquitoes were the carriers of the infection; but it was not until nearly twenty years later that the suggestion was followed up by systematic investigation and eventually established by the work of a commission appointed by the United States Army Department. Numerous theories had previously been brought forward, notably that of a bacillus, named the *bacillus icteroides*, and described by Sanarelli: it is now certain that this organism is not the cause of yellow fever. Other authorities held that the disease was spread by contagion, by miasmata, or some other of the vague agencies which have always been put forward in the absence of exact knowledge. Finlay's mosquito theory remained in abeyance until attention was again drawn to it by the demonstration in recent years of the part played by these insects in the causation of other tropical diseases. Then it was taken up and worked out experimentally with brilliant results by Reed, Carroll, and others. The mosquito selected by Finlay was the *Stegomyia fasciata*, a black insect with silvery markings on the thorax, which is exceedingly common in the endemic area. It frequents towns, and breeds in any stagnant water about houses. Specimens were caught, fed upon yellow fever patients, kept for a fortnight, and then allowed to bite susceptible persons established in a special camp with other susceptible persons as a control. Those bitten developed the fever, the others did not. The experiments were made in 1900, and their publication was followed by a vigorous campaign against mosquitoes in Havana in the year 1901, based on the methods applied to the suppression of malaria, and carried out under the direction of Major W. C. Gorgas of the United States army, chief sanitary officer of Havana. The work was begun on 27th February 1901. An order was issued that all receptacles containing water were to be kept mosquito-proof; sanitary inspectors were told off for each district to maintain a constant house-to-house inspection, and to treat all puddles, &c., with oil; receptacles found to contain larvæ were destroyed and their owners fined; breeding-grounds near the town were treated by draining and oil; hospitals and houses containing yellow fever

Table showing Deaths from Yellow Fever in the City of Havana.

Years.	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870
Months.															
January .	..	.	..		..	..	..	..	..	..	..	..	..	..	..
February .	..		..	..	..	..	..	..	..	..	..	..	..	..	..
March .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
April .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
June .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
July .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
August.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
September .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
October .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
November .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Totals .	1309	2058	1396	1103	430	1020	1386	550	555	238	51	591	290	1000	572

Years.	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886
Months.																
January .	18	20	32	7	16	24	8	26	11	16	7	9	14	26	4	4
February .	23	13	23	4	16	24	9	13	13	9	3	11	9	16	3	0
March .	12	1	27	18	32	29	11	5	6	20	3	14	21	8	1	0
April .	54	4	37	22	34	33	8	28	13	44	6	18	34	32	2	1
May .	91	13	127	85	32	103	16	53	40	40	6	84	75	55	3	1
June .	201	68	378	172	142	292	143	184	237	50	37	176	162	66	4	14
July .	234	68	416	361	187	675	249	504	475	179	90	195	177	131	13	33
August.	138	70	127	416	144	250	285	374	417	148	127	73	148	97	34	30
September .	72	59	35	186	102	97	234	170	148	75	94	56	50	41	32	37
October .	55	38	28	91	109	42	185	106	44	32	30	33	72	24	41	16
November .	51	85	5	42	105	31	150	53	31	21	38	36	45	8	22	13
December .	42	73	9	21	82	19	76	34	9	11	35	24	42	7	6	9
Totals .	991	515	1244	1425	1001	1619	1374	1550	1444	645	485	729	849	511	165	167

Years.	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901
Months.															
January .	5	8	17	10	10	15	15	7	15	10	69	7	1	8	7
February .	6	8	5	4	3	10	6	4	4	7	24	1	0	9	5
March .	8	11	5	4	4	1	4	2	2	3	30	2	1	4	1
April .	22	24	8	13	5	8	8	4	6	14	71	1	2	0	0
May .	84	26	17	23	7	7	23	16	10	27	88	4	0	2	0
June .	128	36	37	38	41	13	69	31	16	46	174	3	1	8	0
July .	102	74	48	67	66	27	118	77	88	116	168	16	2	30	1
August.	73	113	73	60	66	67	100	73	120	262	102	16	13	49	2
September .	36	63	37	33	65	70	68	76	135	166	56	34	18	52	2
October .	33	48	21	32	48	54	46	40	102	240	42	26	25	74	0
November .	20	33	21	15	24	52	28	23	35	214	26	13	18	54	0
December .	15	21	14	9	17	33	11	29	20	147	8	13	22	20	0
Totals .	532	468	303	308	356	357	496	382	553	1282	858	136	103	310	18

patients were screened; infected and adjacent buildings were fumigated with pyrethrum powder. The results exceeded all expectation. There had been 24 cases with 7 deaths in January, and 8 cases with 6 deaths in February. The record of cases for the ensuing months up to February 1902 was—March, 2; April, 2; May, 4; June, 0; July, 4; August, 6; September, 1; October, 0; November, 0; December, 0; January, 0. The cases in July and August were traced to infection introduced from a suburb, which was afterwards placed under control, when the disease wholly ceased. An important point in the evidence is that the second half of the year is always the period of greatest prevalence in Havana.

Two criticisms may be made. One is that the disappearance of yellow fever may have been really due to the general sanitary measures carried out by the administration. On that head Major Gorgas's report (15th February 1902) states that in spite of the most energetic measures and a marked fall in the general death-rate, no impression was made on yellow fever; on the contrary, it increased and became severely epidemic in 1900, with 1244 cases and 310 deaths. The second point is that the fever has similarly disappeared in other places without any mosquito campaign. The answer is that it disappears in parts where frost occurs in winter, and in comparatively small places where immunity is established among the residents and fresh blood is not imported; but it has never before disappeared in Havana. The foregoing table of recorded deaths shows the remarkable change introduced in March 1901. It is a convincing proof of the correctness of the mosquito theory and of the efficacy of the preventive measures described. The experience encourages the hope that yellow fever may be effectually suppressed in the near future. It should be added that the precise nature of the poison conveyed by the mosquitoes remained to be ascertained. Some authorities believe it to be of a protozoal nature like the malarial parasite (see MALARIA), but up to 1902 they had not demonstrated it. Dr Durham, who carried out a special investigation for the British School of Tropical Medicine, believes it to be bacterial. (A. SL.)

Yellow River. See HWANG HO.

Yemen. See ARABIA.

Yeniseisk, a province of Asiatic Russia, eastern Siberia, in the General-Governorship of Irkutsk, bounded on the N. by the Arctic Ocean, on the W. by Tomsk, on the E. and N.W. by Irkutsk and Yakutsk, and on the S. by Mongolia. It has an area of 987,189 square miles, and its population, which was 458,570 in 1890, in 1897 numbered 559,902 (domiciled only), of whom 268,347 were women, and 59,005 lived in towns. The population is almost entirely Russian, there being only some 11,000 Tatars, 2750 Tungus, and a few Germans and Jews. The province is divided into five districts, the chief towns of which are Krasnoyarsk (26,000), Achinsk (6714), Kansk (7504), Minusinsk (10,255), and Yeniseisk, and there is one division (*otdyel*) of Turukhansk and one new district, Usinsk, including the southern gold-mining region. The standard of education is low; in 1898 there were only 237 primary schools, attended by 6570 boys and 3000 girls. Agriculture is the chief occupation of the Russians, and is especially flourishing in the southern part of the province, in the district of Minusinsk. No less than 1,117,000 acres are under crops, and the average yield in 1895–99 was: rye, 2,351,000 cwt.; wheat, 1,541,000 cwt.; oats, 1,528,000 cwt.; and barley, 207,000 cwt.; also potatoes, 866,000 cwt. Cattle-breeding is very extensively carried on, and there are in the province, though the estimates are much too small, 402,000 horses, 272,000 horned cattle, 638,500 sheep, about 70,000 reindeer, and 92,000 pigs. Fishing, especially on the lower Yenisei, is of great importance, yielding the inhabitants their chief supply of food. In 1825 sables were killed to the amount of 3000 pieces a year, but there are now none to be found, and the hunters obtain chiefly squirrels, foxes, Arctic foxes, and bears. Mining has been on the decline for many years. In the 'fifties from 13,000 to 16,400 kilogrammes of gold were obtained annually in the districts of northern and southern Yeniseisk, but in 1897 only 3395 kilogrammes were extracted. The province is extremely rich in iron ores, but the iron industry is in its infancy, and only 44,000 cwt. of pig iron and 38,000 cwt. of iron were obtained in 1897. Salt is extracted to the amount of 43,000 cwt. a year, as well as some Epsom salts. Coal has been found on the lower Tunguska, near the mouth of the Yenisei, and in many places in the south of the province. Silver, copper, lead, brown coal, rock-salt, graphite, and mica are all found in large quantities, but are not yet regularly mined. In 1898 factories employed only 2320 workers; there are several distilleries, and iron-works have been established on the Abakan. The province is now crossed from west to east by the Siberian Railway, and considerable efforts have been made to establish regular steamer communication between the mouth of the Yenisei and western Europe. Hydrographical surveys have been carried out, and a well-protected bay has been discovered in the estuary of the Yenisei. Since 1890, indeed, with the exception of a single summer, European steamers have reached the mouth of the Yenisei, importing all sorts of provisions and machinery for the gold-mines. The Yenisei is navigated by ten steamers, and efforts have been made to clear the rapids of the Angara, so as to bring Lake Baikal into steamer communication with the Yenisei. Owing to the shallowness of the small tributaries of the Yenisei, the canal connecting the Yenisei with the Ob has not yet proved as serviceable as was expected. (P. A. K.)

Yeniseisk, a district town of the above province, on the right bank of the Yenisei, 200 miles north-north-west of Krasnoyarsk, with which it has regular communication by steamer. It is the centre of the north Yeniseisk gold-mining region, and has a public library, a good natural history and archæological museum, and more than the usual number of schools. Population (1897), 11,539.

Yeola, a town of British India, in the Nasik district of Bombay, on the chord line of the Great Indian Peninsula Railway, 18 miles from Manmar junction. There are important manufactures of silk cloth and thread, and of gold and silver wire. Population (1881), 17,685; (1891), 18,861.

Yeovil, a parish, municipal borough, and market town in the southern parliamentary division of Somersetshire, England, on the Yeo, 22 miles south of Wells by rail. Modern erections are Established and Roman Catholic churches, and a Masonic hall. A foundry and motor-car and bicycle works have been established. Area, 699 acres. Population (1881), 8479; (1891), 9648; (1901), 9838.

Yezd. See YAZD.

Yezo, or Ezo, the most northerly of the five principal islands forming the Japanese empire, the five being Yezo, Nippon, Shikoku, Kiushiu, and Formosa. It is situated between 45° 30′ to 41° 21′ N. and 146° 7′ to 139° 11′ E.; its coast line measures 1423·32 miles, and it has an area of 30,148·41 square miles. On the north it is separated from Saghalien by Soya Strait (La Pérouse), and on the south from Nippon by Tsugaru Strait. Its northern shores are washed by the Sea of Okhotsk, its southern and eastern by the Pacific Ocean, and its western by the Sea of Japan.

Orography.—The highest mountain in the island is Ishikari-dake (6955 feet), and the next in importance is Tokachi-yama (6541 feet). Yubari-dake in Ishikari has a height of 6508 feet, and in the province of Kushiro are O-akan-dake (4470 feet) and Me-akan-dake (4500 feet). Dr Rein's investigations led him to state that Tokachi-dake forms a species of central elevation whence most of the principal rivers flow towards the sea, and that the mountain system is a continuation, on the western side, of the Saghalien range, and on the eastern of the Kuriles range; the former consisting of granite and old schists, the latter chiefly of volcanic formations. Near Hakodate are two conspicuous volcanic peaks, Komaga-take (3860 feet) and Tokatsu-dake (3800 feet); and 24 miles from Kushiro (by rail) is a volcano called Atosa-nobori, or Iwo-zan (sulphur mountain), whence great quantities of first-rate sulphur are exported to the United States. Mention must also be made of Rishiri-jima, an islet on the extreme north-west of Yezo, which has a peak of the same name rising to a height of nearly 6000 feet.

Rivers.—Yezo boasts the largest river in the Japanese empire, namely, the Ishikari-gawa, which has not been accurately surveyed, but is believed to measure over 400 miles. Its other large rivers are the Teshio-gawa (192 miles), the Tokachi-gawa (120 miles), the Shiribeshi-gawa (88 miles), the Kushiro-gawa (81 miles), the Toshibetsu-gawa (64 miles), and the Yubetsu-gawa (64 miles). The valley of the Ishikari is believed to be the most fertile part of the island; the Tokachi is navigable to a point 56 miles from its mouth, but the Teshio has a bar which renders its approach extremely difficult. A peculiarity of several of the rivers is that, on approaching the sea-shore, they run parallel to it for some distance before finding an exit. Those flowing to the south coast take, in this way, a westerly direction, those flowing to the east coast, a northerly direction. This phenomenon is attributed to the fact that the prevailing winds set up the sand so as to deflect the rivers from their straight course. Nearly all these rivers abound with salmon, the most remarkable in that respect—though a comparatively small river—being the Nishibetsu-gawa, which yields an average of over two thousand tons of fish annually.

Lakes.—There are no large lakes, the most extensive—Toya, Shikotsu, and Kushiro—not having a circumference of more than 30 miles. Lagoons, however, are not uncommon. The largest of these—Saruma-ko in Kitami—is some 17 miles long by 7 wide. It abounds with oysters nearly as large as those for which the much smaller lagoon at Akkeshi is famous, the molluscs measuring about 18 inches in length.

Climate.—The climate differs markedly from that of the main island of Japan, resembling rather the climate of the British Isles, though the winter is longer and more severe, and the atmosphere in the warm season contains a greater quantity of moisture. During five months the country is under snow, its depth averaging about two feet in the regions along the southern coast, and more than six feet in the northern and western regions. An ice-drift, setting from the north and working southwards as far as the vicinity of Nemuro, effectually stops all sea-trade on the east coast during January, February, and March, though the west coast is protected by the warm current of the Kuro-shiwo against this inconvenience. Fogs prevail along the east coast during the summer months, and it is not uncommon to find a damp, chilly atmosphere near the sea in July, whereas, a mile inland, the thermometer stands at 80° or 90° F. in the shade, and magnolia trees are in full blossom.

Zoology.—Tsugaru Strait has been shown by the late Captain Blakiston, R.A., to form a line of zoological division. Pheasants and monkeys are not found on the Yezo side of this line, though they abound on the island of Nippon, and, on the other hand, Yezo has grouse and solitary snipe which do not exist in Nippon. The Yezo bear, too, is of a distinct species, and the island has an abundance of singing birds which are conspicuous by their absence southwards of the strait. There are also notable differences in the flora, the trees and flowers of Yezo resembling those of the British Isles rather than those of Japan.

Population.—The island seems to have been originally peopled by a semi-barbarous race of pit-dwellers, whose modern representatives are to be found in the Kurilsky or their neighbours of Kamchatka and Saghalien. These autochthons were driven out by the Ainu, and the latter, in their turn, succumbed to the Japanese. The population of Yezo is 605,742, of whom 17,573 are Ainu. There is a steadily growing but not large emigration from Japan proper to Yezo. The actual number of immigrants increased from 14,512 in 1890 to 52,248 in 1898. The population at present being only 20·1 per square mile, whereas even Tsushima and the Ogasawara islands have populations of 144·9 and 168·4 per square mile respectively, Yezo still offers large opportunities for immigration.

Divisions and Towns.—Yezo is divided into ten provinces, the names of which, commencing from the south, are Oshima, Shiribeshi, Ishikari, Teshio, Kitami, Iburi, Hidaka, Tokachi, Kushiro, and Nemuro. Of these Oshima, Shiribeshi, and Shikari are by far the most important. There are only three towns having a population of over 20,000, namely, Hakodate (50,314), Sapporo (46,147), and Otaru (34,586). Other towns of importance are Fukuyama (formerly called Matsumaye), the seat of government in feudal days, Esashi, Mombetsu, Oiwake, Tomakomai, Piratori (the chief Ainu settlement), Muroran, Kushiro, Akkeshi, Nemuro, Horobetsu, Yunokawa, Abashiri, and Mashiki. Yunokawa, 4½ miles from Hakodate, is much frequented for the sake of its hot springs; Oiwake is the junction of the main line of railway with the branch to the Yubari collieries; Kushiro is a special port of export for coal and sulphur; Akkeshi is celebrated for its oysters, there being large reefs entirely composed of them.

Industries and Products.—Marine products constitute the principal wealth of Yezo. Great quantities of salmon, sardines, and cod-fish are taken. The salmon are salted for export to Nippon and other parts of Japan; the sardines are shipped away to be used as an agricultural fertilizer, their value for that purpose varying from £2 to £5 per ton; and the cod-fish serve for the manufacture of oil. An immense crop of edible sea-weed is also gathered and sent to Chinese markets as well as to Japanese. This *kombu*, as it is called, sometimes reaches a length of 90 feet and a width of 6 inches. The herring fishery, too, is a source of wealth, and the canning of Akkeshi oysters as well as of salmon gives employment to many hands. Vast tracts are covered with a luxuriant growth of ash, oak, elm, birch, chestnut, and pine, but owing to difficulties of carriage this supply of timber has not yet been much utilized. One of the earliest acts of the *Meiji* Government was to organize a colonization department for the purpose of developing the resources of Yezo and encouraging Japanese to emigrate thither. Free grants of agricultural land were made, roads were constructed, model farms established, beet-sugar factories and saw-mills opened, horse-breeding undertaken, foreign fruit trees planted, and railways laid. The outlays incurred on these accounts did not immediately bear fruit, and are sometimes thoughtlessly described as wasted. But they accomplished their object, for they attracted large numbers of settlers. During recent years attention has been attracted to the mineral resources of Yezo. Coal of fair quality is abundant, and a railway has been built for its carriage; an apparently inexhaustible supply of sulphur is obtained from a mountain near Kushiro Lake, whence it is carried to the sea coast by rail and river; petroleum seems likely to pay exploiters, and in 1899 gold was discovered at Usotannai, Pankanai, and other places along the Poropetsu river, near Esashi in Kitami province.

Communications.—The roads are few and in bad order, but there is a railway which, setting out from Otaru, on the west coast, runs, *viâ* Sapporo and Iwamizawa, to Mororan on the south coast, a distance of 133¼ miles, with branches from Iwamizawa, eastwards to Horonai and Ikushumbetsu, and northwards to Shibetsu, and from Oiwake north-east to the Yubari coal-mines. In districts beyond the railway route, travelling is done on horseback, there being an abundant supply of ponies. There is good coastwise communication by steamer.

Defence.—Until recent years the defence of Yezo depended on a local militia called *tonden-hei*, but in the programme of armaments expansion drafted in 1896, after the war with China, Sapporo appeared as the headquarters of a new divison, the seventh, now fully organized.

History.—Yezo was not brought under Japan's effective control until mediæval times. In 1604 the island was granted in fief to Matsumaye Yoshihiro, whose ancestor had overrun it, and from the close of the 18th century, the eastern part was governed by officials sent by the shôgun in Edo, whose attention had been attracted thither by Russian trespassers. In 1871 the task of developing its resources and administering its affairs was entrusted to a special bureau, which employed American agriculturists to assist the work and American engineers to construct roads and railways; but in 1881 this bureau was abolished, and the Government abandoned to private hands the various enterprises it had inaugurated. Yezo is not yet included in the general political system of the Japanese empire. It has no local assemblies, nor does it send representatives to the Diet, its affairs being administered wholly by officials sent from Tôkyô.

Yohchow, or YUCHOW, a city in the province of Hunan, China, situated at the outlet of Tungting Lake on the right bank of the Yangtse. It was declared open to foreign trade in 1899, in pursuance of a promise made to the British Government. The actual settlement, however, is not at Yohchow itself, but at a small village named Chinlingki, 5½ miles below Yohchow and half a mile from the Yangtse. The object of selecting this site was its proximity to the great river, which it was supposed would induce the regular river steamers to make it a port of call. The importance of Yohchow is that it is the only open port in the province of Hunan, a province which had been extremely hostile to the advent of foreign trade, while at the same time its trading capabilities were known to be very considerable. From Yohchow the large cities of Changsha and Changteh are accessible for steam vessels drawing up to four or five feet of water by means of Tungting Lake and its affluents, the Siang and Yuen rivers. Changsha, the capital of the Hunan province, has a population of 300,000. Changteh, a short distance up the Yuen river, is a place of great trade, with an enormous junk traffic and a population estimated by Captain Barton at 500,000.

Yola. See NIGERIA.

Yonge, Charlotte Mary (1823–1901), English novelist and writer on religious and educational subjects, daughter of William Crawley Yonge, 52nd Regiment, and Frances Mary Bargus, was born 11th August 1823 at Otterbourne, Hants. She was educated by her parents, and from them inherited much of the religious feeling and High Church sympathy which coloured her work. She resided at Otterbourne all her life, and was one of the most prolific writers of the Victorian era. In 1841 she published no fewer than five works of fiction, including *The Clever Woman of the Family*, *Dynevor Terrace*, and *The Trial;* and after that she was the author of about 120 volumes, including novels, tales, school manuals, and biographies. Her first conspicuous success was attained with *The Heir of Radclyffe* (1853), which enjoyed an enormous vogue. *The Daisy Chain* (1856) continued the success; and among her other popular books may be mentioned *Heartsease* (1854), *The Young Stepmother* (1861), and *The Dove in the Eagle's Nest* (1866). In more serious fields of literature she published *Landmarks of History* (three series, 1852–57), *History of Christian Names* (1863), *Cameos of English History* (1868), *Life of Bishop Patteson* (1874), *English Church History for Use in Schools* (1883), and many others. She also edited various educational works, and was for more than thirty years editor of *The Monthly Packet.* She died at Otterbourne, on 24th March 1901. The fault of Miss Yonge's work lies on the other side of its dominant quality; she was essentially earnest, and her earnestness led her at times into dull didacticism. Her books are mainly suited to young girls, among whom they have exercised a wide and wholesome influence. The sincerity of her piety has been often proved in generous practice. It is said that the money realized by the early sales of *The Daisy Chain* was given to the building of a missionary college at Auckland, N.Z., while a large portion of the proceeds of *The Heir of Radclyffe* was devoted to the missionary schooner *The Southern Cross.* Few writers have done so much to mould the mind of the "English girl, divine, demure," and the standards of gentleness and grace which she maintained have been of abiding value to her generation. (A. WA.)

Yonkers, a city of Westchester county, New York, U.S.A. It is situated in 40° 56′ N. and 73° 54′ W., on high ground on the east bank of the Hudson river, opposite the Palisades, adjoining New York on the north. It is a residence suburb of New York, and is connected with it by the New York Central and Hudson River, and the New York and Putnam railways. Its site is hilly, rising from the river in terraces, and its plan is irregular. It has a good water-supply and sewerage. It contains many beautiful and expensive residences built on the terraces, which afford fine views of the river and the Palisades. It has considerable importance as a manufacturing city. In 1900 it contained 387 manufacturing establishments, with a total capital of $13,097,205. They employed 8615 hands, and the product had a value of $19,580,324. The principal items were carpets, hats and caps, foundry and machine-shop products, and silk and silk goods. In 1900 the assessed valuation of real and personal property was $38,211,230, the net debt was $3,375,224, and the rate of taxation was $23.93 per $1000. Population (1890), 32,033; (1900), 47,931, of whom 14,634 were foreign-born and 1005 negroes.

Yonne, a department of central France, watered by the river naming it.

Area, 2894 square miles. From 355,364 inhabitants in 1886 the population in 1901 had declined to 316,047. The births in 1899 were 5125, of which 336 were illegitimate; deaths, 6957; marriages, 2124. The schools in 1896 numbered 949, with 50,000 pupils, less than 1½ per cent. of the population being illiterate. Out of 1,729,000 acres of land under cultivation in 1896, 1,101,620 acres were arable and 83,980 acres were under vines. Woods and forests covered a surface of more than 320,000 acres. The wheat reaped in 1899 was valued at £1,485,000; rye, £88,000; barley, £106,000; oats, £620,000; potatoes, £201,000; mangold-wurzel, £272,000; green crop (trefoil, lucern, and sainfoin), £521,000; beetroot, £28,300; vines, £408,000; cider-apples, £67,100. The live-stock in 1899 comprised 47,070 horses, 5170 asses, 151,380 cattle, 298,850 sheep, 31,290 pigs, and 4890 goats. The production in milk (1899) was valued at £711,000. In 1898, 73 metric tons of lignite were cut. A great deal of building stone was quarried. There was a mediocre production of work in metals. In 1898 there were distilled 22,100 gallons of alcohol. There are thriving sugar refineries, glass-works, and saw-yards. Auxerre, the capital, had (1901) 18,901 inhabitants.

York, a north-eastern county of England, by far the largest in extent, but second to Lancashire in population, bounded on the N. by Durham, on the E. by the North Sea, on the S. by Lincoln, Nottingham, and Derby, on the S.W. by Cheshire, and on the W. by Lancashire and Westmorland.

Area and Population.—The county is divided into East, North, and West Ridings (properly Thriding, from Icelandic *thriding*= a third part, the loss of the *th* being probably due to the wrong division of the compounds East-thriding, West-thriding). The total area of the ancient county is 3,882,848 acres, or 6067 square miles, of which 749,513 are in the East Riding, 1,361,465 in the North Riding, 1,768,279 in the West Riding, and 3591 in the city of York. The following table gives the population of the ancient county and its subdivisions in 1881, 1891, and 1901:—

Year.	East Riding.	North Riding.	West Riding.	City of York.	Yorkshire.
1881	309,408	340,687	2,174,737	61,789	2,886,621
1891	341,546	360,383	2,439,895	67,004	3,208,828
1901	367,319	393,143	2,746,867	77,793	3,585,122

Males in 1891 numbered 1,568,843, and females 1,639,985. In 1901 the number of persons per square mile was 599, and of acres to a person 1·08, the proportions in the East Riding being 314 and 2·04, in the North Riding 185 and 3·46, in the West Riding 994 and 0·64, and in the city of York 14,144 and ·04. The area of the administrative county of the East Riding (including the county borough of Kingston-upon-Hull) in 1891 was 750,053 acres, with a population of 341,560; of the North Riding (including the county borough of Middlesbrough), 1,360,925 acres, with a population of 360,369; of the West Riding (including the county boroughs of Bradford, Halifax, Huddersfield, Leeds, and Sheffield), 1,773,782 acres, with a population of 2,444,931; of the city of York, 3591 acres, with a population of 67,004, the total area of the administrative counties being 3,888,351 acres, with a population of 3,213,864. Since 1891, however, various changes have been made in the administrative areas: in 1893 part of the contributary place of Clifton in the North Riding was transferred to the city of York; and in 1895 the part of the township of Linthorpe in the borough of Stockton was transferred from the North Riding to Durham, and the part of the parish of Wallingwells in the West Riding was transferred to Nottingham, while the part of the parish of Auckley in Nottingham was transferred to the West Riding, the parts of the parishes of Humberton and Milby in the West Riding, and four detached parts of the parish of Nunwick with Howgrave, from the West Riding to the North Riding, a detached part of the township of Knedlington from the

East Riding to the West Riding, and the parts of the parishes of Lower Dunsforth and Upper Dunsforth with Branton Green, from the North Riding to the West Riding. Excluding county boroughs, the populations of the new administrative divisions in 1901 were as follows:—East Riding, 145,194; North Riding, 285,671; and West Riding, 1,460,861. The area of the registration county of the East Riding (including the city of York) is 692,995 acres, with a population in 1901 of 454,271; of the North Riding, 1,277,104 acres, with a population of 375,909; and of the West Riding, 1,750,992 acres, with a population of 2,766,215. In the East Riding the percentage of increase between 1881 and 1891 was 10·41; in the North Riding, 5·96; and in the West Riding, 12·12, the corresponding increases for the period between 1891 and 1901 being 8·9, 9·9, and 12·6 per cent., and for the whole county 11·7 per cent. The excess of births over deaths in the whole registration area of Yorkshire between 1881 and 1891 was 387,664, and the increase in resident population was 324,080. The following table gives the numbers of marriages, births, and deaths, with the number of illegitimate births, in Yorkshire and the several Ridings for 1880, 1890, and 1898:—

	Marriages.			Births.			Deaths.			Illegitimate Births.		
	1880.	1890.	1898.	1880.	1890.	1898.	1880.	1890.	1898.	1880.	1890.	1898.
East Riding .	2,844	3,154	3,756	12,482	12,106	13,407	7,656	7,696	7,882	689	650	724
North Riding	2,212	2,778	2,905	11,445	10,939	10,905	6,624	6,541	6,628	673	645	619
West Riding .	16,661	20,329	23,083	77,457	74,549	79,397	46,794	51,617	49,131	3886	3475	3554
Yorkshire	21,717	26,261	29,744	101,344	97,594	103,709	61,074	65,854	63,641	5248	4770	4897

The number of marriages in the East Riding in 1899 was 3730, of births 13,670, and of deaths 7851; of marriages in the North Riding 3048, of births 11,021, and of deaths 6882; of marriages in the West Riding 23,572, of births 79,837, and of deaths 49,704.

The following table gives the marriage-, birth-, and death-rates per thousand of the population in the East, North, and West Ridings, with the percentage of illegitimate births, for a series of years:—

	East Riding.						North Riding.						West Riding.					
	1870–79.	1880.	1880–89.	1890.	1888–97.	1898.	1870–79.	1880.	1880–89.	1890.	1888–97.	1898.	1870–79.	1880.	1880–89.	1890.	1888–97.	1898.
Marriage-rate .	18·3	15·8	15·8	15·9	16·1	17·5	15·3	13·4	13·8	15·7	14·1	15·8	17·7	15·3	15·4	16·6	16·1	17·3
Birth-rate .	35·5	36·6	33·2	30·5	31·3	31·3	36·5	34·7	33·7	31·0	30·1	29·6	38·7	35·6	32·9	30·5	30·7	29·8
Death-rate .	21·5	21·3	19·7	19·4	18·8	18·4	20·1	20·0	18·3	18·5	17·7	18·0	23·8	21·5	20·1	21·1	19·3	18·4
Percentage of illegitimacy .	6·2	5·6	5·8	5·4	5·4	5·4	7·0	5·9	6·0	5·9	5·9	5·7	5·2	5·0	5·1	4·7	4·6	4·5

A striking feature is the diminution in both the birth- and death-rates. In 1891 there were in the county 21,387 natives of Scotland, 43,098 natives of Ireland, and 15,755 foreigners.

Constitution and Government.—Each of the three Ridings is, for most purposes, a distinct county; but there is one sheriff for the whole county. The municipal boroughs of Bradford, Halifax, Huddersfield, Kingston-upon-Hull, Leeds, Middlesbrough, Sheffield, and the city of York, are county boroughs. The East Riding contains five municipal boroughs: Beverley (13,185), Bridlington (12,473), Hedon (1010), Kingston-upon-Hull (240,618), and York (77,793). Its urban districts are Cottingham (3752), Filey (3004), Great Driffield (5766), Hessle (3754), Hornsea (2381), Norton (3842), Pocklington (2463), and Withernsea (1439). The North Riding contains four municipal boroughs: Middlesbrough (91,317), Richmond (3836), Scarborough (38,160), and Thornaby-on-Tees (16,053). The following are urban districts: Eston (11,182), Guisborough (5645), Hinderwell (1937), Kirklington-cum-Upsland (255), Loftus (6508), Malton (4758), Northallerton (4009), Ormesby (9477), Pickering (3491), Redcar (7965), Saltburn-by-the-Sea (2578), Skelton and Brotton (13,239), South Bank in Normanby (9645), and Whitby (11,748). The West Riding contains the following municipal boroughs: Barnsley (41,083), Batley (30,321), Bradford (279,809), Brighouse (21,735), Dewsbury (28,050), Doncaster (28,924), Halifax (104,933), Harrogate (28,414), Huddersfield (95,008), Keighley (41,565), Leeds (428,953), Morley (23,638), Osset (12,886), Pontefract (13,422), Pudsey (14,907), Ripon (8225), Rotherham (54,348), Sheffield (380,717), Todmorden (25,419), and Wakefield (41,544). The urban districts are too numerous for complete mention, but the following is a list of those with a population of over 10,000: Bingley (18,448), Castleford (17,382), Cleckheaton (12,523), Elland (10,412), Featherstone (12,093), Goole (16,576), Handsworth (14,157), Hoyland, Nether (12,464), Liversedge (13,978), Mexborough (10,417), Mirfield (11,346), Normanton (12,353), Rawmarsh (14,587), Rothwell (11,702), Saddleworth (12,319), Shipley (25,570), Skipton (11,986), Sowerby Bridge (11,477), Stanley (12,158), Swinton (12,217), Thornhill (10,290), Wombwell (13,252), and Worsborough (10,335). The ancient county of York contains 1135 ecclesiastical parishes and districts and parts of 13 others; it is situated partly in the dioceses of Durham, Lincoln, Manchester, Ripon, Southwell, Wakefield, and York.

Education.—Leeds and Sheffield are the seats of university colleges. In connexion with both there are day training colleges for schoolmasters and schoolmistresses; at York there is a residential training college (diocesan) for schoolmasters, and at Ripon a residential training college (diocesan) for schoolmistresses. There are board deaf schools at Bradford, Kingston-upon-Hull, Leeds, Middlesbrough, and Sheffield; at Bradford there is a blind school, at Leeds a board home and school for the blind, at Sheffield an institution for the blind, at York the Yorkshire school for the blind, at Boston Spa an institution for the deaf and dumb, and at Doncaster the Yorkshire institution for the deaf. The total number of elementary schools in the county on 31st August 1899 was 2098, of which 692 were board and 1406 voluntary schools, the latter including 1112 National Church of England schools, 76 Wesleyan, 107 Roman Catholic, and 111 "British and other." The average attendance at board schools was 279,503, and at voluntary schools 238,458. The total school board receipts of the united county boroughs for the year ended 29th September 1899 were over £808,708. Their income under the Technical Instruction Act was £3080, and that under the Agricultural Rates Act over £1621. Excluding the county boroughs, the total school board receipts of the East Riding were over £14,373, of the North Riding £70,793, and of the West Riding over £460,672. In the East Riding there was no income under the Technical Instruction Act, and that under the Agricultural Rates Act was over £1469; in the North Riding the two several incomes were over £214 and over £2126, and in the West Riding over £3844 and over £7293.

Agriculture.—Nearly seven-eighths of the total area of the East Riding is under cultivation, but of the North and West Ridings only about two-thirds. Wheat is largely grown in all the Ridings—in the East and West Ridings occupying about two-sevenths of the corn crop acreage, and in the North Riding about one-sixth. Oats are now the principal corn crop, barley holding an intermediate position. Of the green crop acreage, the bulk is devoted to turnips and swedes; but in the West Riding about one-fourth is usually under potatoes, in the East Riding about one-ninth, and in the North Riding about one-seventh. In the flat East Riding only about 2000 acres are in hill pasture, but in the North Riding about 315,000, and in the West Riding about 216,000. Both the North and West Ridings are well wooded, but in the East Riding the acreage under woods is only about 17,000. The following table gives the acreages of the larger main divisions of the cultivated area in the several Ridings at intervals from 1885:—

	Total Area under Cultivation.	Corn Crops.	Green Crops.	Clover.	Permanent Pasture.	Fallow.
1885.						
East Riding	662,506	262,134	111,076	86,217	184,241	18,428
North Riding	854,605	206,270	78,809	72,714	469,874	26,923
West Riding	1,211,928	220,971	99,744	82,969	791,483	16,208
1890.						
East Riding	668,626	253,067	105,016	91,814	200,037	17,500
North Riding	863,756	193,052	74,897	75,026	497,286	23,115
West Riding	1,216,528	206,286	92,274	82,418	820,783	13,069
1895.						
East Riding	669,993	245,765	108,698	94,345	206,342	14,037
North Riding	864,297	183,298	75,834	75,826	509,071	19,567
West Riding	1,201,897	192,497	94,732	78,267	824,568	9,715
1900.						
East Riding	672,354	247,500	109,421	92,232	211,220	11,062
North Riding	865,729	183,627	76,928	71,918	518,972	13,698
West Riding	1,197,768	192,246	94,747	74,463	827,630	6,992

The following table gives particulars regarding the principal live-stock for the same years :—

	Total Horses.	Total Cattle.	Cows or Heifers in Milk or in Calf.	Sheep.	Pigs.
1885.					
East Riding	37,625	88,189	27,070	424,724	46,472
North Riding	39,704	171,473	55,566	636,221	50,864
West Riding	51,327	274,506	123,894	630,054	74,007
1890.					
East Riding	40,068	83,989	26,326	483,338	61,400
North Riding	42,074	168,402	54,756	710,643	64,042
West Riding	54,494	263,399	126,052	685,167	91,028
1895.					
East Riding	46,033	83,136	24,936	436,237	63,080
North Riding	45,493	164,254	51,867	676,762	58,667
West Riding	61,413	260,296	122,504	672,856	103,351
1900.					
East Riding	43,743	88,860	26,342	429,856	56,074
North Riding	44,177	174,744	53,712	733,757	47,673
West Riding	59,993	271,922	127,321	676,485	89,001

Industries and Trade.—According to the report for 1898 of the chief inspector of factories (1900), the total number of persons in the East Riding employed in factories and workshops was 30,734, as compared with 28,353 in 1896 ; in the North Riding 39,750, as compared with 38,546 ; and in the West Riding 538,002, as compared with 535,764. In the West Riding textile factories employed 237,344 persons, there being an increase between 1895 and 1896 of 0·7 per cent., but between 1896 and 1897 a decrease of 5·7. In the woollen and worsted industries nearly fifteen times as many persons (191,622) were employed as in Lancashire, which comes next. Nearly all the important towns are engaged in this industry, several districts having their own special branches. The cotton industry in the West Riding employed 31,337 persons, chiefly in the neighbourhood of Halifax : silk 9998, and flax, hemp, &c., 3774. Non-textile industries employed in the East Riding 23,449 persons, in the North Riding 35,337, and in the West Riding 257,882, the increase in the East Riding between 1895 and 1896 being 5·2 per cent., and between 1896 and 1897, 7·0 per cent. ; while in the North Riding the percentages of increase were 17·0 and 4·3, and in the West Riding 5·6 and 5·0. In the manufacture of machines, conveyances, appliances, and tools, 9248 persons were employed in the East Riding, 11,514 in the North Riding, and 87,137 in the West Riding. Metal extracting, founding, and conversion employed in the North Riding 15,414, and in the West Riding 40,716. Leeds, Sheffield, and Middlesbrough are the chief seats of the metal industries. In the North Riding the manufacture of chemicals employed 4739, and in the West Riding 4901. Other important industries of the West Riding are clothing, employing 25,802 ; printing, bleaching, &c., 20,294 ; paper making, &c., 12,463 ; the making of jewellery, &c., 9895 ; glass making, 6398 ; food industries, 6060 ; drink industries, 5441 ; furniture making, 5699 ; and clay and stone industries, 5269. Workshops in the East Riding employed 7051, in the North Riding 4175, and in the West Riding 42,776. Of those in the West Riding 20,939 were employed in clothing industries, 6829 in the manufacture of machines, &c., 4070 in furniture making, 1847 in cotton and woollen industries, and 1571 in the manufacture of jewellery, &c. The total number of persons employed in connexion with mines and quarries in 1899 was 113,096. In the same year 1,352,995 tons of clay were raised, 997,915 tons of limestone, 940,951 tons of sandstone, 180,800 tons of igneous rocks other than granite, 50,249 tons of chalk, 15,820 tons of alum shale, 5656 tons of slate, and 2358 tons of barytes. Of salt 44,481 tons were obtained from brine. But the principal mineral productions are coal and iron. In 1885 the pig iron made in the North Riding (Cleveland) amounted to 1,747,598 tons, and in the West Riding it amounted to 165,857 tons ; in 1890 the amounts were 1,961,328 tons and 248,581 tons ; in 1895 they were 2,058,279 tons and 195,123 tons, and in 1899 they were 2,211,222 tons and 305,583 tons. The following table gives the tonnage and value of the coal and iron ore production at intervals from 1885 :—

	COAL.				IRON ORE.			
	North Riding.		West Riding.		North Riding.		East and West Ridings.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1885	3906	£1433	18,497,778	£4,624,444	5,032,244	£963,989	126,596	£63,298
1890	3776	1463	22,335,110	9,771,610	5,617.573	1,053,295	77,433	47,750
1895	3531	1148	22,807,507	7,317,408	5,285,617	858,913	45,538	29,030
1899	2970	965	26,901,495	10,312,240	5,612,742	1,109,821	59,136	32,525

The fisheries are of some importance, but not so much as the amount of fish landed at Hull would seem to indicate. The quantity landed there in 1899 was 1,249,123 cwt., valued at £941,712 ; at Scarborough it was 187,100 cwt., valued at £117,696 ; the total value of the port's fish, including shell-fish, being £119,601. The total quantity landed at all other fishing ports was 49,583 cwt., valued at £31,007 ; the total value, including shell-fish, being £40,256.

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York, a cathedral city, municipal, county (1888), and parliamentary borough, and the county town of Yorkshire, England, on the river Ouse, 188 miles north of London by rail. New municipal offices were erected in 1889–91, and new courts of justice (£25,000) in 1892. In 1891 the nave of the cathedral was restored, and in 1892 the corporation purchased the building of the York Institute of Science and Art for a free library. In 1893 the area of the city and county borough was extended by the transference to it of part of the contributory place of Clifton, an addition of 138 acres with a population of 995. Population (1891), 67,749 ; (1901), 77,793.

York, a city of Nebraska, U.S.A., capital of York county, at the intersection of the Chicago, Burlington, and Quincy, the Fremont, Elkhorn, and Missouri Valley, and the St Joseph and Grand Island railways, in the south-eastern part of the state. Population (1890), 3405 ; (1900), 5132, of whom 477 were foreign-born

York, a borough of Pennsylvania, U.S.A., capital of York county. It is situated in 39° 58′ N. and 76° 40′ W., on Codorus creek, in the south-eastern part of the state, at an altitude of 381 feet. It has an undulating site, on which it is laid out with great regularity. It is divided into thirteen wards, has a good water-supply from springs by gravity, and good sewerage. It is surrounded by a rich farming country, made tributary to it by four railways—the Northern Central, the Pennsylvania, the Western Maryland, and the York Southern. In 1900 it contained 464 manufacturing establishments, with a total capital of $9,640,784. They employed 7785 hands, and the product was valued at $11,961,706. Among these products were foundry and machine-shop products, carriages and waggons, lumber, confectionery, iron and steel, tobacco and cigars, and agricultural implements. Population (1890), 20,793 ; (1900), 33,708, of whom 1304 were foreign-born and 776 negroes.

York River, a tributary to Chesapeake Bay, U.S.A. Its sources, the Mattapony and Pamunkey rivers, rise in the "piedmont" region of Virginia, and, flowing south-east, join at West Point to form York river, which is throughout a tidal estuary. Situated upon it, a few miles above its mouth, is Yorktown, one of the oldest settlements of Virginia.

Yorktown, capital of York county, Virginia, U.S.A., situated in the south-eastern part of the state, at the mouth of the York river. It is famous as the scene of the surrender of Lord Cornwallis, 19th October 1781, the closing event of the Revolutionary War. Cornwallis, with a force of about 8000 men, had established himself at Yorktown, where he was besieged by the combined American and French forces, under Washington and Lafayette, numbering about

16,000. The arrival of British reinforcements was prevented by Count de Grasse, who had a large French fleet in the harbour. After several days of hard fighting and an ineffectual sortie, the British commander was obliged to surrender his whole force. In May 1862, during the Civil War, Yorktown was a second time besieged, this time by General McClellan with a large body of Union troops. A great contest was anticipated, but after the elaborate preparations for the siege were completed, it was discovered that the Confederates under General Johnston had secretly evacuated the place, taking with them everything of any value. Population (1890), 221; (1900), 151.

Yoruba. See Nigeria.

Yosemite, a famous valley on the western slope of the Sierra Nevada of California, about 150 miles east of San Francisco and 4000 feet above the sea. It is 7 miles long, half a mile to a mile wide, and nearly a mile deep, eroded out of hard massive granite by glacial action. Its precipitous walls present a great variety of forms and sculpture, determined by the grain or cleavage of the rock—domes, gables, towers, battlements, and majestic mountain cliffs, partially separated and individualized by recesses and side cañons. The bottom, a filled-up lake basin, is level and park-like, diversified with groves of oak and pine, clumps of flowering shrubs, and spacious ferny meadows and wild gardens through which the river Merced meanders in tranquil beauty; while the whole valley resounds with the booming of its unrivalled waterfalls. The most notable of the wall rocks are: El Capitan, 3300 feet high, a sheer, plain mass of granite, the end of one of the most enduring of the mountain ridges, which stands forward beyond the general line of the north wall in imposing grandeur; the Three Brothers, North Dome, Glacier Point, the Sentinel, Cathedral, Sentinel Dome and Cloud's Rest, from 2800 to nearly 6000 feet high; and Half Dome, the noblest of all, which rises at the head of the valley from a broad, richly-sculptured base to the height of 4740 feet. These rocks are majestic glacial monuments, illustrating on a grand scale the action of ice in mountain sculpture. For here five large glaciers united to form the grand trunk glacier that eroded the valley and occupied it as its channel. Its moraines, though mostly obscured by vegetation and weathering, may still be traced; while on the snowy peaks at the headwaters of the Merced a considerable number of small glaciers, once tributary to the main Yosemite glacier, still exist. The Bridal Veil Fall, 900 feet high, is one of the most interesting features of the lower end of the valley. Towards the upper end the great Yosemite Fall pours its white floods from a height of 2600 feet, bathing the mighty cliffs with clouds of spray and making them tremble with its thunder-tones. The valley divides at the head into three branches, the Tenaya, Merced, and South Fork cañons. In the main (Merced) branch are the Vernal and Nevada Falls, 400 and 600 feet high, in the midst of most novel and sublime scenery. The Nevada is usually ranked next to the Yosemite among the five main falls of the valley. Its waters are chafed and dashed to foam in a rough channel before they arrive at the head of the fall, and are beaten yet finer by impinging on a sloping portion of the cliff about halfway down, thus making it the whitest of all the falls. The Vernal, about half a mile below the Nevada, famous for its afternoon rainbows, is staid and orderly, with scarce a hint of the passionate enthusiasm of its neighbour. Nevertheless it is a favourite with visitors, because it is better seen than any other. One may safely saunter along the edge of the river above it, and stand beside it at the top, as it calmly bends over the brow of the precipice. At flood time it is a nearly regular sheet about 80 feet wide, changing as it descends from green to purplish grey and white, and is dashed into clouds of irised foam on a rugged boulder talus that fills the gorge below. In the south branch, a mile from the head of the main valley, is the Illilouette Fall, 600 feet high, one of the most beautiful of the Yosemite choir. It is not nearly as grand a fall as the Yosemite, as symmetrical as the Vernal, or as airily graceful as the Bridal Veil; nor does it ever display as tremendous an outgush of snowy magnificence as the Nevada; but in fineness and beauty of colour and texture it surpasses them all.

Considering the great height of the snowy mountains about the valley, the climate of the Yosemite is remarkably mild. The vegetation is rich and luxuriant. The tallest pines are over 200 feet high; the trunks of some of the oaks are from 6 to 8 feet in diameter; violets, lilies, goldenrods, ceanothus, manzanita, wild rose, and azalea make broad beds and banks of bloom in the spring; and on the warmest parts of the walls flowers are in blossom every month of the year.

The valley was discovered in 1851 by a military company in pursuit of marauding Indians; regular tourist travel began in 1856. The first permanent settler in the valley was Mr J. C. Lamon, who built a cabin in the upper end of it in 1860 and planted gardens and orchards. In 1864 the valley was granted to the State of California by Act of Congress on condition that it should be held as a place of public use, resort, and recreation inalienable for all time. In the number and height of its vertical falls and in the massive grandeur of El Capitan and Half Dome rocks Yosemite is unrivalled. But there are many other valleys of the same kind. The most noted of those in the Sierra, visited every summer by tourists, hunters, and mountaineers, are the Hetch Hetchy Valley, a wonderful counterpart of Yosemite in the Tuolumne cañon; Tehipitee Valley, in the Middle Fork cañon of King's river; and the King's river Yosemite in the South Fork cañon, the latter being larger and deeper than the Merced Yosemite. All are similar in their trends, forms, sculpture, and vegetation, and are plainly and harmoniously related to the ancient glaciers. The Romsdal and Naerödal of Norway and Lauterbrunnen of the Alps are well characterized glacial valleys of the Yosemite type, and in south-eastern Alaska many may be observed in process of formation.

(J. Mu*.)

Youghal, a maritime town and urban sanitary district in the county of Cork, Ireland, on the estuary of the Blackwater, 157 miles south-west of Dublin by rail. The number of vessels registered in the fishery district in 1900 was 84, and the number of men and boys employed 411. Population (1881), 5826; (1891), 4317. Extension of the town boundaries has since increased the population to nearly 6000.

Youngstown, a city of Ohio, U.S.A., capital of Mahoning county. It is situated in 41° 07′ N. and 80° 38′ W., on the Mahoning river, in the Western Reserve, in the north-eastern part of the state, at an altitude of 837 feet. The business portion of the city lies in the bottom land, while the residences have spread up the bluffs on both sides of the valley. It is irregularly planned, and is divided into ten wards. It derives its water-supply from the river, and is well sewered. Its business streets are paved with brick and asphalt, and many of its residence streets are macadamized. Youngstown has ample railway accommodation, since five railways enter it. These are the Erie, the Lake Shore and Michigan Southern, the Pennsylvania, the Pittsburg and Lake Erie, and the Pittsburg and Western, and they give it a large transportation business. It is an important manufacturing centre, especially of iron and steel goods. It has blast furnaces, rolling and puddling mills, foundries, machine and boiler works, and bridge works. In 1900 there were 260 manufacturing establishments, with a total capital of $22,360,097. They employed 9150 hands, and the product was valued at $34,801,101. Of this iron and steel goods composed over three-quarters, or $28,303,856. In 1900 the assessed valuation of real and personal property was $14,896,410, the net debt of the city was only $662,880, and the rate of taxation was $32.20 per $1000. Population (1890), 33,220; (1900), 44,885, of whom 12,207 were foreign-born and 915 negroes.

Ypres, a town of Belgium, in the province of West Flanders, 32 miles south-west of Bruges by rail. Linen and lace are its chief manufactures. Population (1890), 16,505; (1899), 17,394.

Ypsilanti, a city of Washtenaw county, Michigan, U.S.A. It is on the Huron river and on the Lake Shore and Michigan Southern and the Michigan Central railways, in the south-eastern part of the Lower Peninsula, at an altitude of 712 feet. It is regularly laid out on both sides of the river, is divided into five wards, and has an excellent water-supply. It is in a farming region for which it serves as a market place, and has also varied manufactures. It was settled in 1824, and chartered as a city in 1858. Population (1880), 4984; (1890), 6129; (1900), 7378, of whom 899 were foreign-born and 608 negroes.

Ystad, a seaport town of Sweden, county of Malmöhus, on the south coast, 39 miles by rail east-south-east of Malmö. It is an ancient place, two of its churches dating originally from the 13th century. Its harbour, which will admit vessels drawing 19 feet, is the freest from ice in winter of any Swedish Baltic port. Apart from a growing import trade in coal and machinery, its commerce is declining. The shipping clearing the port decreased from 776 vessels of 140,000 tons in 1888 to 247 of 55,850 tons in 1899. Population (1880), 7025; (1890), 8235; (1900), 9862.

Ystrad-y-fodwg, an extensive coal-mining parish and town, Glamorganshire, South Wales (the parish forming the Rhondda division of the county), on the Rhondda, 20 miles north-west of Cardiff by rail. Since 1894 the district has been governed by an urban district council, and the name changed to Rhondda. Population (1891), 88,351; (1901), 113,735.

Yucatan, a state of Mexico, bounded on the N. by the Gulf of Mexico, on the E. by the Caribbean Sea, on the S. by British Honduras and Guatemala, and on the W. by the state of Campeachy. Area, 35,214 square miles. Population (1879), 302,315; (1895), 298,850. The climate is generally pleasant. The principal agricultural product is henequen, and in the north-west some sugar-cane is raised. The state is divided into seventeen *partidos*. Capital, Merida, 36,935 inhabitants. The principal towns are Acanceh (22,916 inhabitants), Tekax (18,346), Motul (17,995), Temax (16,807), Espita (10,179), Maxcanú (9613), Hunucmá (8920), Tixkokob (6934), Peto (6739), Progreso (5911).

Yuchow. See Yohchow.

Yukon River. See Alaska.

Yule, Sir Henry (1820–1889), British Orientalist and administrator, was the youngest son of Major William Yule of the Bengal army, and was born 1st May 1820 at Inveresk, near Edinburgh. He was educated in Scotland, and, being destined for an Indian military career, entered Addiscombe College in February 1837. In the following year he was gazetted lieutenant in the Bengal Engineers, and proceeded to India early in 1840. His first employment was in connexion with the canals in the North-Western Provinces, and his first experiences of real warfare were in the Sutlej and Punjab campaigns, 1848–49. On the outbreak of war with Burma he was appointed to survey the Arakan frontier, and coming under the notice of Sir Arthur Phayre, accompanied that officer on his special mission to Ava in 1855 as private secretary, and afterwards wrote an account of the embassy, enriched with archæological, historical, and geographical details. In 1857 he was employed on defensive works in Allahabad, Benares, and Mirzapore, and was attached to the railway department in the following year. From 1857 to 1862 he was secretary of the Public Works Department, but in the latter year, partly on account of ill-health, he retired from the service with the honorary rank of colonel and settled at Palermo. It was not until 1875 that he returned to official life, and then, having been appointed a life member of the India Council, he acted in that capacity as long as health would permit, a period of about six months. But it is by the work done during the long intervals of retirement that Sir Henry is most widely known and will be longest remembered. In 1866 he edited for the Hakluyt Society, under the title of *Cathay and the Way Thither*, a collection of mediæval notices of the attempt to reach China overland, and showed himself to be a geographical expert of the first rank. This he followed up five years later by a critical edition of *The Book of Ser Marco Polo*. Then in conjunction with Mr Burnell he compiled the famous learned and humorous glossary of Anglo-Indian terms, *Hobson-Jobson*, published in 1886. For the Hakluyt Society, of which he was for some time president, he also edited the *Mirabilia descripta* of Jordanus (1863) and the *Diary of William Hedges* (1887), and he contributed to the transactions of many other learned societies and to the leading periodicals. Sir Henry was considered particularly happy in composing epitaphs, the best known being those on the well at Cawnpore and the statue of Outram at Calcutta. He was a model editor, a severe critic of himself and others, and a sure guide in the intricacies of Asiatic research. He studiously avoided politics, and all through the vexed Central Asian controversy he adopted a neutral attitude. To this fact probably he owes his great reputation as an accurate historian, for it is certain that the stores of information he accumulated were the result of an unbiassed and diligent inquiry into truth. The honour of K.C.S.I. was conferred upon him less than a year before his death, which took place in London on 30th December 1889.

Yuriev.—This is now the official name of the Russian town formerly called Dorpat, in the government of Livonia (*q.v.*). It is on the river Embach, and is picturesquely situated, with a station on the Riga and Reval railway. The ancient University is the principal centre of higher education in the province, and its activities are well maintained. Population (1891), 40,880; (1901), 42,421.

Yuzgat, the chief town of a sanjak of the same name in the Angora vilayet of Asia Minor, altitude 4380 feet, situated near the head of a narrow valley through which the Angora–Sivas road runs. The town was built, largely out of the ruins of Nefez Keui (*Tavium*), by Chapan Oghlu, the founder of a powerful Dere Bey family. There is a trade in yellow berries and mohair. The sanjak is very fertile, and contains good breeding grounds, upon which horses, camels, and cattle are reared. The population of 15,000 includes a large Armenian community.

Zaandam, a town in the province of North Holland, Netherlands, at the influx of the canalized Zaan into the Y. It is the junction of the line Amsterdam–Helder with the line to Hoorn and Enkhuizen, with which places and Haarlem, the North Sea, and the Noord-Hollandsche canal it has also steamboat communication. On both banks of the Zaan is the "Zaanstreek," a series of industrious villages, with 400 mills, now in large part steam mills. Population (1901), 21,597

Zabern (French, *Saverne*), a town of Germany, in Alsace–Lorraine, district of Lower Alsace, 27 miles north-west of Strasburg, on the Rhine–Marne canal, and at the foot of a pass over the Vosges. Its principal building, the former episcopal residence, built by Cardinal de Rohan in 1779, is now used for military purposes. There are also a 15th-century church and an antiquarian museum. In the vicinity are the ruined castles of Hohbarr, Grossgeroldseck, Ochsenstein, Greifenstein, &c. It has stone quarries and factories for machinery. Population (1885), 6936; (1900), 8499.

Zacatecas, a state of Mexico, bounded on the N. by Coahuila, on the E. by San Luis Potosí, on the S. by Aguascalientes, and on the W. by Durango. Area, 35,214 square miles. Population (1879), 422,506; (1895), 452,578. Its mean altitude is 7000 feet above sea-level. Cereals, sugar-cane, and maguey are valuable products, and stock-raising is important. It is immensely rich in minerals, especially in silver; gold, mercury, iron, copper, zinc, lead, coal, bismuth, and salt are also found. Commercially it is one of the great centres of the republic. Its exports are estimated at about $19,000,000 annually, its imports at $15,000,000, its local trade at $7,000,000. The principal manufacturing industries are the production of sugar, rum, and wine, reduction of ores, cotton and woollen mills, &c. The capital, ZACATECAS, on the Mexican Central Railway, 442 miles from Mexico City, has a population of 39,212. Other principal towns are Sombrerete (10,082), Ciudad Garcia (9420), Guadalupe (8781), Pinos (8183), San Juan del Mezquital (7113), Fresnillo (6757), and Rio Grande (5008).

Zagrab. See AGRAM.

Zaisan, a district town of Russian Central Asia, in the province of Semipalatinsk, near the Chinese frontier, at an altitude of 2200 feet, on the Jemen river, 29 miles south-east of where it flows into the south corner of Lake Zaisan. In 1897 it had a population of 4471. LAKE ZAISAN, situated in an open valley between the Alai range on the north-east and the Tarbagatai in the south, lies at an altitude of 1800 feet. It has a length of about 87 miles, a width of from 10 to 20 miles, an area of 707 square miles, and a maximum depth of 50 feet. Its water is fresh, as it receives the Black Irtysh and the Kendyrlyk from the east and several small rivers from the west, all of which leave the lake at its north-west corner in the White Irtysh. The fisheries, which yield abundantly, are in the hands of the Siberian Cossacks.

Zambezi, the fourth in size of the rivers of Africa, and the largest of those flowing eastwards to the Indian Ocean. Its length is estimated at about 2000 miles, and the area of its basin is 513,500 square miles, according to Dr Bludau, or rather less than half that of the Nile. Additions to our knowledge of the Zambezi system have been mainly the work of Major Gibbons and his assistants, who during two expeditions, in 1895–96 and 1898–1900, ably continued the work of exploration begun by Dr Livingstone in the upper basin and central course of the river. The source of the Zambezi—the main channel of which is, according to Major Gibbons, clearly marked from beginning to end, no tributary being at all comparable to it in size—is now placed in 11° 21′ 3″ S., 24° 22′ E., or some 40 miles west of the position previously assigned to it. It lies in a depression of an undulating country 5000 feet above the sea, covered with bracken and open forest, the water, like that of all the rivers of the neighbourhood, issuing from a black marshy bog, and quickly collecting into a well-defined stream. In the first hundred miles of its course the river is known as the Yambeshe—in sound almost identical with its name on its lower course, though intervening sections are known as Liambeshe and Liambai. From the source eastwards the water-parting between the Congo and Zambezi basins is a well-marked belt of high ground, falling abruptly north and south, and running nearly east and west between 11° and 12° S. West of the source also the parting of the waters is more complete than was once supposed, Lake Dilolo belonging to the Zambezi system only, and sending none of its water to the Kasai.

Tributaries.

The course of the main stream will be spoken of below, in connexion with its use as a navigable channel, the new information respecting the tributaries being first summarized. The Kabompo, which flows in from the east in about 14° 8′ S., rises not far from 11° 34′ S., 25° 17′ E. In 13½ S. it receives on the right bank a tributary, the Lunga, said to be more important than the upper Kabompo itself, and rising somewhat farther north. The Lungwebungu, which enters the Zambezi from the west in 14° 35′ S., is a strong, deep stream 200 yards wide in its upper course, flowing in a valley bordered, like others of this part of the country, by undulations of white sand covered by thin forest, its floor forming at times an inundated plain 2 to 3 miles wide. The Kwando, formerly known as the Chobe, rises in about 12° 40′ S., 18° 50′ E., and flows in a generally straight course south-east to 17° 30′ S., at which point it makes a sudden bend to the south before flowing east to the Zambezi. Apart from its head-streams, it receives most of its tributaries from the west, and at its most southern bend is joined by the Magwe'kwana, which in time of flood receives some of the surplus water of the Okavango (see NGAMI). In its lower course the Kwando presents the phenomenon of a double rise, one occurring at the height of the dry season, which has been attributed to the nature of the soil in its source region.

Of the streams which enter the upper Zambezi from the east, the largest, after the Kabompo, is the Luena, which rises in 16° S., 26° E., and flows first north-west, afterwards west-south-west, joining the main river a little north of 15° S. Others are the Njoko, joining in 17° 8′ S., and the Machili, which enters in about 25° E. The largest tributary of the middle Zambezi—the Kafukwe—has been found to rise in about 11° 40′ S. The main head-stream, which flows first south-east, afterwards south-west, is joined in 14° 35′ S. by the Lunga or Luanga, an important right-bank tributary, the united stream then flowing first south, afterwards due east. The lower Kafukwe is a large navigable river until about 40 miles from its mouth, but it then descends from the plateau by a series of falls and cataracts, the drop being over 1000 feet in 15 miles, one very high fall occurring in a stupendous chasm. The next great tributary to the east—the Loangwa—has, with its branches, been explored since 1890 by many travellers, including officials of the British Central Africa Protectorate and South Africa Company. The main stream flows in a generally level valley, bounded by steep plateau escarpments, and is for the most part shallow and rapid, though fairly wide. In 14° 30′ S., however, it passes through narrow gorges with a speed of 8 or 9 miles an hour. In 15° 5′ S. it is joined by the Lunsefwa, which, with its tributary, the Lukosasi, drains a large extent of the western plateau, its basin being separated by the Mchinga mountains from that of the Loangwa.

Navigation.

The entrance of vessels from the sea to the Zambezi has been much facilitated since the discovery by Mr D. J. Rankin in 1889 of a practicable channel north of the main mouths of the river. It is known as the Chinde mouth, and, though for the most part narrow and winding, has a minimum depth at low water of about 7 feet at the entrance and of 12 feet farther within. The channel is, however, subject to changes. From the sea to the Kebrabasa rapids, a distance of 400 miles, navigation is always possible for shallow-draught steamers, though difficult on account of sandbanks. The Kebrabasa rapids are in their present condition quite impassable (as was found by Livingstone in 1858); but Major Gibbons suggests that the difficulty may be removed, either by the cutting of a side channel or the building of a dam to convert the gorge into a lake, to be connected with the river below by a lock and weir. The middle Zambezi, from Kebrabasa to a short distance below the Victoria Falls, has a length of about 800 miles, during which navigation, though quite practicable for nine months in the year, is much impeded at low water by the rocky nature of the gorges which occur on this section and the impetuosity of the current. One of the most difficult passages is that of a grand gorge a little above the mouth of the Loangwa, in about 30° E., named by Major Gibbons Livingstone's Kariba, in distinction from a second Kariba (="gorge") a little beyond the Kafukwe confluence. Between the two gorges the river is generally unobstructed, but at the western end of the second Kariba navigation is dangerous at low water. At the Molele rapids, 140 miles below the Victoria Falls, a broken section begins, within which the fall is 800 feet, which makes the upper Zambezi practically a separate river. Of this the 100-miles section beginning just below the Kwando confluence and ending with the series of rapids including the Gonye falls is navigable, and above Gonye there is a clear stretch of 300 miles, terminated by the Sapuma cataract in 13° 7′ S. The Lungwebungu, which enters in this section, is likewise navigable for a long distance, thus supplying communication with the extreme north-west corner of the Zambezi basin. Beyond the Sapuma there is another 120-miles stretch of navigable water on the upper Zambezi, while parts at least of the Luena, Kafukwe, and Loangwa tributaries are also capable of being navigated. The possibility of connecting the Kwando with the navigable waters of the Okavango, at the point where the above-mentioned overflow takes place, has likewise been suggested. The Shire, which flows from Lake Nyasa, has for many years been navigated with the exception of a stretch of 80 miles between Katunga and Malope, which involves a troublesome portage. A scheme has, however, been set on foot for connecting these two points by a light railway. The sum of such navigable reaches within the Zambezi basin as exceed 100 miles is estimated at nearly 4000 miles.

See Rankin in *Proc. R.G.S.*, March 1890.—Sharpe, *ibid.*, December 1890.—Gibbons, Reid, and Bertrand in *Geog. Journal*, February 1897.—Gibbons, *ibid.*, February 1901; and *Journ. R. Colonial Inst.*, February 1901.—Coillard, *On the Threshold of Central Africa*. London, 1897.—Grey, in *Geog. Journal*, July 1901. (E. He.)

Zamboanga, a town situated at the extreme point of the peninsula of Mindanao, Philippine Islands. It was formerly the capital of the district of Zamboanga, but in 1901 was made the capital of the department of Mindanao and Sulu. It has one of the most healthful sites in the islands, its climate being decidedly cooler than that of Manila. There is an abundant supply of water, which flows in canals down the principal street. The town was set on fire by insurgents in 1899 and was badly injured, but was afterwards rapidly rebuilt. Zamboanga is a port of entry, and has good anchorage for large vessels close to the shore. In earlier days it was the base of Spanish operations against the Moro pirates of the southern Philippines. A large and strong stone fort, which was constructed at that time, is still well preserved. Many of the inhabitants are descendants of slaves who escaped from the Moros and sought Spanish protection. A Spanish patois, called "Zamboangueño," is spoken by most of the native inhabitants. A large Moro town, ruled over by Dato Mandij, has sprung up beside the settlement of Christian natives. Agriculture is less highly developed in the vicinity of Zamboanga than in many of the northern provinces of the Philippines. Guttapercha, damar, and other valuable forest products from the neighbouring forests are exported in increasing quantity. Population, 18,000.

Zamora, a province of Spain, with an area of 4135 square miles. Population (1887), 270,072; (1897), 275,354. The birth-rate is 3·81 per cent., and the death-rate 3·23 per cent. The proportion of illegitimate births is 3·77 per cent. It is divided into 8 districts and 300 parishes, and has 25 miles of railway. Education is in a very backward condition. In 1897 there were 2,600,000 acres under culture, 324,105 producing wheat, 102,580 rye, barley, oats, maize, 29,502 pod fruit, 132,422 covered with vines, and 1200 with olives. The commons and forests cover about 300,000 acres. In the same year there were 2324 horses, 5047 mules, 7442 asses, 23,770 cattle, 220,553 sheep, 34,799 goats, and 18,700 pigs. Much live-stock is exported to Portugal. Insufficiency of means of communication paralyses the mining interests.

Zamora, capital of the above province, on the Douro, 57 miles west by south of Valladolid. Agricultural products from the surrounding country are the staple trade. It is the seat of a bishopric. Population (1887), 15,292; (1897), 16,453.

Zamość (Russian, *Zamostie*), a district town of Russian Poland, in the government and 50 miles east of the town of Lublin. It is an old town founded by the Zamoiskis, and was annexed to Austria after the third partition of Poland in 1795, but afterwards came into the hands of Russia. At the beginning of the 19th century it was an important fortress, but none of the fortifications now remain. It has a bent-wood furniture factory, and two gymnasia for boys and girls. Population (1897), 12,400.

Zanardelli, Giuseppe (1826– ——), Italian jurisconsult and statesman, was born at Brescia on 29th October 1826. A combatant in the volunteer corps during the war of 1848, he returned to Brescia after the defeat of Novara, and for a time earned a livelihood by teaching law, but was molested by the Austrian police and forbidden to teach in consequence of his refusal to contribute pro-Austrian articles to the press. Elected deputy in 1859, he received various administrative appointments, but only attained political office in 1876 when the Left, of which he had been a prominent and influential member, came into power. Minister of Public Works in the first Depretis cabinet of 1876, and Minister of the Interior in the Cairoli cabinet of 1878, he in the latter capacity drafted the franchise reform, but created dissatisfaction by the indecision of his administrative acts, particularly in regard to the Irredentist agitation. Overthrown with Cairoli in December 1878, he returned to power as Minister of Justice in the Depretis cabinet of 1881, and succeeded in completing the Commercial Code. Abandoned by Depretis in 1883, he remained in opposition until 1887, when he again joined Depretis as Minister of Justice, retaining his portfolio throughout the ensuing Crispi ministry until 31st January 1891. During this period he promulgated the Penal Code, and began the reform of the magistracy. After the fall of the Giolitti cabinet in 1893, Zanardelli made a strenuous but unsuccessful attempt to form an administration. Elected President of the Chamber in 1894 and 1896, he exercised that office with ability until, in December 1897, he accepted the portfolio of Justice in the Rudini cabinet, only to resign in the following spring on account of dissensions with his colleague, Visconti-Venosta, over the measures necessary to prevent a recurrence of the tumults of May 1898. Returning to the presidency of the Chamber, he again abandoned his post in order to associate himself with the obstructionist campaign against the Public Safety Bill (1899–1900), and was rewarded by being enabled to form an administration with the support of the Extreme Left upon the fall of the Saracco cabinet in February 1901. Consistently Liberal, though doctrinaire, in his political ideas, honest, and gifted with considerable oratorical powers, he has long been regarded as the leader of the constitutional Left, though the indecision of his temperament has hitherto prevented him from being classed among Italian statesmen of the first rank. As Premier at the moment of the birth of Princess Yolanda Margherita of Savoy (1st June 1901), he received the honour of Knighthood of the Supreme Order of the Annunziata.

Zanella, Giacomo (1820-1888), Italian poet, was born at Chiampo, near Vicenza, 9th September 1820, and was educated for the priesthood. After his ordination he became professor at the lyceum of his native place, but his patriotic sympathies excited the jealousy of the Austrian authorities, and although protected by his diocesan, he was compelled to resign in 1853. After the liberation of Venetia, the Italian Government conferred upon him a professorship at Padua, and he achieved distinction as a poet on the publication of his first volume of poems in 1868. In 1872 grief for the death of his mother occasioned a mental malady, which led to the resignation of his professorship. After his complete and permanent recovery he built himself a villa on the bank of his native river, the Astichello, and lived there in tranquillity until his death on the 17th of May 1888. His last published volume contains a series of sonnets of singular beauty, addressed to the river, resembling Wordsworth's "Sonnets to the Duddon," but more perfect in form; and a blank verse idyll, "Il Pettirosso" ("The Redbreast"), bearing an equally strong, though equally accidental, resemblance to the similar compositions of Coleridge. His ode to Dante, and that on the opening of the Suez Canal, are distinguished by great dignity. Of his other compositions, the most individual are those in which, deeply impressed by the problems of his day, he has sought to reconcile science and religion, especially the fine dialogue between Milton and Galileo, where the former, impressed by Galileo's predictions of the intellectual consequences of scientific progress, resolves "to justify the ways of God to man." Zanella was that rare personage in modern Italy, a broad-minded and patriotic ecclesiastic, and his character is justly held in equal honour with his poetry, which, if hardly to be termed powerful, wears a stamp of peculiar elegance and finish, and asserts a place of its own in modern Italian literature. In character, talent, and fortune Zanella offers a strong resemblance to Cowper.

(R. G.)

Zanesville, a city of Ohio, U.S.A., capital of Muskingum county. It is situated in 39° 58′ N. and 81° 59′ W., on the river Muskingum, east of the centre of the state, at an altitude of 704 feet. The city has a level site on both banks of the river, is laid out regularly with broad streets, has an excellent water supply and good sewerage, and is divided into ten wards. It has ample railway accommodation in the seven railways which centre there. These are the Baltimore and Ohio; the Bellaire, Zanesville, and Cincinnati; the Cincinnati and Muskingum Valley; the Cleveland, Akron and Columbus; the Columbus, Sandusky, and Hocking; the Wheeling and Lake Erie; and the Ohio and Little Kanawha. Surrounded by a rich and productive farming region, these lines give the city a large trade. Zanesville is a manufacturing city. In 1900 it had 293 manufacturing establishments, with a total capital of $5,162,067. They employed 4603 hands, and the product had a value of $7,468,839. The products were very varied, the principal ones being bricks, tiles, and pottery, flour, railway cars and repairs, foundry and machine-shop products, glass, soap, and candles. Population (1890), 21,009; (1900), 23,538, of whom 1435 were foreign-born and 1012 negroes.

Zanján, or ZINJÁN, a town of Persia, capital of the Khamseh province, about 205 miles north-west of Tehran, on the high road thence to Tabríz, at an elevation of 5180 feet. It has a population of about 25,000, post and telegraph offices, and was one of the original strongholds of the Bábí sectarians, who held it against a large Persian force from May 1850 to the end of the year, when most of them were massacred. It has extensive gardens, well watered by the Zanjáneh, which flows south of it. The well-stocked bazaar supplies the neighbouring districts.

Zante. See GREECE: *Ionian Islands.*

Zanzibar, a sultanate and British protectorate of East Africa. After many losses it still comprised in 1887 some strips of the mainland and several of the adjacent islands, with a total area of 7420 square miles and a population of 765,000. Subsequently the process of dismemberment was continued until 1890, when the sultan's dominions were reduced to the two islands of Zanzibar and Pemba. They have a collective area of 1020 square miles and a population (1902) of 200,000. On 12th June 1890 the sultanate was proclaimed a British protectorate in conformity with the Anglo-German and Anglo-French Conventions, by which Great Britain ceded Heligoland to Germany and renounced all claims to Madagascar in favour of France. Soon afterwards the Sultan Seyyid Ali, who had succeeded his brother, Seyyid Khalifah, in February 1890, took measures gradually to suppress the slave trade, and slavery itself was abolished with compensation on 6th April 1897. Seyyid Ali was succeeded in March 1893 by Hamed bin Thwain, on whose death in August 1896 his cousin, Seyyid Khalid, proclaimed himself sultan, but was dispossessed by the British authorities in favour of Hamud bin Mahommed, brother of Hamed bin Thwain (27th August 1896). The government was reconstituted under British auspices in October 1891, when Sir L. Mathews was appointed Prime Minister, and the sultan made virtually a Crown pensioner, with a civil list of 120,000 rupees. Other salutary reforms were followed by the proclamation of ZANZIBAR, the capital, as a free port on 1st February 1892, and since then the protectorate has made steady progress, the total imports advancing from £1,148,000 in 1893, and £1,400,000 in 1897, to £1,555,000 in 1898; and the exports from £1,002,000 and £1,190,000 to £1,498,000 in the same period. In 1900 the foreign imports and exports were £1,116,000 and £1,168,000 respectively. In 1900 the imports from Great Britain, British India, and British East Africa (chiefly piece-goods, rice, coal, and groceries) were valued at about £585,000, and the exports to these countries (cloves, ivory, copra, rubber) at £331,000. In the same year the capital (which had an estimated population in 1902 of 50,000 to 60,000) was visited by 200 vessels of 348,000 tons, including 68 British of 107,000 tons.

Mahommedanism is the dominant religion, but there are several Protestant and Roman Catholic missions with branches extending far into the mainland. The administration of justice has also shared in the general improvement, and in December 1892 the sultan delegated to the British agent and consul-general his right to try all cases in which a British subject is plaintiff or accuser, and the defendant or accused is a Zanzibar subject. There is a regular army of nearly 1000 men, including police, under a British officer.

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(A. H. K.)

Zara (Serbo-Croatian, *Zadar*), seaport town, capital of Dalmatia, and seat of the Diet, 73 miles north-west by west of Spalato, Austria. Population (1890) of town, 11,496; of commune, 28,230; (1900), 32,506, including garrison of 1339 men. The Italian element is chiefly concentrated in the town proper. The industry now includes corn-milling and the preparation of wax and oil. The shipping shows a considerable increase—in 1895 over 2300 vessels entered and cleared, with a total tonnage of 499,300.

Zaraf, Bahr el. See NILE.

Zaragoza, or SARAGOSSA, a province of Spain. Area, 6607 square miles. Population (1887), 415,195; (1897), 413,480. The birth-rate is 3·68 per cent., the death-rate 3·35 per cent., and the proportion of illegitimate births 4·71 per cent. The province is divided into 13 districts and 306 parishes. There are 260 miles of railway. Education is well cared for both by the provincial council and the parishes. The industries are less important than the agricultural interests. Since 1885, however, the Aragonese have bestirred themselves, especially since the extremely protectionist policy of 1890, which gave great impetus to native industries all over Spain. The growing industries include paper, leather, soap, brandies, liqueurs, machinery, carriages of all sorts, railway material, pianos, beds, glass, bronze, chocolate, jams, woollen and linen goods, and foundries. Much timber is drawn from the forests of the northern part, and the chief exports are live stock, excellent wines, flour, oil, and fruit. In 1897 there were 1,400,000 acres under culture, of which nearly 200,000 were irrigated from wells, and 3,000,000 acres of commons and forests (public, communal, and private property included); 285,900 acres devoted to wheat crops, 285,900 to rye, barley, oats, maize, and other cereals, 8500 to pod fruit, 238,015 to vines, and 13,600 to olives. The live stock in the same year included 4396 horses, 31,408 mules, 21,145 asses, 6458 cattle, 533,608 sheep, 57,319 goats, and 34,556 pigs. The province contains important mineral resources, the bulk of which, however, await development.

Zaragoza, capital of the above province, on the Ebro and the Huerva. There is now a splendid railway bridge. Several lines converge upon the town. It owes part of its development to the fertile, well-watered districts in the Ebro valley that lie all around the city. The industries are increasing, and include machinery, iron foundries, tanneries, carriages, preserves, breweries, glass, candles, soap, liqueur, distilleries, and porcelain. Population (1887), 92,407; (1897), 98,188.

Zarhon, a hill in Morocco, 9½ miles north of Mequinez. A city of refuge on the hill, forbidden to all but the Faithful, has grown around the tomb of Mulai Idrees I., founder of the Moorish empire (8th century). Close by are the ruins of the Roman capital, *Volubilis.*

Zaslav, or ZASLAVL, a district town of Russia, in the government of Volhynia, on Goryñ river, 155 miles south-west of Zhitomir. It is a very old town, supposed to have been founded in 987, and mentioned in the Russian annals in 1127. It afterwards became part of Lithuania, and was finally annexed to Russia in 1795. It is the centre of a flourishing district containing several large sugar works, distilleries, paper-mills, and tanneries. Population (1897), 12,688.

Záyendeh. See ISFAHAN.

Zeeland, a province in the south-west of the Netherlands, constituting part of the Rhine, Maas and Scheldt delta. It was gradually built up in a shallow bay, separated by dunes from the North Sea. The rivers named, depositing their silt in the bay, constructed a series of oblong islands, between which the rivers force their way in channels westwards to the sea, which in turn ascends them on the flood. The uncultivated land, mostly dunes on the western side of the islands, forms 1·5 per cent. of the land of the province. The soil of these low-lying islands consists of fertile clay, well adapted for agriculture and stock raising. The once flourishing commercial towns—Veere, Arnemuiden, Aardenburg, Sluis, &c.—have, owing to the silting up of their harbours and the opening of new highways of commerce, been reduced to provincial trading and fishing ports. Area, 690 square miles. Population (1900), 216,295.

Zeerust. See TRANSVAAL.

Zeilah. See SOMALILAND.

Zeitún, a town in the Aleppo vilayet of Asiatic Turkey, situated in the heart of Mount Taurus, about 20 miles north-north-west of Marash. The Armenians, about 10,000, are interesting from their character and historical position as a remnant of the kingdom of Lesser Armenia. The importance of Zeitún dates from the capture of Leo VI. by the Egyptians in 1375. The town long maintained practical independence, and it was only in 1878 that the Turks, after a long conflict, were enabled to station troops there. In 1890 there was a serious revolt, and in 1895, when the Armenian massacres commenced, the people again rose and, after holding out for more than three months against a large Turkish force, secured honourable terms of peace.

Zeitz, a town of Prussia, province of Saxony, on the Weisse (white) Elster, 28 miles by rail from Leipzig. In 1899 a statue of the Emperor William I. was unveiled. There are manufactures of cloth and other textiles, pianofortes, perambulators, and machinery; dyeing and market-gardening are also carried on. Population (1885), 19,797; (1895), 24,834.

Zeller, Eduard (1814——), German philosopher, was born at Kleinbottwar in Würtemberg on the 22nd of January 1814. In 1840 he was *privat-docent* of theology at Tübingen, in 1847 professor of theology at Bern, in 1849 professor of theology at Marburg, migrating soon afterwards to the faculty of philosophy as the result of disputes with the Clerical party. He became professor of philosophy at Heidelberg in 1862, removed to Berlin in 1872, and retired in 1895. His great work is his *Philosophie der Griechen* (1844–52), most of which has been translated into English. He has also written on theology, and published three volumes of philosophical essays. Like most of his contemporaries, he began with Hegelianism, and then shook himself free of it to develop a soberer thought of his own. He saw the necessity of going back to Kant in the sense of demanding a critical reconsideration of the epistemological problems which Kant had made but a partially successful attempt to solve. Zeller's not inconsiderable merits as an original thinker are far outshone by his splendid services to the history of philosophy. It is true that his view of Greek thought is somewhat warped by Hegelian formalism. He is not alive enough to the very intimate relation which thought holds to national life and to the idiosyncrasy of the thinker. He lays too much stress upon the "concept," and explains too much by the Hegelian antithesis of subjective and objective. But, these allowances made, his history of Greek Philosophy, which went into several new editions, remains a noble monument of solid learning informed with natural sagacity, and will always be interesting and valuable.

Zerafshan, a province of Samarkand, Russian Turkestan. Prior to its incorporation it was itself a province of Russian Turkestan, being formed in 1868 out of the eastern portions of Bokhara annexed to Russia.

It was enlarged in 1871 by the addition of the then annexed semi-independent bekdoms of Upper Zerafshan and Farab (on the Kashka-daria), and was finally included in Samarkand under the name of Zerafshan district.

Zerbst, a town of Germany, duchy of Anhalt, 27 miles by rail south-east from Magdeburg. It is still surrounded with walls, towers, and moats. Famous for its vegetables, and for centuries for its bitter beer. There is an archæological museum. Zerbst is the seat of very various industries (machinery, gold and silver thread, starch, &c.). Population (1885), 15,069; (1895), 16,983.

Zermatt, a mountain village at the head of the Visp valley and at the foot of the Matterhorn, in the canton of the Valais, Switzerland. It is 22½ miles by rail from Visp in the Rhône valley, and there is also a railway from Zermatt past the Riffel inns to the very top of the Gornergrat (10,289 feet). The village is 5315 feet above the sea, and in 1900 had 752 permanent inhabitants (all Romanists, and almost all German-speaking), resident in 52 houses. Formerly Zermatt was called "Praborgne," and this name was mentioned in the Swiss census of 1888. Its originally Romance population seems to have been Teutonized in the course of the 15th century, the name "Matt" (now written "Zermatt," *i.e.*, the village on the meadows) first occurring at the very end of that century. Zermatt was long known to botanists and geologists only, and has an interesting though very local history. De Saussure in 1789 was one of the first tourists to visit it. But it was not till the arrival of M. Alexandre Seiler in 1854 that its fame as one of the chief tourist resorts in the Alps was laid, for tourists abound only where there are good inns. When M. Seiler died in 1891 he was proprietor of most of the great hotels in and around Zermatt. The Matterhorn, which frowns over the village from which it takes its name, was not conquered till 1865, Mr Whymper and two guides then alone surviving the terrible accident in which their four comrades perished.

See Sir MARTIN CONWAY. *Climbers' Guides to the Central and Eastern Pennine Alps,* 2 vols. London, 1890–91.—W. A. B. COOLIDGE. *How Zermatt became a Mountaineering Centre* (in his "Swiss Travel and Swiss Guide-Books," p. 251–322). London, 1889.—JOSEPH RUDEN.—*Familien-Statistik d. löblichen Pfarrei von Zermatt.* Ingenbohl (Schwyz), 1870. (W. A. B. C.)

Zhukovski. See ALEXANDER II.

Zilah, a corporate town of Hungary, capital of the county of Szilágy, 38 miles north-west of Kolozsvár. Among its public buildings, besides the administrative and other offices, are the gymnasium, the hospital, and an old mansion where Charles XII. of Sweden rested after the battle of Bender. It has a county museum. There is a large trade in wine. Population (1891), 6595; (1901), 7639.

Zimbabwe. See SOUTH AFRICA, BRITISH.

Zinc.—The improvements made of late years in zinc metallurgy are only the natural developments of the process first employed. The metal is distilled from a mixture of ore and carbon in closed fire-clay vessels, and condensed in cooler vessels also of fire-clay just outside the furnace walls. These distilling vessels are called retorts if they are supported only at the ends, and the furnace using them is termed a Belgian furnace. If they are supported at intervals along a flat side, they are called muffles, and the furnace is known as a Silesian furnace. Various combinations and modifications of these two types of furnace have given rise to distinctive names, and as each system has its advantages and disadvantages, local conditions determine which is the better. In the following paragraphs are enumerated improvements made of late years that may be applied to furnaces of either system.

Gas Firing.—Three modes of gas firing must be noticed, each of which is adapted to special local conditions. (*a*) The gas is made from the fuel in a detached fireplace and conducted hot into the combustion chamber of the furnace, and the air for complete combustion is heated by the products of combustion on their way to the chimney. (*b*) Both the producer gas and the air are heated before they enter the combustion chamber, as in the Siemens system of regenerative firing. (*c*) Natural gas is piped to the furnace, where it meets air heated by the chimney gases. The primary advantages of gas firing are that less fuel is required, that there is better control of the heat in the furnace, and that larger and more accessible furnaces can be built. In Silesia the introduction of gas firing has led to the use of furnaces containing eighty muffles. In the United States, Belgian furnaces of type (*a*) are built to contain 864 retorts; of type (*b*), to contain 300 to 400 retorts; and of type (*c*), preferably about 600 retorts. The use of gas-fired furnaces greatly simplifies manual labour. On a direct-fired furnace at least one man, the brigadier, must be an expert in all the operations involved; but with a gas furnace a division of labour is possible that makes it easier to get workmen and keep them content. One man who understands the use of gaseous fuel can regulate the heat of a thousand or more retorts. The men who charge and empty the retorts, those who draw and cast the metal, and those who keep the furnace in repair, need not know anything about the making or using of gas, and the men who make the gas need not know anything about a zinc furnace. Again, in direct-fired furnaces there are commonly seven or eight rows of retorts, one above another, so that to serve the upper rows the workman must stand upon a table, where he is exposed to the full heat of the furnace and requires a helper to wait upon him. With gas firing the retorts can be arranged in four horizontal rows, all within reach of a man on the furnace-room floor. Furthermore, with the large furnaces which gas firing makes possible mechanical appliances may be substituted for manual labour in many operations, such as removing and replacing broken retorts, mixing and conveying the charge, drawing and casting the metal, charging and emptying the retorts, and removing the residues and products.

Machine-made Retorts.—Even a machine of simple type, like the ordinary drain-pipe machine, in which the retorts are made by forcing the plastic clay mixture through a die, may result in greater economy and uniformity than is possible when retorts are made by hand. When hydraulic pressure to the amount of 2000 to 3000 ℔ per square inch is applied, the saving is unquestioned, since less time is required to dry the pressed retort, its life in the furnaces is longer, its absorption of zinc is less, and the loss of zinc by passage through its walls in the form of vapour is reduced.

Mechanical Roasters.—For the desulphurization of zinc blende where it is not intended to collect and save the sulphur there are many mechanical kilns, generally classified as straight-line, horse-shoe, turret, and shaft kilns; all of these may be made to do good work on moderately clean ores which do not melt at the temperature of desulphurization. But the problem of saving the sulphur is yearly becoming more important. In roasting a ton of rich blende containing 60 per cent. of zinc enough sulphur is liberated to produce one ton of strong sulphuric acid, and unless this is collected not only are poisonous gases discharged, but the waste is considerable. When sulphuric or sulphurous acid is to be collected, it is important to keep the fuel gas from admixture with the sulphur gases, and kilns for this purpose require some modification. If hot air is introduced into the kiln, the additional heat developed by the oxidation of the zinc and the sulphur is sufficient to keep up a part of the reaction; but for the complete expulsion of the sulphur an externally-fired muffle through which the ore is passed is found to be essential.

Labour-saving Machinery.—Machinery has been substituted for manual labour in handling the coal, ore, fireclay, residues, and metal, from the raw material to the finished product. These improvements are applicable only in large works, and their full value is realized only where manual labour is expensive. Moreover, difficulties are met with in the permanent and economical construction of large furnaces, and it cannot be demonstrated that they effect a saving of metal as compared with direct-fired furnaces properly proportioned to the work of three men—the brigadier, the long-shift man, and the short-shift man—particularly when each of these men is skilful and careful to save all of the zinciferous crusts and coatings which collect about the furnace. Neither do the improvements remedy any of the defects of the process to which the high loss of metal must be attributed, such as volatilization in the roasting kiln, absorption of zinc by the retort, or the passage of zinc vapour through the walls of the retort, the breaking of retorts, and the losses due to incomplete condensation and to zinc remaining in the residue. These losses vary with the conditions from 10 to 35 per cent. of the metal in the ore.

As ores of zinc are usually shipped before smelting from widely separated places—Sweden, Spain, Algiers, Italy, Greece, Australia, and the Rocky Mountains region of North America—it is important that they be separated from their mixtures at the mines. The difficulty in separating zinc blende from iron pyrites is well known, and probably the most elaborate ore-dressing works ever built have been designed with this end in view. The Wetherill system of magnetic concentration has been remarkably successful in separating the minerals contained in the well-known deposit in Sussex county, N.J. Here very clean non-magnetic concentrate of willemite, which is an anhydrous silicate of zinc and a very high-grade zinc ore, is separated from an intimate mixture of willemite, zincite, and franklinites, with calcite and some silicates of manganese. The magnetic concentrates contain enough zinc to be well adapted to the manufacture of zinc oxide. Magnetic concentration is also applied in the removal of an excess of iron from partially roasted blende. Neither mechanical nor magnetic concentration can effect much in the way of separation when, as in many complex ores, carbonates of iron, lime, and magnesia replace their isomorph zinc carbonate, when some iron sulphide containing less sulphur than pyrites replaces zinc sulphide, and when gold and silver are contained in the zinc ore itself. Hence only in exceptional circumstances is it possible to utilize a large class of widely distributed ores, carrying from 10 to 35 per cent. of zinc, in which the zinc alone, estimated at four cents (2d.) a pound, is worth from $8 to $28 per ton of ore. The ores of the Joplin district, in the Ozark uplift in the Mississippi valley, are remarkable in that they are specially adapted to mechanical concentration. The material as mined will probably not average over 10 per cent. of zinc, but the dressed zinc ore as sold ranges from 45 to 62 per cent. of zinc. This region now furnishes the bulk of the ore required by the smelters of Illinois, Missouri, and Kansas.

The specific effects of different impurities on the physical properties of zinc have not been sufficiently studied. Fortunately, the small amounts of any of them that are likely to be found in commercial zinc are not for most purposes very deleterious. It is generally recognized that the purest ores produce the purest metal. Grades of commercial zinc are usually based on selected ores, and brands when they mean anything usually mean that the metal is made from certain ores. Chemical control of the metal purchased is not nearly as common as it should be, and the refining of zinc is at best an imperfect operation. To obtain the metal chemically pure a specially prepared chemically pure oxide or salt of zinc is distilled. A redistilled zinc, from an ordinarily pure commercial zinc, is often called chemically pure, but redistillation is seldom practised except for the recovery of zinc from galvanizer's dross and from the skimmings and bottoms of the melting furnaces of zinc rolling mills. The only other method of refining is by oxidizing and settling. A bath, even of very impure zinc, is allowed to stand at about the temperature of the melting-point of the metal for forty-eight or more hours, whereupon the more easily oxidizable impurities can be largely removed in the dross at the top, the heavier metals such as lead and iron settling towards the bottom. This method is rarely practised except by the rollers of zinc. A certain amount of refined zinc can be dipped from the furnace; a further amount, nearly free from iron, can be liquated out of the ingots cast from the bottom of the bath in a subsequent slow remelting, and it is sometimes possible to eliminate a zinciferous lead which collects in the sump of the furnace. Owing to the fact that at temperatures between its melting and boiling point zinc has a strong affinity for iron, it is often contaminated by the scraper while being drawn from the condenser, as is shown by the fact that the scraper wears away rapidly. As each retort in a furnace is in all essentials a separate crucible, and as the metal from only a few of them goes into a single ingot, there can be no uniformity either in the ingots made from the same furnace during a day's run or in those made from several furnaces treating the same ore. Some brassfounders break from a single ingot the quantity of zinc required to produce the amount of brass they wish to compound in one crucible, but when perfect uniformity is desired the importance of remelting the zinc on a large scale cannot be too strongly emphasized.

Zinc oxide is manufactured for paint by two processes—directly from the ore mixed with coal by volatilization on a grate, as in the Wetherill oxide process, and by oxidizing the vapour given off by a boiling bath of zinc metal. The oxide made by the latter method has generally a better colour, a finer texture, and a greater covering power. It is also manufactured by the latter process from the metallic zinc liquated out of galvanizer's dross.

The following table gives the world's production of zinc for the years 1888–99, the production of Holland being divided between Belgian and English companies. All weights are given in tons of 2000 ℔ avoirdupois.

Year.	Austria.	Belgium.	England.	France.	Germany.	Russia.	Spain.	United States.	Total.
1888	4410	88,928	29,998	18,695	146,853	4265	5640	55,921	354,710
1889	5335	90,968	34,504	19,822	149,884	4058	6217	58,878	369,666
1890	6006	91,161	32,644	21,354	153,512	4154	6525	67,363	382,719
1891	5518	94,797	32,940	22,703	153,609	4051	6235	80,287	400,140
1892	5773	100,911	33,949	22,796	154,254	3968	6531	84,082	412,264
1893	6471	105,452	31,778	24,712	157,580	4985	6340	76,234	413,552
1894	7507	106,968	35,911	25,780	158,265	5527	5622	74,003	419,583
1895	7116	118,678	33,033	26,676	165,660	5543	6443	81,840	444,989
1896	7593	124,958	27,864	50,248	168,762	6897	6760	77,637	470,719
1897	6874	127,941	26,240	41,961	166,160	6466	6883	100,386	482,911
1898	8049	131,248	31,291	40,956	170,710	6243	6648	114,103	509,248
1899	8052	154,829	35,518	29,742	168,823	6972	7165	129,679	540,280

This table is compiled from figures given in *The Mineral Industry: its Statistics, Technology, and Trade*, vols. i.–viii., edited by Dr R. P. Rothwell, New York, 1892–1900, to which reference should be made for the latest details of production and for full particulars of present practice in zinc metallurgy. The comprehensive *Handbook of Metallurgy*, by Dr Carl Schnabel, in its translation by Henry Louis (Macmillan and Co., London and New York, 1898), affords for English readers a storehouse of valuable facts.

While the files of technical literature are filled with statements of actual operations in other branches of metallurgy, the literature of zinc is meagre and scattered. Instead of being an openly practised art, zinc metallurgy is like a gild mystery of the Middle Ages. Its well-known imperfections are partly the cause of this state of affairs and partly the consequence of it, and it cannot be doubted that greater liberality on the part of those in the business, and greater publicity, would be to the advantage of all concerned.

(F. L. C.)

Zinder, an important town on the northern margin of the central Sudan, a great emporium of the trade across the Sahara between the Hausa states of the south and the Tuareg countries and Tripoli in the north. Its ruler was formerly subordinate to Bornu, but with the decline of that kingdom shook off the yoke of the sultan, and on the conquest of that country by Rabah seems to have maintained his independence. By the Anglo-French agreement of 1898 the territory round Zinder was included in the French sphere, having already been the object of French political action. The explorer Cazemajou was assassinated there in 1897, but the town was occupied in 1899, after a slight resistance on the part of its inhabitants, by Lieutenant Pallier of the reconstructed Voulet-Chanoine mission. A French post (named Fort Cazemajou) has been established just outside the town on a mound of huge granite blocks. Zinder was the first point in the Sudan reached by M. Foureau after his great journey across the Sahara through Air in 1899. It is described by him as a large and fine town surrounded with high earthen walls, very thick at the base and pierced with seven gates. It covers a large area, and its houses, in part built of clay, in part of straw, are interspersed with trees, which give the place a pleasing aspect. There is an important colony of Tuareg merchants, who occupy the suburb of Zengu, and who deal in a variety of wares, from cottons, silks, spices, ostrich feathers, &c., to French scent bottles. A busy market is held outside one of the gates.

See CAZEMAJOU, in *Bul. Com. de l'Afrique Française*, 1900.—FOUREAU, in *La Géographie*, December 1900 ; *D'Alger au Congo par le Tchad*, Paris, 1902.—JOALLAND, in *La Géographie*, vol. iii., 1901.

Zionism.—One of the most interesting results of the anti-Semitic agitation (see ANTI-SEMITISM) has been a strong revival of the national spirit among the Jews in a political form. To this movement the name Zionism has been given. In the same way that anti-Semitism differs from the Jew-hatred of the Early and Middle Ages, Zionism differs from previous manifestations of the Jewish national spirit. It was originally advocated as an expedient without Messianic impulses, and its methods and proposals have remained almost harshly modern. None the less it is the lineal heir of the attachment to Zion which led the Babylonian exiles under Zerubbabel to rebuild the Temple, and which flamed up in the heroic struggle of the Maccabees against Antiochus Epiphanes. Without this national spirit it could, indeed, never have assumed its present formidable proportions. The idea that it is a set-back of Jewish history, an unnatural galvanization of hopes long since abandoned for a spiritual and cosmopolitan conception of the mission of Israel, is a controversial fiction. The consciousness of a spiritual mission exists side by side with the national idea. The great bulk of the Jewish people have throughout their history remained faithful to the dream of a restoration of their national life in Judea. Its manifestations have suffered temporary modifications under the influence of changing political conditions, and the intensity with which it has been held by individual Jews has varied according to their social circumstances, but in the main the idea has been passionately clung to.

The contention of some modern rabbis that the national idea is Messianic, and hence that its realization should be left to the Divine initiative (*e.g.*, Chief Rabbi Adler, *Jewish Chronicle*, 25th November 1898), is based on a false analogy between the politics of the Jews and those of other oppressed nationalities. As all Hebrew politics were theocratic, the national hope was necessarily Messianic. It was not on that account less practical or less disposed to express itself in an active political form. The Messianic dreams of the Prophets, which form the framework of the Jewish liturgy to this day, were essentially politico-national. They contemplated the redemption of Israel, the gathering of the people in Palestine, the restoration of the Jewish state, the rebuilding of the Temple, and the re-establishment of the Davidic throne in Jerusalem with a prince of the House of David. How little the dispersed Jews regarded this essentially political programme as a mere religious ideal is shown by their attitude towards the pseudo-Messiahs who endeavoured to fulfil it. Bar Cochba (A.D. 117–138) lived at a period when a Jewish national uprising might well have been exclusively political, for the dissolution of the kingdom was scarcely half a century old, and Palestine still had a large Jewish population. None the less Bar Cochba based his right to lead the Jewish revolt on Messianic claims, and throughout the Roman Empire the Jews responded with enthusiasm to his call. Three centuries later Moses of Crete attempted to repeat Bar Cochba's experiment, with the same results. In the 8th century, when the Jews of the West were sufficiently remote from the days of their political independence to have developed an exclusively spiritual conception of their national identity, the Messianic claims of a Syrian Jew named Serene shook the whole of Jewry, and even among the Jews of Spain there was no hesitation as to whether they had a right to force the hands of Providence. It was the same with another pseudo-Messiah named Abu-Isa Obadia, who unfurled the national banner in Persia some thirty years later.

During the Middle Ages, though the racial character of the Jews was being transformed by their Ghetto seclusion, the national yearning suffered no relaxation. If it expressed itself exclusively in literature, it was not on that account undergoing a process of idealization. (Cf. Abrahams's *Jewish Life in the Middle Ages*, pp. 24–25.) The truth is that it could not have expressed itself differently. There could have been no abandonment of national hopes in a practical sense, unless the prospect of entering the national life of the peoples among whom they dwelt had presented itself as an alternative. Of this there was not the remotest sign. The absence of militant Zionism during this period is to be accounted for partly by the want of conspicuous pseudo-Messiahs, and partly by the terror of persecution. Unlike the modern Greeks, the mediæval Jews could expect no sympathy from their neighbours in an agitation for the recovery of their country. One may imagine what the Crusaders would have thought of an international Jewish conspiracy to recapture Jerusalem. In the 15th century the aversion from political action, even had it been possible, must have been strengthened by the fact that the Grand Signor was the only friend the Jews had in the world. The nationalist spirit of the mediæval Jews is sufficiently reflected in their liturgy, and especially in the works of the poet, Jehuda Halevi. It is impossible to read his beautiful *Zionide* without feeling that had he lived another twenty years he would have gladly played towards the pseudo-Messiah David Alroy (*circa* 1160) the part that Akiba played towards Bar Cochba.

The strength of the nationalist feeling was practically tested in the 16th century when a Jewish impostor, David Reubeni (*circa* 1530), and his disciple, Solomon Molcho (1501–1532), came forward as would-be liberators of their people. Throughout Spain, Italy, and Turkey they were received with enthusiasm by the bulk of their brethren. In the following century the influence of the Christian Millenarians gave a fresh impulse to the national idea. Owing to the frenzy of persecution and the apocalyptic teachings of the Chiliasts, it now appeared in a more mystical form, but a practical bias was not wanting. Menasseh ben Israel (1604–1657) co-operated with English Millenarians to procure the resettlement of the Jews in England as a preliminary to their national return to Palestine, and he regarded his marriage with a scion of the Davidic family of Abarbanel as justifying the hope that the new Messiah might be found among his offspring. The increasing dispersion of the Marranos or crypto-Jews of Spain and Portugal through the Inquisition, and the persecution of the Jews in Poland, deepened the Jewish sense of homelessness the while the Millenarians encouraged their Zionist dreams. The Hebraic and Judeophil tendencies of the Puritan revolution in England still further stirred the prevailing unrest, and some Jewish rabbis are said to have visited England in order to ascertain by genealogical investigations whether a Davidic descent could be ascribed to Oliver Cromwell. It only wanted a leader to produce a national movement on a formidable scale. In 1666 this leader presented himself at Smyrna, in the person of a Jew named Sabbatai Zevi (1626–1676), who proclaimed himself the Messiah. The news spread like wildfire, and despite the opposition of some of the leading rabbis, the Jews everywhere prepared for the journey to Palestine. Not alone was this the case with the poor Jews of Lithuania and Germany, but also with well-to-do communities like those of Venice, Leghorn, and Avignon, and with the great Jewish merchants and bankers of Hamburg, Amsterdam, and London. Throughout Europe the nationalist excitement was intense. Even the downfall and apostasy of Sabbatai were powerless to stop it. Among the wealthier Jews it partially subsided, but the great bulk of the people refused for a whole century to be disillusionized. A Messianic frenzy seized upon them. Encouraged on the one hand by Christian Millenarians like Pierre Jurien, Oligér Pauli, and Johannes Speeth, pandered to by Sabbataic impostors like Cardoso, Bonafoux, Mordecai of Eisenstadt, Jacob Querido, Judah Chassid, Nehemiah Chayon, and Jacob Franks, and maddened by fresh oppressions, they became fanaticized to the verge of demoralization.

The reaction arrived in 1778 in the shape of the Mendelssohnian movement (*Ency. Brit.*, art. JEWS). The growth of religious toleration, the attempted emancipation of the English Jews in 1753, and the sane Judeophilism of men like Lessing and Dohm, showed that at length the dawn of the only possible alternative to nationalism was at hand. Moses Mendelssohn (1729–1786) sought to prepare his brethren for their new life as citizens of the lands in which they dwelt, by emphasizing the spiritual side of Judaism and the necessity of Occidental culture. His efforts were successful. The narrow nationalist spirit everywhere yielded before the hope or the progress of local political emancipation. In 1806 the Jewish Sanhedrin convened by Napoleon virtually repudiated the nationalist tradition. The new Judaism, however, had not entirely destroyed it. It had only reconstructed it on a wider and more sober foundation. Mendelssohnian culture, by promoting the study of Jewish history, gave a fresh impulse to the racial consciousness of the Jews. The older nationalism had been founded on traditions so remote as to be almost mythical; the new race consciousness was fed by a glorious martyr history, which ran side by side with the histories of the newly adopted nationalities of the Jews, and was not unworthy of the companionship. From this race consciousness came a fresh interest in the Holy Land. It was an ideal rather than a politico-nationalist interest—a desire to preserve and cherish the great monument of the departed national glories. It took the practical form of projects for improving the circumstances of the local Jews by means of schools, and for reviving something of the old social condition of Judea by the establishment of agricultural colonies. In this work Sir Moses Montefiore, the Rothschild family, and the Alliance Israélite Universelle were conspicuous. More or less passively, however, the older nationalism still lived on—especially in lands where Jews were persecuted—and it became strengthened by the revived race consciousness and the new interest in the Holy Land. Christian Millenarians also helped to keep it alive. Lord Ashley, afterwards Lord Shaftesbury, Colonel Gawler, Mr Walter Cresson, the United States consul at Jerusalem, Mr James Finn, the British consul, Mr Laurence Oliphant, and many others organized and supported schemes for the benefit of the Jews of the Holy Land on avowedly restoration grounds. Another vivifying element was the reopening of the Eastern Question and the championship of oppressed nationalities in the East by the Western Powers. In England political writers were found to urge the re-establishment of a Jewish state under British protection as a means of assuring the overland route to India (Hollingsworth, *Jews in Palestine*, 1852). Lord Palmerston was not unaffected by this idea (Finn, *Stirring Times*, vol. i. pp. 106–112), and both Lord Beaconsfield and Lord Salisbury supported Mr Laurence Oliphant in his negotiations with the Porte for a concession which was to pave the way to an autonomous Jewish state in the Holy Land. In 1854 a London Jew attempted to float a company "for the purpose of enabling the descendants of Israel to obtain and cultivate the Land of Promise" (*Hebrew Observer*, 12th April). In 1876 the publication of George Eliot's *Daniel Deronda* gave to the Jewish nationalist spirit the strongest stimulus it had experienced since the appearance of Sabbatai Zevi.

It was not, however, until the spread of anti-Semitic doctrines through Europe made men doubt whether the Mendelssohnian denationalization of Judaism possessed the elements of permanency that the Jewish nationalist spirit reasserted itself in a practical form. As long as the anti-Semites were merely polemical, the nationalists were mute, but when in Russia their agitation took the form of massacres and spoliation, followed by legislation of mediæval harshness, the nationalist remedy offered itself. In 1882 several pamphlets were published by Jews in Russia, advocating the restoration of the Jewish state. They found a powerful echo in the United States, where a young Jewish poetess, Miss Emma Lazarus, passionately championed the Zionist cause in verse not unworthy of Jehuda Halevi. But the movement did not limit itself to literature. A society, "Chovevi Zion," was formed with the object of so extending and methodizing the establishment of agricultural colonies in Palestine as to make the eventual acquisition of the country by the Jews possible. From the beginning it was a great success, and branches, or "tents" as they were called, were established all over the world. At the same time two other great schemes for rescuing the Jewish people from oppression were brought before the public. Neither was Zionist, but both served to encourage the Zionist cause. One was due to the initiative of Mr Cazalet, a financier who was interested in the Euphrates Valley Railway project. With the assistance of Mr Laurence Oliphant he proposed that the concession from the Porte should include a band of territory 2 miles wide on each side of the railway, on which Jewish refugees from Russia should be settled. Unfortunately the scheme failed. The other was Baron de Hirsch's colossal colonization association (see HIRSCH, MAURICE DE). This was neither political nor Zionist, but it was supported by a good many members of the "Chovevi Zion," among them Colonel Goldsmid, on the ground that it might result in the training of a large class of Jewish yeomen who would be invaluable in the ultimate settlement of Palestine. (Interview in *Daily Graphic*, 10th March 1892.)

None of these projects, however, proved sufficiently inspiring to attract the great mass of Jewish nationalists. The Chovevi Zion was too timid and prosaic; the Hirsch scheme did not directly appeal to their strongest sympathies. In 1897 a striking change manifested itself. A new Zionist leader arose in the person of a Viennese journalist and playwright, Dr Theodore Herzl (born 1860). The electoral successes of the anti-Semites in Vienna and Lower Austria in 1895 had impressed him with the belief that the Jews were unassimilable in Europe, and that the time was not far distant when they would be once more submitted to civil and political disabilities. The Hirsch scheme did not, in his view, provide a remedy, as it only transplanted the Jews from one uncongenial environment to another. He came to the conclusion that the only solution of the problem was the segregation of the Jews under autonomous political conditions. His first scheme was not essentially Zionist. He merely called for a new exodus, and was ready to accept any grant of land in any part of the world that would secure to the Jews some form of self-government. The idea was not new. In 1566 Don Joseph Nasi had proposed an autonomous settlement of Jews at Tiberias, and had obtained a grant of the city from the Sultan for the purpose. In 1652 the Dutch West India Company in Curaçao, in 1654 Oliver Cromwell in Surinam, and in 1659 the French West India Company at Cayenne had attempted similar experiments. Marshal de Saxe in 1749 had projected the establishment of a Jewish kingdom in South America, of which he should be sovereign; and in 1860 Judge Noah purchased Grand Island, on the river Niagara, with a view to founding upon it a Jewish state. All these projects were failures. Dr Herzl was not slow to perceive that without an impulse of real enthusiasm his scheme would share the fate of these predecessors. He accordingly resolved to identify it with the nationalist idea. His plan was set forth in a pamphlet, entitled *The Jewish State*, which was published in German, French, and English in the spring of 1896. It explained in detail how the new exodus was to be organized and how the state was to be managed. It was to be a tribute-paying state under the suzerainty of the Sultan. It was to be settled by a chartered company and governed by an aristocratic republic, tolerant of all religious differences. The Holy Places were to be exterritorialized. The pamphlet produced a profound sensation. Dr Herzl was joined by a number of distinguished Jewish literary men, among whom were Dr Max Nordau and Mr Israel Zangwill, and promises of support and sympathy reached him from all parts of the world. The *haute finance* and the higher rabbinate, however, stood aloof.

The most encouraging feature in Dr Herzl's scheme was that the Sultan of Turkey appeared favourable to it. The motive of his sympathy has not hitherto been made known. The Armenian massacres had inflamed the whole of Europe against him, and for a time the Ottoman Empire was in very serious peril. Dr Herzl's scheme provided him, as he imagined, with a means of securing powerful friends. Through a secret emissary, the Chevalier de Newlinsky, whom he sent to London in May 1896, he offered to present the Jews a charter in Palestine provided they used their influence in the press and otherwise to solve the Armenian question on lines which he laid down. The English Jews declined these proposals, and refused to treat in any way with the persecutor of the Armenians. When, in the following July, Dr Herzl himself came to London, the Maccabæan Society, though ignorant of the negotiations with the Sultan, declined to support the scheme. None the less, it secured a large amount of popular support throughout Europe, and to-day Dr Herzl has a following of over a quarter of a million Jews, 100,000 of whom are paying members of the Zionist organization, while the remainder are connected with affiliated societies. The Zionist organization has a thousand electoral districts throughout the world, with 950 societies in Russia alone. The English membership is about 7000.

Of practical work the Zionist organization has done little. It has held five congresses (four at Basel—in 1897, 1898, 1899, and 1901—and one in London in 1900), at which it has discussed the condition of the Jews all over the world, has drawn up a political programme and a colonization scheme, and has established a colonial bank and a Jewish national fund. The political programme which was adopted at the first Basel congress runs as follows:—

> "Zionism aims at establishing for the Jewish people a publicly and legally assured home in Palestine. For the attainment of this purpose the Congress considers the following means serviceable: (1) The promotion of the settlement of Jewish agriculturists, artisans, and tradesmen in Palestine. (2) The federation of all Jews into local or general groups, according to the laws of the various countries. (3) The strengthening of the Jewish feeling and consciousness. (4) Preparatory steps for the attainment of those governmental grants which are necessary to the achievement of the Zionist purpose."

As yet the "preparatory steps" have yielded no result. In May 1901 and August 1902 Dr Herzl had audiences of the Sultan, and was received with great distinction at Yildiz Kiosk. At the latter interview concessions were proposed by the Porte, but they were not considered adequate by the Zionists, and the negotiations consequently failed. The colonization scheme has made no progress, chiefly because the Turkish Government, fearful of a new nationality question in Palestine, has placed severe restrictions on Jewish immigration. The colonial bank, which was founded at the second congress, is the financial instrument of political Zionism. Of its capital of £2,000,000 in £1 shares, £352,000 has been subscribed by 126,000 shareholders. Nothing, however, is known of the business it has transacted. The object of the national fund is to purchase land, but nothing will be done until £200,000 has been subscribed. Notwithstanding this barren record, the enthusiasm of Dr Herzl's adherents has not diminished, and the Zionist movement is to-day the greatest popular movement that Jewish history has ever known.

Despite the great ability of Dr Herzl and the number and faith of his supporters, it is doubtful whether the nationalist aspirations of the Jewish people can, humanly speaking, be fulfilled. No Turkish Sultan has ever willingly relaxed his hold on any portion of his dominions, and even if the present Sultan were disposed to come to terms with the Zionists, it is questionable whether Christendom—and especially the Roman and Greek Churches—would permit the Holy Land to pass to the

Jews, even though the Holy Places were exterritorialized. In the event of these obstacles being overcome, still more formidable difficulties would await the Jewish state. The chief of these is the religious question. The state would have to be orthodox or secular. If it were orthodox it would desire to revive the whole Levitical polity, and in these circumstances it would either pass away through internal chaos or would so offend the modern political spirit that it would be soon extinguished from outside. If it were secular it would not be a Jewish state. The great bulk of its present supporters would refuse to live in it, and it would ultimately be abandoned to an outlander population consisting of Hebrew Christians and Christian Millenarians.

Dr Herzl's scheme is vitiated by its erroneous premisses. It is based on the idea that anti-Semitism is unconquerable. Reasons have been adduced in the article on Anti-Semitism for believing that the whole movement is artificial and doomed to extinction. Under the influence of religious toleration and the naturalization laws, nationalities are daily losing more of their racial character. The coming nationality will be essentially a matter of education and economics, and this will not exclude the Jews as such. With the passing away of anti-Semitism, Jewish nationalism will disappear. If the Jewish people disappear with it, it will only be because either their religious mission in the world has been accomplished or that they have proved themselves unworthy of it.

Literature.—A Zionist bibliography has been published by the Federation of American Zionists. Besides the works already cited in the body of this article, see on the early nationalist movement Graetz, *Geschichte der Juden*, under the heads of the various pseudo-Messiahs and their adherents. Jewish agricultural colonies will be found discussed very fully in *The Jewish Encyclopædia*, vol. i. pp. 240–262. For early Zionist projects see *Publications of the American Jewish Historical Society*, No. 8, pp. 75–118; Laurence Oliphant, *Land of Gilead;* Mrs Oliphant, *Life of Laurence Oliphant*, pp. 168 *et seq.* The Zionist movement since 1895 is fully recorded in the *Jewish Chronicle* (London) and *Die Welt* (Vienna). For proceedings of the Congresses see the *Official Protocols* published for each year by the society "Erez Israel" of Vienna; also Herzl, *Der Baseler Congress*, Vienna, 1897. On the movement generally, see J. de Haas, *Zionism, Jewish Needs and Jewish Ideals;* also articles by Dr Herzl in *Contemporary Review*, October 1897; I. Zangwill in *Cosmopolis*, October 1897, and *Contemporary Review*, October 1899; Dr Gaster in *Asiatic Quarterly Review*, October 1897; H. Bentwitch in *Nineteenth Century*, October 1897, and *Fortnightly Review*, December 1898; Reich, *Nineteenth Century*, August 1897. (L. W.)

Zittau, a town of Germany, on the Mandau, near its confluence with the Neisse, 25 miles by rail south-east of the town and in the circle of Bautzen, near the Bohemian and the Silesian frontier, kingdom of Saxony. In 1883–90 a Roman Catholic church was erected. The schools include a building, a mining, and a technical drawing school. The public library numbers over 40,000 volumes. The corporation owns estates yielding an annual income of about £15,000. Population (1885), 23,215; (1895), 28,132; (1900), 30,921.

Žižkov, chief town of a government district in Bohemia, Austria, and a suburb of Prague, with which it is now practically merged. Population (1890), 41,236; (1900), 60,089, mostly Czech.

Złoczów, the chief town of a government district in Galicia, Austria, on a tributary of the river Bug, east of Lemberg. Linen weaving is the chief industry. Population (1890), 10,113; (1900), 12,209, including garrison of 1699 men, mostly Polish-speaking.

Znaim (Czech, *Znojmo*), a town in Moravia, Austria. Its industries include the manufacture of textiles, earthenware, vinegar, and tanning. There is a considerable trade in corn, fruit, cucumbers, vegetables, mustard, and wine, together with important fairs and weekly markets. Population (1890), 14,156; (1900), 16,261.

Zoantharia. See Anthozoa.

Zobeir Ahmet (1830– ——), Egyptian Pasha and Sudanese governor, known as the Black Pasha, is supposed to have been born about 1830, but his parentage and birthplace are unknown, and he first appears about 1870 as chief of the slave-dealers in equatorial Africa. He had gradually established an extended range of strongholds along the upper Nile, a flotilla and depôts of military stores; and during a quarter of a century he flooded Egypt, Turkey, and Persia with slaves sold by his agents in the markets of Bahr-el-Ghazal. About 1860 he had attained so strong a position that he ventured to refuse payment of the tribute to the Khedive, his nominal sovereign, who consequently ceased to connive at the slave trade, and in 1869 sent an expedition against him. It was, however, utterly defeated and the commander was slain, and Zobeir established himself in a position of complete independence of the Khedive, who made feeble attempts at conciliation by making him first a bey and then a pasha. Finding that nothing short of the office of governor-general of the Sudan would satisfy his ambitious vassal, the Khedive sent first Sir Samuel Baker and then General Gordon into the Sudan to uphold his authority. In 1873, when Gordon was appointed governor of the Sudan, Zobeir, having been deprived of the governorship of Darfur, went to Cairo to plead his cause in person. There he was detained, but his son Suleiman rose against the new governor in obedience to orders from his father, and was not subdued until after twelve bloody battles. For this Zobeir was condemned to death, but the sentence was remitted, and he remained at Cairo. In 1884 General Gordon, who had been sent to Khartum to effect, if possible, the relief of the Egyptian garrison which was being besieged by the Mahdi, astonished Europe by requesting that Zobeir, whose son he had overthrown and whose trade he had ruined, should be sent up to Khartum as his successor. But to reinstate the notorious slave-dealer was naturally regarded as far too perilous an expedient, even in the extreme circumstances then existing. In March 1885 Zobeir was arrested in Cairo by order of the British Government for treasonable correspondence with the Mahdi and other enemies, and was interned at Gibraltar.

Zola, Émile Édouard Charles Antoine (1840–1902), French novelist, was born in Paris on the 2nd April 1840, of a French mother, his father being an engineer, part Italian and part Greek. The father seems to have been an energetic, visionary man, who, dying while his only son was yet but a little lad, left to his family no better provision than a law-suit against the municipality of the town of Aix. It was at Aix, which figures as Plassans in so many of his novels, that the boy received the first part of his education. Thence he proceeded, in 1858, to Paris, where, as later at Marseilles, he failed to obtain his bachelor's degree. Then came a few years of terrible poverty; but at the beginning of 1862 he obtained a clerkship, at the modest salary of a pound a week, in the house of Hachette the publisher. Meanwhile he was writing apace, but nothing of particular merit. His first book, *Contes à Ninon*, appeared on the 24th October 1864, and attracted some small amount of attention, and in January 1866 he determined to abandon clerking and take to literature. Vigorous and aggressive as a critic, his articles on literature and art in Villemessant's paper *L'Événement* created a good deal of interest. So did the gruesome but powerful novel, *Thérèse Raquin*, which came out in 1867. But meanwhile, with characteristic energy, Zola was projecting something larger and more important: the creation of a world of his own, like that of Balzac's *Comédie Humaine*—the history of a family in its various ramifications during the Second Empire. The history of this family, the Rougon-Macquart, was to be told in a series of novels containing a scientific study of heredity—science was always Zola's *ignis fatuus*—and a picture of French life and society. The first novel of the series, *La Fortune des Rougon*, appeared in book form at the end of 1871. It was followed by *La Curée*, *Le Ventre de Paris*, *La Conquête de Plassans*, *La Faute de l'Abbé Mouret*, *Son Excellence Eugène Rougon* (1875)—all books unquestionably of immense ability, and in a measure successful, but not great popular successes. Then came *L'Assommoir* (1877), the epic of drink, and the author's fortune was made. Edition followed edition. He became the most discussed, the most read, the most bought novelist in France—the sale of *L'Assommoir* being even exceeded by that of *Nana* (1880) and *La Débâcle* (1892). From the *Fortune des Rougon* to the *Docteur Pascal* (1893) there are some twenty novels in the *Rougon-Macquart* series; Zola also wrote a series of three romances on cities, *Lourdes*, *Rome*, *Paris*, novels on the "gospels" of population (*Fécondité*) and work (*Travail*), a volume of plays, several volumes of criticism, and other things besides. And these books are based on study and observation; the novels are crowded with characters. It is a gigantic *opus*, the fruit of immense labour, of an admirable tenacity—so many pages written, morning after morning, without intermission, during some thirty years. He prided himself on his motto, *Nulla dies sine linea*.

Zola was the apostle of the "realistic" or "naturalistic" school; but, as has been often shown, he was in truth not a "naturalist" at all, in so far as "naturalism" is to be regarded as a record of fact. He was an idealist, but while other idealists idealize the nobler elements in human nature, so has he, for the most part—the later books, however, show improvement—idealized the elements that are bestial. He saw man's lust, greed, gluttony, as in a vision, magnified, overwhelming, portentous. And what he saw he presented with tremendous power. His style may lack the classic qualities of French prose—lightness, delicacy, sparkle; it certainly has not Daudet's colour and felicity of touch. The first impression it produces may be one of heaviness, and the later "gospels" on population and work are distinctly ponderous. But for rendering the gloomy horror of the subjects in which he most delights—detail on detail being accumulated till the result is overwhelming—Zola has no superior. There are some of his descriptions of crowds in movement that have never been surpassed.

Zola played a very important part in the Dreyfus affair, which convulsed French politics and social life at the end of the 19th century. At an early stage he came to the conclusion that Dreyfus was the innocent victim of a nefarious conspiracy, and on the 13th January 1898, with his usual intrepidity, he published in the *Aurore* newspaper, in the form of a letter beginning with the words *J'accuse*, a terrible denunciation of all those who had had a hand in hounding down that unfortunate officer. Zola's object was a prosecution for libel, and a judicial inquiry into the whole *affaire*, and at the trial, which took place in Paris in February, though the court used every effort to circumscribe the field of investigation, a fierce flood of light was thrown on the case. The chiefs of the army put forth all their power, and Zola was condemned. He appealed. On the 2nd April the Cour de Cassation quashed the proceedings. A second trial took place at Versailles, on the 18th July, and without waiting the result Zola, by the advice of his counsel and friends, and for reasons of legal strategy, abruptly left France and took refuge in England. Here he remained in hiding, writing *Fécondité*, till the 4th June 1899, when, immediately on hearing that there was to be a revision of the first Dreyfus trial, he returned to Paris. Whatever may be thought of the *affaire* itself, there can be no question of Zola's superb courage and disinterestedness.

On the morning of the 29th of September 1902 Zola was found dead in the bedroom of his Paris house, having been accidentally asphyxiated by the fumes from a defective flue. This sudden and tragical death caused a great sensation. He received a public funeral, at which Captain Dreyfus was present, but no serious public disturbance occurred. M. Anatole France delivered an impassioned oration at the grave. At the time of his death Zola had just completed a novel, *Verité*, dealing with the incidents of the Dreyfus trial. A sequel, *Justice*, had been planned, but not executed. After a life of constant struggle and an obloquy which never relaxed, the sensational close of Zola's career was the signal for an extraordinary burst of eulogy. The verdict of posterity will probably be kinder than the first, and less unmeasured than the second. Zola's literary position would have more than qualified him for the French Academy. He was several times a candidate in vain. (F. T. M.)

ZOOLOGICAL DISTRIBUTION.

I. Marine.

At the date of the publication of the first volume of the ninth edition of the *Encyclopædia Britannica*, the *Challenger* expedition had not returned to England. This, despite its many successors, still stands out as the most important of the oceanographic expeditions, alike by the work achieved, the distance traversed, the time occupied, and the money devoted to the publication of the results. Though it did not confirm the dramatic expectations of those who half hoped to find Jurassic monsters at great depths, yet, what was of far greater consequence, it laid the foundation of our knowledge of the physics and chemistry of ocean water, of oceanic and atmospheric currents, of the contour of the sea-bottom, and of the main features of distribution of deep-sea life. Later work has confirmed and expanded, but not revoked, the conclusions thus attained. But, in spite of this and of several subsequent expeditions, it cannot be pretended that we are in a position to formulate general canons of marine distribution other than of the most tentative character. A dredge or trawl cast here and there, almost at random, is ludicrously disproportionate to the immensity of the ocean, and years of systematic labour must pass before even such "laws" as are assigned to the distribution of terrestrial organisms can be accepted in marine zoology. Two fallacies underlie many attempts to define distributional oceanic areas for special groups: the one, that such areas can be made to bear some relation to existing geographical or even national divisions; the other, that what is true for one group of the animal kingdom must hold good equally for another. It is necessary at the outset to divest oneself of these errors; oceanic conditions depend only very indirectly upon the distribution of the land, and strongly swimming or freely floating animals are not to be confined by the same factors as determine the distribution of sessile forms, whose range is governed by a variety of circumstances.

As Wyville Thomson pointed out long ago, there is but one ocean. This surrounds the southern half of the globe, and has two large gulfs, generally called the Atlantic and Pacific Oceans, which meet through narrow channels in the small Arctic Ocean, and a half gulf, the Indian Ocean. The Atlantic and Pacific exhibit a striking homology of atmospheric pressure and of prevalent wind and current; the Indian, to a great extent, resembles the southern half of a larger one, but this resemblance is modified by the neighbourhood of vast land masses. The prevalent winds, dependent on the fairly constant distribution of atmospheric pressure over the great oceans, are the most important determinant of currents. As at most points in the ocean the temperature, salinity, and chemical composition of the water are mainly determined by the currents—that is, by the condition at the place whence the water came—it is obvious that a study of currents must precede any general view of the distribution of marine forms.

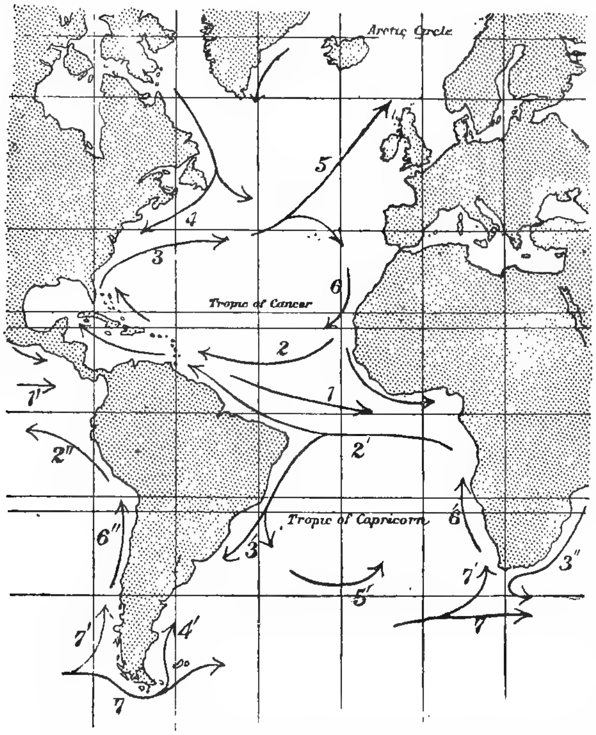

FIG. 1.—Diagram of the Atlantic Ocean, showing the main surface currents (some are seasonal only): the corresponding Indian and Pacific currents are cited in parentheses; they are rarely so strongly marked as in the Atlantic. 1. Counterequatorial (also 1′ Pacific and Indian); 2. North Equatorial (also Pacific); 2′. The Equatorial (also 2″ Pacific and Indian); 3. Gulf Stream proper (Japan Stream); 3′. Brazil Current (Australian Current); 3″. Mozambique Current (recurved off Cape Agulhas); 4. Labrador Current (Kamchatka Current); 4′. Falkland Current; 5. North Atlantic Drift, generally called Gulf Stream (North Pacific Drift); 5′. South Atlantic Drift, ill defined (South Pacific Drift); 6. North African Current (Mexico Current); 6′. Benguela Current; 6″. Peru Current; 7. Antarctic Circumpolar Drift, and 7′, its northerly branches on the west sides of Africa and South America.

Regard must be had not merely to the superficial currents indicated in Fig. 1, but also to the movements of the deeper layer. Ice melting at the poles, together with polar precipitation of hail, snow, and rain, yields large quantities of water of low salinity and very low temperature; this water sinks under the warmer salter surface water drifted from lower latitudes, and, creeping slowly north and south from the poles, covers the bottom of all the great open oceans at very uniformly low temperatures (in some cases as low as 30° F.). Between surface and bottom the temperature gradually decreases (except where affected by local circumstances), and in the middle layers the existence of slow currents is suspected. The cold bottom water wells up to the surface in certain areas, replacing the surface water drained away by currents, notably to the westward of the great land masses. Ocean water is remarkably uniform as regards its contained salts and gases, and it does not seem likely that we can look to these to explain the facts of distribution. In its temperature, on the contrary, there is enormous variation. While the bottom water of the ocean is very cold, and the mid-water of a more or less intermediate temperature, the surface water, according as it has drifted from the equator polewards or in the reverse direction, has a mean annual temperature somewhere between 84° and 30° F., losing or gaining heat on its way. In the case of narrow or "closed" seas, and near land masses, sea water does not exhibit that uniformity of composition which characterizes the open ocean; but even in such cases the temperature is largely influenced by adjacent currents, and, though less obviously than in the open ocean, seems to be a very important agent in distribution.

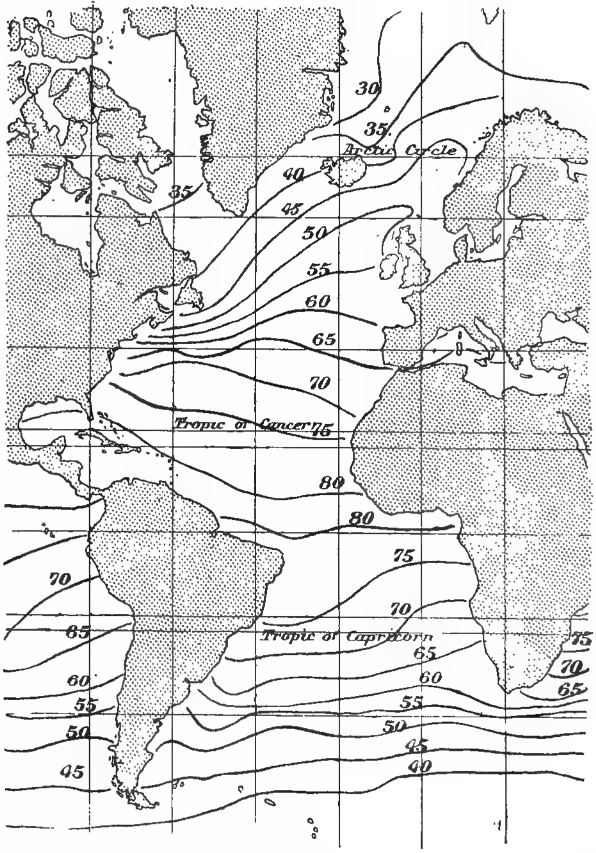

FIG. 2.—Mean Annual Surface Isotherms of the Atlantic. (After Buchan, "*Challenger*" *Report* on "Oceanic Circulation.") On the north-east and south-west sides they are deflected polewards by the warm North Atlantic Drift and Brazil Current; on the south-east and north-west sides equatorwards by the cold Labrador and Benguela Currents. Note the markedly different latitudes of the same isotherms east and west of South America and Africa; also the effect of the Falkland Current against the Brazil Current.

The fauna of the sea is divisible into the *plankton*, the swimming or drifting fauna which never rests on the bottom (generally taken now to include Hæckel's *nekton*, the strong swimmers, such as fish and cephalopods), and the *benthos*, which is fixed to or crawls upon the bottom. These groups require a further subdivision according to depth—the more necessarily since, to some zoologists, any water over 100 fathoms is "deep" or even "abyssal." It is simplest to begin with the benthos. From the shore seawards we may distinguish several zones. Even the tidal zone, between high and low water-mark, is subdivisible by its fauna and flora. There generally follows on this a very gentle slope to the depth of about 100 fathoms, locally subdivisible into many lesser zones. It has been termed the continental shelf or littoral zone, not very appropriately, since it occurs round many oceanic islands, and even away from any land. In this zone, if near land, fall to the bottom the heavy materials produced by land waste and river drainage. The fauna of this zone, generally very well characterized, may be distinguished as the *epibenthos*. As with the shallowest or tidal zone, its nature varies much more according to latitude and the character of the coast than the deeper zones. Everywhere, however, the epibenthic fauna is exposed to certain definite environmental conditions, as compared with a deeper fauna: namely, a high or fairly high temperature (except near the poles); a fairly good light, with its important consequence, a vegetable basis of food supply; tide and current to distribute the larvæ to a suitable habitat, which the varied nature of the bottom near land is likely to furnish. Passing farther seawards, we find a steeper slope to about the 500-fathom line, the so-called continental slope. In this zone the environment is absolutely different. The water, no longer subject to seasonal variations of temperature, or to direct sunlight, is cold, and of a nearly uniform annual temperature (300 fathoms, ±44·7° F.). Light has disappeared from all but the shallower part, and with it plant life; tide and current are no longer felt. To the latter fact is due, however, a great part of the food supply which maintains in this zone an abundant fauna: a great quantity of organic matter, brought down by river action, produced by disintegrated seaweed, and due to the death of surface organisms, together with the finer clayey materials of land waste, settles to the bottom in quiet water, near the 100-fathom contour, thus making the *mud-line* the richest feeding-ground in the ocean (Murray). The mud-line is the real upper limit of this zone: it typically begins at about 100 fathoms, but may begin at 5 to 20 fathoms in deep sheltered firths, or be pushed down to 300 fathoms where currents are strong. The fauna of this zone may be termed the *mesobenthos*; it is not so abundant, nor so sharply characterized, as the epibenthos, and yet is sufficiently distinct to deserve at any rate a provisional name. Another difference of condition between epibenthos and mesobenthos is the pressure of the water; at a depth of 500 fathoms this is, roughly speaking, half a ton to the square inch. It is very doubtful whether this enormous pressure makes the slightest difference to marine invertebrates, the tissues of which are uniformly permeated by fluids, so that the pressure is uniform in every direction; but animals with free gases naturally require time to adjust the gas-pressure when altering their levels. As regards the penetration of light, assimilative rays useful to plant life probably do not reach beyond 150 fathoms. Photographic rays have been detected as low as 220 fathoms, and if any light penetrate beyond this depth, it will consist only of blue, violet, and ultra-violet rays: it has been suggested that the red colour prevalent in many deep-sea animals may be a screen from these hurtful rays. Below the 500-fathom line the ocean bottom exhibits almost uniform conditions everywhere, varied only by the character of the bottom deposit and the amount of food supply. In this zone, which extends from about 500 fathoms to the greatest depths (which may in some cases exceed 5000 fathoms, or more than 5½ miles), the temperature at any given point is uniform throughout the year, and is always very low: the mean at 2200 fathoms is 35·2° F.; at greater depths and in special circumstances less than 30° F. has been recorded. The darkness is probably absolute; for food the animals are dependent upon each other and upon the incessant rain of dead plankton from higher levels; the pressure may be anything between half a ton and five tons per square inch. To the fauna which lives in these remarkable circumstances the name *hypobenthos* may be applied.

That each of the three benthic groups is well characterized by a special fauna is shown by the following table, out of the total numbers of species captured by the *Challenger* at seventy stations in these three zones:—

	Species confined to this Zone.	Species occurring in other Zones.
Epibenthos . .	91 per cent.	8 per cent.
Mesobenthos . .	74 ,,	25 ,,
Hypobenthos . .	61 ,,	38 ,,

Out of the 25 per cent. of its species which the mesobenthos shares with other zones, 59 per cent. occur also in the epibenthos, about 40 per cent. in the hypobenthos; the mesobenthos therefore, on these figures, may be taken to consist of 74 per cent. of peculiar species, 15 per cent. shared with the epibenthos, 10 per cent. with the hypobenthos. Speaking of the benthos as a whole, it may be said that the following statement holds good:—The number of individuals, the proportion of species to genera, and the number of individuals of a given species, all decrease with increasing depth. Animal life also tends to diminish with increasing distance from land; this may be partly due to the greater food supply near land, partly to the fact that population is obviously thinnest on the advancing fringe of a migration.

The plankton can be subdivided into at least two groups. The fauna to which light and warmth are more or less necessary, which feeds either upon plants or upon organisms nearly dependent upon plant life, may be termed the *epiplankton*. This fauna is capable of a good deal of vertical movement upwards and downwards, the causes of which are still obscure, but most of its members seem rarely to descend lower than about 100 fathoms. Below this depth the fauna may be called the *mesoplankton*. In every area this appears to have its peculiar species, but the careful study by opening and closing tow-nets of the distribution of the mesoplankton is of so recent a growth, that no statistics, such as we have of the benthos, are available. It is now generally admitted that the mesoplankton extends to the lowest depths yet searched (2730 to 2402 fathoms, Valdivia); but the number of specimens decreases rapidly after 200 fathoms, and below 1000 fathoms very little is captured. The conditions of light, temperature, pressure, &c., are practically those of the corresponding depths of the benthos; as regards the food, however, the mesoplankton can only depend on intercepting dead organisms which are falling from higher horizons, or on capturing the scanty prey of its own zone. It is possible that the plankton immediately over the bottom may prove to be sufficiently distinct to be separately classed as *hypoplankton*.

The main subdivisions of the marine fauna having thus been briefly sketched, it is advisable to consider them in somewhat more detail. The *epibenthos* is obviously that fauna to which, except in polar regions, light and warmth are necessary; and the absence of these at greater depths is probably the chief barrier to its vertical extension; the food supply is sufficiently plentiful in, at any rate, the upper parts of the mesobenthic zone to present no obvious barrier. The chemical constitution of the water (except to animals in brackish water near river mouths) and the pressure appear to exert little or no influence; and only those species which attach themselves to clean hard substances would be repelled by the mud-line. The chief barrier to a horizontal extension of the epibenthos is undoubtedly temperature. As an example of its distribution may be taken the Gastropod and Lamellibranch Molluscs, as groups of which the distribution has been studied for many years by specialists. The shallow-water species fall into provinces (compare Cooke, *Camb. Nat. Hist.*, vol. "Molluscs," ch. xii.), and a comparison of Figs. 1 and 3 shows at once the profound influence upon them of the great currents. Taking the Atlantic Ocean, we find the Arctic species, tempted southwards by the cold Labrador Current, repelled northwards by the warm North Atlantic Drift. The Boreal or sub-Arctic species, many of which are identical on both sides of the ocean (2 and 2′, Fig. 3), lie much farther southwards on the west than on the east side, from the same causes. The warm-water molluscs of West Africa (5) are cut off from those of the east side (7) by the cold water from the great easterly Antarctic Drift, which impinges on the Cape, giving it a special fauna (6). On the South American coasts the tropical and temperate fauna reach respectively to 28° S. and 45° S. on the east coast, owing to the warm Brazil Current; but the corresponding groups on the west coast only to 5° S. and 37° S., being kept back by cold upwelling and Humboldt's Current. This influence is visible in individual species as well as in the facies of a fauna: *Purpura lapillus*, a temperate form, reaches on the east side of the Pacific to 24° N. and on the East Atlantic to 32° N.; but on the West Pacific only to 41° N. and the West Atlantic to 42° N., being repelled by the Japan Stream (and other warm currents of the south-west monsoon) and Gulf Stream respectively.

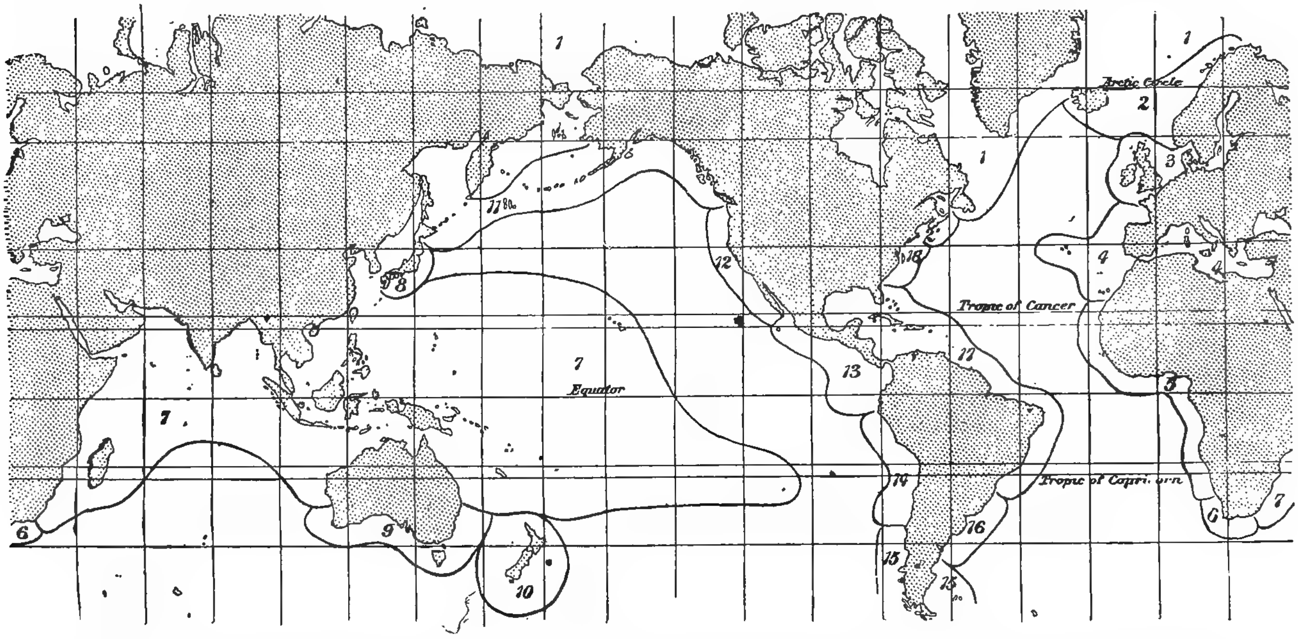

FIG. 3.—Diagram showing the coastwise (*not* seaward) extension of the provinces of Epibenthic Gastropods and Lamellibranchs. Provinces: 1, Arctic; 2, Boreal of East Atlantic; 2′, Boreal of West Atlantic; 3, Celtic; 4, Lusitanian; 5, West African; 6, South African; 7, Indo-Pacific; 8, Japanese; 9, Australian; 10, New Zealand; 11, Aleutian; 12, Californian; 13, Panama; 14, Peruvian; 15, generally termed Patagonian or Magellanic for purely epibenthic forms, but in many Orders part of the circumpolar Antarctic region; 16, Argentinian; 17, Caribbean; 18, Transatlantic.

But while some species may be confined to a bay, others to a province, others to an ocean, there are cosmopolitan species which either vertical or horizontal barriers, or both, fail to restrain. In relation to temperature the wide-ranging species are termed *eurythermal*, the limited, *stenothermal* (Moebius); the terms are useful to record a fact, but are not explanatory. It seems to be the case that to every organism is assigned a minimum temperature below which it dies, a maximum temperature above which it dies, and an optimum temperature at which it thrives best; but these have to be studied separately for every species. Similarly, in regard to depth, species have been classed as *eurybathic* and *stenobathic*, but, since increased depth practically means diminished temperature, these are probably merely expressions of the same fact in another form. That an Arctic shallow-water species should stretch to considerable depths is not surprising, but it is remarkable to find such forms as, for example, *Venus mesodesma* on a New Zealand beach at 55° F. and in 1000 fathoms at 37° F. off Tristan d'Acunha. The provinces of zoological distribution, like the geographical divisions of mankind, must be taken merely to indicate the facies of a well-characterized fauna, not to imply the restriction of all its habitants to that area.

In considering the effect of temperature (and this applies to plankton as well as to benthos down to 100 fathoms), attention must be directed not only to the question of general warmth or cold as expressed by the mean annual temperature, but also to the range between the annual extremes: these ranges of variation have been carefully mapped by Murray (*Geog. Journ.*, xii. 113; compare *ibid.*, xiv. 34). Still more important to the death-rate than these is the suddenness with which such variations occur: many animals are known to endure great extremes of heat and cold if exposed to them gradually, but to succumb to rapid alterations of temperature. Hence the frontier districts (*Mischgebiete*) between opposing currents are characterized by a heavy death-rate, and constitute marked barriers. A conspicuous instance of such a barrier in distribution is afforded at the Cape. The warm Mozambique Current, with a south-westerly direction off Natal, meets a north-east branch of the cold Antarctic Drift, and is beaten back eastwards: a result of the constant warring of these hot and cold currents is a high range of sudden temperature variation. Hence the Cape fauna consists mainly of only such species from neighbouring provinces as can endure high sudden variations; and the district is practically impassable. For example, nineteen species of Echinoids are known from the Cape district. Of these twelve are peculiar to the Indo-Pacific province, which stretches from East Africa to the Sandwich Islands and from Japan to Australia; two species are Southern Ocean forms, all but confined to south of 40° S.; four species are peculiar to the Atlantic Ocean: of these eighteen, not one gets past the Cape into the next province; the nineteenth is practically a cosmopolitan (Agassiz, "*Challenger*" *Reports*: "Echinoidea"; compare also Chun, *Aus den Tiefen des Weltmeeres*, pp. 157, 158).

Among the barriers to the horizontal extension of epibenthos must be mentioned a wide deep ocean. The Indo-Pacific fauna ranges from East Africa to about 108° W., stepping from island to island over the Pacific; but this continuity is then broken by 37 degrees of longitude and more than 2000 fathoms of water, and such sessile species as are most Mollusca (cf. Fig. 3) are unable to reach the American coast. This is presumably due to the fact that the planktonic larvæ of epibenthic adults must settle on a suitable bottom within a certain period or die. In spite of the direct set of the currents from Florida to the British Isles, the epibenthos of the two is absolutely dissimilar; the similarity of the two Boreal provinces (2 and 2′, Fig. 3) is to be assigned to a former continuity by way of Greenland, Iceland, and Faroe; a similar continuity, still unbroken, is exhibited by the Aleutian province on both sides of the Pacific. Though larvæ cannot cross wide oceans, adults may no doubt traverse great stretches occasionally on floating timber, &c.

This barrier by distance may be instanced in another way. In the Arctic regions land masses are continuous or contiguous, and there are many circumpolar species, as, for example, *Rhynchonella psittacea*: towards the South Pole the southern continent is almost ice-bound, and the available land consists only of the tips of the continents and of the few oceanic islands. Hence few if any littoral species are circumpolar. For example, not a single littoral Ophiurid surrounds the South Pole, but five or six species are circumpolar in the northern hemisphere.

Taking next the *mesobenthos* and *hypobenthos*, living at depths where temperature is constant and current practically negligible, there appears theoretically to be no reason why an organism which can thrive at 500 fathoms should not have a world-wide range over the bottom of all oceans. Yet this is not often, although occasionally, known to be the case; and although perhaps, speaking generally, hypobenthic species have wider ranges than epibenthic, still they also seem to be limited. It must, however, be remembered that the ocean is large, deep hauls of trawl or dredge few, and individuals at great depths scattered, so that too much stress must not be laid on this point. The *Challenger* results seem to allow of at least one generalization—the deeper the fauna, the wider its range. This is shown by the following table of the *Challenger* benthos: the first column gives the number of benthos species captured at depths indicated in fathoms by the second column; the percentage of these species which is known to have been captured between the tropics, as well as south and north of the tropics, is shown in the third column:—

Number of Specimens.	Horizon.	S. T. N.
4248	0–100	0·6
1887	100–500	2
616	500–1000	4
493	1000–1500	7
394	1500–2000	7
247	2000–2500	9
153	over 2500	9

We can only guess at the causes of the apparently limited range of many deep-sea types. (*a*) One of these is probably the limited food supply: presumably, as with a land fauna, there are as many mouths in a given area as it will support, and an equilibrium of species is maintained which will at least hinder the extension of any one. For food the bulk of the deep-water fauna is dependent upon the rain of dead organisms falling from higher levels; these, slowly disintegrating (probably under chemical, not bacterial, action), seem to form with the bottom deposit a kind of nitrogenous ooze, through which many deep-sea organisms slowly swallow their way, as an earthworm goes through earth, extracting nutriment. (*b*) Another hindrance to the extension of many deep-sea species is that they are *holobenthic*, that is, do not pass through a free-swimming larval stage; the means of dispersal is therefore regulated by the animal's own power of locomotion. Generally speaking, as might be expected, the freely-moving hypobenthos, fish and crustacea, have the widest ranges, and even these are not helped by currents, as are epibenthic or planktonic forms. The larval history of deep-water forms is, however, unfortunately obscure. (*c*) Lastly, extension of area of a species being at best difficult in deep water for non-swimmers, the place and date of their first migration must be taken into account; forms which have comparatively recently adopted deep-water life cannot be expected to have spread far from their original centre. As regards this point, in the first place, it is with migration, not with local evolution, that we have to deal: no classes and orders, only a few families and genera, rarely sub-orders, are peculiar to the hypobenthos; the deep members of each group consist for the most part of widely separated genera, the species do not grade into each other, as is so often the case in the epibenthos; and evolution could hardly have produced these species and genera under the uniformity of their present environment. This migration downwards from the mud-line has no doubt occurred all over the world, notably in the Southern Ocean, if we may judge by the richness of the deep-water fauna there to-day; probably also largely in Arctic and sub-Arctic regions, less so in tropical and temperate zones. As to the date of migration, the following fact seems to show that it is of comparatively recent origin, and is indeed still in progress: taking the *Challenger* species from the epibenthos, from the mesobenthos, and then from zones of 500 fathoms down to 2500, each zone shares a larger percentage of species with the zone above it than with that below it (except in one case where they are nearly equal). But it is not to be supposed that all our present-day deep-water forms began their migration simultaneously, and we can say with fair certainty that migration to deep water did not begin before the close of the Mesozoic epoch. Had it begun earlier, we should find typical Mesozoic and even older forms, or their congeners, at great depths: so far is this from being the case, that the most venerable animals of to-day—*Lingula*, *Amphioxus*, *Limulus*, 75 per cent. of Crinoids, 90 per cent. of Brachiopoda, &c.—are epibenthic or mesobenthic. On the other hand, it is extremely likely that the

Cretaceous epoch marked the commencement of migration. The hexactinellidan sponges are known to have lived in quite shallow water at the date of deposition of the Inferior Oolite; to-day none occur at a less depth than 95 fathoms; and as only two genera are known from the shallow Tertiary deposits, it would seem that the migration began about Cretaceous times (“*Challenger*” *Reports*: “Hexactinellida,” Schulze). In 1881 (Agassiz, “*Challenger*” *Reports*: “Echinoidea”) 105 living genera of Echinoidea were admitted; of these 23 per cent. were known from Cretaceous but not from Tertiary deposits, 35 per cent. from Tertiary but not Cretaceous, and 40 per cent. as Recent only. The species of Cretaceous genera constituted only 29 per cent. of the epibenthic Echinoids, 44 per cent. of the mesobenthic, and no less than 55 per cent. of the hypobenthic. These species of Cretaceous genera were distributed fairly evenly over all three zones, but 72 per cent. of the species of Tertiary genera and 55 per cent. of the Recent forms were confined to the epibenthos. As out of the twenty-five living genera known from the Cretaceous only seven are known also from Jurassic deposits, it is obvious that the close relationship is between Cretaceous and hypobenthos, rather than between any other geological and bathymetric horizons. Other instances, such as that of the Eryonidæ, seem to point to similar conclusions.

Excepting the essential air-breathers, practically every phylum and class and most orders are represented in the benthos. The epibenthos of warm seas appears to be especially wealthy in such forms as secrete heavy calcareous skeletons; but in colder water, among the epibenthos of polar or subpolar regions, and the hypobenthos everywhere in open oceans, the predominant forms are those which exhibit little or no calcareous secretion: even the apparent exceptions, Madreporaria and Echinoderma from great depths, tend to develop slighter skeletons than their warm-water congeners. The following table will serve to illustrate this point, and to give an idea of the composition of the epibenthos of cold and warm seas and of the hypobenthos: the figures are the percentages of total species captured in each locality by H.M.S. *Challenger*, the balance being made up by few specimens in scattered groups:—

	Kerguelen Area—over 1260 fm.	Kerguelen Area—0 to 150 fm.	Cape York—0 to 12 fm.	
Madreporaria .	0·8	0·0	3·3	Calcareous skeleton well developed.
Alcyonaria .	1·2	1·0	3·3	
Shelled Mollusca	8·0	19·7	57·3	
Decapoda . .	3·6	0·8	8·1	
Echinodermata .	33·6	11·7	7·9	
Actiniaria . . Hydrozoa . .	6·8	4·6	1·7	Calcareous skeleton light or absent.
Annelida . .	6·8	8·0	0·9	
Crustacea . . exc. Decapoda.	16·5	25·0	7·6	
Tunicata . .	4·4	6·8	1·1	
	81·7	77·6	91·2	

While the Madreporaria represent only 3·3 of the species at the tropical station, it must be remembered that they probably made up 80 per cent. or more of the weight.

The *epiplankton* is dependent either directly or proximately upon light, warmth, and the presence of plant life. The wealth of minute organisms near the surface is inconceivable to those who have not seen the working of a tow-net: it may be gauged by the fact that a single species is sometimes present in such quantities as to colour the sea over an appreciable area, and by the estimate that the skeletons of epiplankton from a square mile of tropical ocean a hundred fathoms deep would yield 16 tons of lime. In the tropics the wealth of species, and towards the poles the number of individuals of comparatively few species, are characteristic of these latitudes. In temperate and tropical regions there is a great difference between the epiplankton near land and that far out at sea: the former is termed *neritic*; it extends, roughly speaking, at least as far out as the mud-line, and is characterized by the predominance of what may be termed *hemibenthic* forms, that is, benthic forms with a planktonic larval stage (*Decapoda*, *Polychæta*, &c.), or with a planktonic phase (metagenetic Medusæ). The horizontal barriers to the neritic plankton are practically those mentioned as governing the epibenthos; indeed, it would seem that the distribution of hemibenthic adults is determined by that of their more delicate larvæ. Special conditions of wind and current may of course carry into the neritic zone forms which are characteristic of the open sea, and *vice versâ*. In the neritic epiplankton of polar waters the larvæ of hemibenthic forms are almost absent; indeed, the development of cold-water benthos, whether shallow or abyssal, appears to be in most cases direct, that is, without a larval metamorphosis. The epiplankton of the open sea is described as *oceanic*; it consists almost entirely of *holoplanktonic* forms and their larvæ. The chief barrier to horizontal distribution, here as elsewhere, is doubtless temperature. For example, through the reports of the *National* cruise (German Plankton Expedition) runs the same story; one fauna characterized their course from Shetland to Greenland and Newfoundland, another the traverse of the Gulf Stream, Sargasso Sea, and the Equatorial Currents. The influence of temperature may be gauged in another way: where hot and cold currents meet, occur “frontier” districts, in which the respective organisms are intermingled, and can only exist till their maxima or minima are reached. Well-marked examples of such districts occur off New Jersey (Gulf Stream and Labrador Current), in the China Sea (warm currents of the south-west monsoon and Kamchatka Current), in the Faroe Channel, south of the Cape (recurving of the Agulhas Current): in some of these the range of variation amounts to as much as 50° F. in the year, with the result of a colossal death-rate of the plankton, and its corollary, a rich bottom fauna, for which food is thus amply supplied. The majority of the oceanic epiplankton appears to be stenothermal; for example, few components of the well-characterized fauna of the Gulf Stream and Sargasso Sea ever reach the British shores alive, although, if current and salinity were the determining factors and not temperature, this fauna should reach to Shetland, and even to Lofoten. It will only be possible to make satisfactory distributional areas for these oceanic forms by such systematic traverses as that of the *National*; at present it would seem that adjacent species have such different maxima and minima that every species must be mapped separately (compare the distribution-maps of the *National* Plankton Expedition. Some members of the epiplankton are, however, extraordinarily eurythermal and eurybathic; for example, *Calanus finmarchicus* ranges from 76° N. to 52° S. (excepting perhaps for 10° each side of the equator), and is apparently indifferent to depth.

In the first hundred fathoms at sea the fall of temperature is gradual and slight, and forms practically no hindrance to the *diurnal oscillation* of the oceanic epiplankton—the alleged rise and fall of almost the entire fauna. Roughly speaking, the greatest number of animals is nearest the surface at midnight; but different species sink and rise at different times, and to or from different depths. Apart from this diurnal oscillation, unfavourable conditions at the surface send or keep the fauna down in a remarkable way: for example, in the Bay of Biscay few organisms are to be found in the first fathom in bright sunlight, but on a still, hot day the next few fathoms teem with life; yet, after a few minutes' wind or rain, these upper layers will be found almost deserted. This leads to the consideration of the *hydrostatics* of the plankton: apart from strong swimmers, the majority contests the tendency to sink either by some means of diminishing specific gravity (increasing floating power), or by increased frictional resistance. The former is generally attained (*a*) by increase of bulk through development of a fluid secretion of low specific gravity (vacuoles of *Foraminifera, Radiolaria*, &c.); (*b*) or of a gelatinous secretion of low specific gravity (*Medusæ*, Chætopod and Echinoderm larvæ, *Chætognatha, Thaliacea:* the characteristic transparence of so many oceanic forms is probably attributable to this); (*c*) by secretion or retention of air or other gas (*Physalia, Minyas, Evadne*); (*d*) by development of oil globules (*Copepoda, Cladocera*, fish ova). Increased frictional resistance is obtained by flattening out of the body (*Phyllosoma, Sapphirina*), or by its expansion into lateral processes (*Tomopteris, Glaucus*), or by the development of long delicate spines or hairs (pelagic *Foraminifera*, many *Radiolaria*, many Chætopod and Decapod larvæ). In many cases two or more of these are combined in the same organism. Notwithstanding the above adaptations, some of which are adjustable, it is difficult to understand the mechanics of the comparatively rapid oscillations of the epiplankton, of which both causes and methods are still obscure.

It will be seen from the distribution of the Thecosomatous Pteropoda—a purely oceanic group—how difficult it will prove to draw distributional areas for classes of epiplankton. Pelseneer recognizes in all ten such provinces ("*Challenger*" *Reports:* "Zool.," xix., xxiii.) and 42 good species: of the latter 1 is confined to the Arctic, 4 to the Antarctic province, but of the remaining 37 species and eight provinces, 30 per cent. occur in all eight, 16 per cent. in seven, and only 35 per cent. have as yet been captured in a single province only.

The *mesoplankton* has only received serious attention during the last few years. In the *Challenger*, open nets towed at various depths seemed to show the existence of a deep-water plankton, but this method gives no certain information as to the horizon of capture, the nets being open in their passage down and up. Chun constructed the first efficient net which could be opened and shut at known depths, using a propeller mechanism (*Bibl. Zool.*, vol. i.); and he improved his original pattern for the *National* and *Valdivia* expeditions. The present writer has devised a net, of which the opening and closing are effected from the deck by heavy weights; this has been used successfully on the Siboga expedition and in cruises of the *Research* (*Proc. Zool. Soc.*, 1898). Garstang has constructed an ingenious net which is useful in comparatively shallow water, but is open to criticism as being too light for depths beyond 100 fathoms; and several other types are in use. The existence of a mesoplankton, that is, of a plankton living between 100 fathoms from the surface and the bottom, has been generally considered as definitely proved by these nets. On the other hand, Agassiz, using the Tanner tow-nets, contends that while a mixture of surface and bottom species may occur in a closed sea near land, there is no intermediate fauna in the open ocean between about 200 fathoms from the surface and the bottom; his conclusions, based on negative evidence, have not met with general acceptance. Animals captured below the first hundred fathoms in the open sea (the Mediterranean, for special physical reasons, is on a special footing) are divisible into at least three categories: (1) those which are eurythermal and eurybathic, *e.g.*, *Calanus finmarchicus*; (2) those which, so far as we know, are purely mesoplanktonic and never come to the surface, for example, the Radiolarian family *Tuscaroridæ;* (3) those which, like some *Schizopoda*, spend a larval period in the epiplankton, and seek deeper water when adult, rising to the surface, if at all, only at night. But until the publication of the results of expeditions provided with efficient mesoplankton nets, generalizations about this fauna had better be stated with all reserve. There is, however, a certain amount of evidence to show that the mesoplankton includes different organisms in different latitudes; that surface animals of the north and south, unable to spread into the warmer surface water of lower latitudes, there sink into the cooler waters of the mesoplankton; the distributional area of such an organism will be in three dimensions bounded by isotherms (isobathytherms) and isothermobaths. As with the hypobenthos, there seems to be no theoretical reason against the universal distribution of the mesoplankton.

When a more systematic investigation of the various horizons has been carried out, many of the present cases of supposed *discontinuous distribution* will doubtless disappear. There are, however, undoubted cases of discontinuity where physical barriers have cut across a distributional area, an example of which may be cited here. The Isthmus of Panama was apparently only upraised about Miocene time, having been previously an archipelago through which a great circumequatorial current could pass; consequently the benthos of the Panama region shows marked alliance with the Caribbean, with which it was formerly continuous, but practically none with the Indo-Pacific. To the same cause is doubtless attributable the distribution of the five Decapoda which are characteristic of the Sargasso Sea, which are circumequatorial oceanic types, only occasionally littoral: three of these are known only from the Atlantic, one occurs in the Atlantic and Pacific, one in the Atlantic, Pacific, and Indian Oceans. The damming of a great circumequatorial current by the Isthmus of Panama is probably also responsible for that dislocation of currents which resulted in the present relations of the Gulf Stream and North Atlantic Drift to the Labrador Current, and cut the Atlantic Boreal fauna into two discontinuous districts (2 and 2′, Fig. 3).

Under the head of discontinuous distribution, the alleged phenomenon known as *bipolarity* must be mentioned. In summarizing the work of the *Challenger*, Sir John Murray maintained on the basis of the reports that numerous species occurred in both polar and subpolar areas which were absent from the tropics. He regarded them as the hardy survivors of a universal fauna which had withstood that polar cooling which set in towards the close of the Mesozoic period (Murray, *Trans. Roy. Soc. Edin.*, xxxviii., 1896; Pfeffer, *Verh. deutsch. Zool. Gesell.*, ix., 1899). This view and the facts on which it was based have been acutely contested, and the question is still far from settlement (for lists of the literature see Ortmann, *Am. Nat.*, xxxiii. 583; and Pratt, *Mem. Manchester Soc.*, xlv., 1901). As regards the purely epibenthic and sessile fauna, there are a few undoubted instances of actual specific identity: in some classes, however, such as the Echinoderms, this does not appear to hold (*Hamburger Magalhaensche Sammelreise;* and Römer and Schaudinn's *Fauna Arctica*); but even in these the general composition of the fauna and the presence of certain identical and peculiar genera seem to point to something more than a mere "convergence" due to similar environment. As regards the plankton of the two polar regions and such epibenthic forms as extend also into deep water, the suggestion has been made that the Arctic and Antarctic benthos and plankton are really continuous by way of deep water in the main oceans, where the organisms can find a suitably low temperature. As an instance of this, Chun (*Bezieh. zwischen dem arkt. und antarkt. Plankton*, 1897) cites *Krohnia hamata*, a characteristic Arctic and sub-Arctic constituent of the epiplankton and mesoplankton, known only from the mesoplankton in the tropics, but rising to 38 fathoms at 40° S. 26° E. More exact information, such as may be expected from the various Antarctic expeditions, is required to settle this interesting question with its far-reaching corollaries; and, like other matters of marine distribution, it can only be solved by a more systematic, more restricted, and more co-ordinated scheme of exploration than has characterized former expeditions. (G. H. Fo.)

II. Terrestrial.

The discoveries and investigations which have taken place since 1887 render it advisable to make some emendations in the scheme of zoological regions into which the land surface of the globe was parcelled out in the ninth edition of this work (vol. vii. p. 269). Much of the evidence in favour of these new ideas has been drawn from the remarkable palæontological discoveries which have taken place in Patagonia. The result of these has been to demonstrate that while in certain respects the fauna of South America is even more peculiar than had been supposed, yet at the same time it exhibits previously unsuspected relationships with that of Australia (as exemplified by the discovery of Australian types of extinct marsupials), while its connexions with that of Africa have likewise been intensified. Another result of such discoveries has been to engender a wide belief that the alternations of land and sea on different parts of the surface of the globe have been much greater than was formerly considered probable. Indeed, several lines of evidence indicate that during the Jurassic and Cretaceous epochs of the Mesozoic, or Secondary, period of the earth's history there was a continuous land-connexion between Africa (by way of Madagascar and the Seychelles) and India; while at some time in the Mesozoic era South America was in communication with South Africa by way of what is now the South Atlantic.[1] This latter connexion appears to have been a survival from an older Palæozoic girdle of land, which, from the evidence of fossil floras, seems to have existed in low latitudes round nearly three-quarters of the circumference of the globe, and was cut off by sea from the land to the north. One of the problems still remaining for solution is whether a remnant of this old land-girdle served to connect the southern continents in Tertiary times, or whether these communications were by means of an Antarctic continent. For it is now generally admitted that both Africa and South America have been connected to the southward with Australasia during the Tertiary epoch, although not necessarily (or indeed probably) at the same time or for any very long period. Dr H. O. Forbes[2] was one of the first to urge that these connexions took place by way of the Antarctic continent; and although this view has been controverted,[3] it has been accepted by several American writers, among them Dr W. B. Scott. For the present the question may be left open, with the remark that there is no evidence to indicate that during the Tertiary period such an Antarctic continent was ever suited to the existence of temperate forms of animal life. Some may, however, contend that this remark is in favour of the Antarctic theory, seeing that the forms common to the three areas are but few, and that these few just managed to effect a crossing under unfavourable climatic conditions, while other types that made the attempt perished.

One of the defects in the scheme of zoological regions adopted in the article in the ninth edition was that it did not bring into sufficient prominence the essential and striking differences by which the mammalian (and to a great extent also the avian) faunas of Australasia and South America are respectively distinguished from that of the whole of the remaining land-surface of the globe. To remedy this defect Dr W. T. Blanford[4] in 1890 proposed to make three primary zoological divisions of the land area of the earth, which he respectively called the Australian, the South American, and the Arctogæan regions. A weak point in this otherwise admirable scheme is that since the term "region" is likewise applied to the subdivisions of Arctogæa, there is considerable danger of confusion between the primary and secondary divisions. An amendment proposed anonymously[5] in 1893 was to substitute the names Notogæa, Neogæa, and Arctogæa for the three primary divisions of Dr Blanford. Yet another emendation, suggested by the present writer,[6] and subsequently adopted by Professor H. F. Osborn,[7] was to designate these three primary divisions as "realms," and to reserve the name "region" for their subdivisions.

In addition to these all-important changes in the main scheme of zoological division of the globe, various modifications of the limits of these regions, as defined in vol. vii. of this work (p. 269), have from time to time been suggested by different writers. One of the most important of these—the separation from the Ethiopian of a distinct Malagasy region—was urged by Dr Blanford in the address already cited. The same writer also advocated the union of the Palæarctic and the northern part of the Nearctic region, under the name of Aquilonian, while he separated the southern portion of the Nearctic as the Medio-Columbian region. For this latter region Dr C. H. Merriam[8] adopted the less cumbrous title Sonoran. It may be added that if the Palæarctic and Nearctic regions (exclusive of their southern portions) are regarded as one, it seems preferable to employ the term Holarctic, which appears to have been proposed by Dr Heilprin in 1878. Yet another important innovation was made in 1896 by Mr W. L. Sclater,[9] who proposed the transference of the island of Celebes from the Australian to the Oriental region, this view being subsequently supported by Dr Max Weber.[10] A further step in the same direction was made in 1898 (partly on information obtained from Dr Blanford) by the present writer,[11] who suggested that a similar transference should be made in the case of Lombok, Flores, and Timor. The effect of this change was to do away with "Wallace's line" (the channel between Bali and Lombok), to which so much importance was attached in the ninth edition of this work, but it appears that the deepest channel is really situated to the eastward of the island of Timor.

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[1] See M. Neumayr, *Erdgeschichte*, vol. ii. p. 263 (1895).

[2] "The Chatham Islands; their Relation to a former Southern Continent," *Supplemental Papers R. Geographical Society*, 1893, pp. 607-637.

[3] R. Lydekker, *A Geographical History of Mammals*, p. 134 (1896).

[4] *Proc. Geol. Soc.*, 1890, p. 76.

[5] *Natural Science*, vol. iii. p. 289.

[6] Lydekker, *op. cit.*, p. 27.

[7] "Correlation between Tertiary Mammal Horizons of Europe and America," *Annals New York Academy*, vol. xiii. p. 48 (1900).

[8] "The Geographical Distribution of Life in North America, with special reference to the Mammalia," *Proc. Biol. Soc. Washington*, vol. vii. pp. 1-64 (1892).

[9] "The Geography of Mammals," part v., *Geographical Journal*, 1896.

[10] "On the Origin of the Fauna of Celebes," *Ann. Mag. Nat. Hist.*, ser. 7, vol. iii. pp. 121-136 (1899).

[11] Lydekker, "Celebes; a Problem in Distribution," *Knowledge*, vol. xxi. pp. 175-177 (1898); see also "Deer of All Lands," p. 168 (1898).

Still another modification of the older scheme already referred to has to be recorded. Several writers had suggested the advisability of regarding the southern portion of the Palæarctic as a distinct region, and in 1896 this idea was carried into execution by Dr P. Matschie,[1] who defined a Mediterranean–Chinese region, which should include northern Africa, south and a part of central Europe, and that portion of Asia lying between the Himalaya and the Altai (inclusive) and its eastern extension. To this region the name Mediterranean seems most suitable. It may be added that Dr Matschie, together with several American writers such as Dr Merriam and Professor Osborn, also advocate a Boreal, or Arctic region, to embrace the northern parts of both hemispheres, which extends farther south on the eastern coast of North America than elsewhere. There are, however, many arguments against the claims of this tract to rank as a distinct zoological region of Arctogæa.

The zoological realms and regions of the land surface of the globe, as indicated by the distribution of mammals, may accordingly be tabulated as follows (Fig. 4):—i. Notogæa, containing the Australian region; ii. Neogæa, with the Neotropical region; and, iii., Arctogæa, including, 1, the Malagasy; 2, the Ethiopian; 3, the Oriental, or Indo-Malayan (which is taken to embrace Celebes, Flores, Timor, &c.); 4, the Mediterranean; 5, the Holarctic (regarded by many authors as two, the Palæarctic and Nearctic), and 6, the Sonoran region. It may be added that the name Indo-Malayan is preferable to Oriental, on account of the latter term being employed by botanists to denote Asia Minor and the adjacent countries; also that perhaps a Polynesian and a Hawaiian region may be recognized in Notogæa, although from a mammalian standpoint these regions are of little or no importance, owing to the practical absence of mammals from the islands by which they are represented. One other point needs mention before this portion of the subject is dismissed. In the ninth edition of this work the Ethiopian region was taken to include Arabia south of the tropic, but Mr R. I. Pocock [2] has pointed out that the distribution of scorpions does not support this division of Arabia, and he would refer the whole of it to the Holarctic or Mediterranean region. This contention is in some degree supported by the discovery of a species of thar (*Hemitragus*) in southern Arabia, since this group of animals has no representative in Africa, but occurs elsewhere only in the Himalaya and the mountains of southern India. Other writers, however, have not accepted Mr Pocock's emendation; and the reference of the northern half of Arabia to the Mediterranean and of the southern half to the Ethiopian region is usually followed.[3] The area is admittedly a meeting-ground of at least two faunas, so that a difference of opinion in regard to its classification is only to be expected.

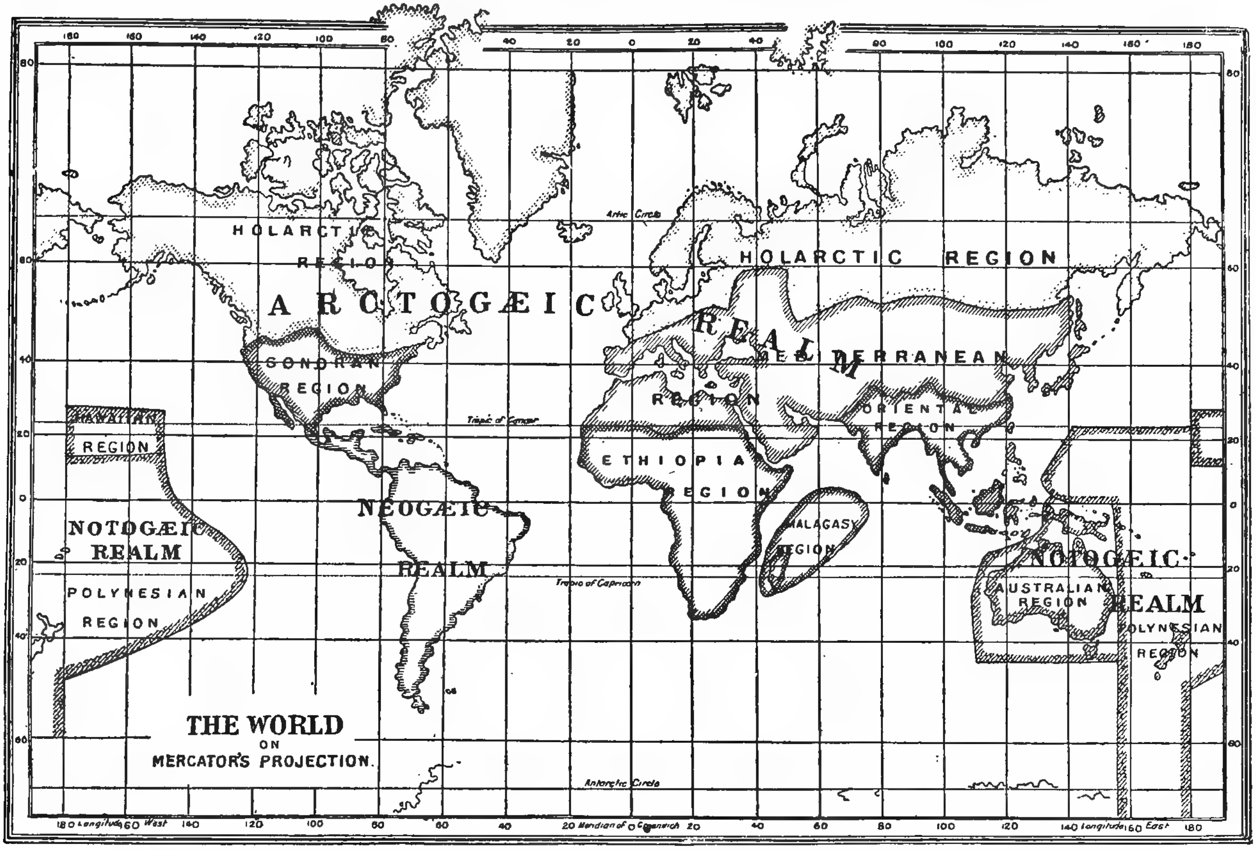

Fig. 4.—Map of the World showing the Zoological Realms and Regions of the Land Surface.

To a very large degree the distribution of birds accords with the foregoing zoo-geographical regions, which are made on the evidence of mammals. This, however, is not so with regard to reptiles, amphibians, and fishes; and to a certain extent this discrepancy may be explained by the greater antiquity of these groups, which began their wanderings at an epoch when mammals occupied a very subordinate position among the world's inhabitants. But there is some difficulty in accepting this explanation as altogether sufficient, since it has been shown by Mr Pocock[1] that the distribution of scorpions (which form an extremely ancient group) and of certain other groups of Arachnida indicates zoological regions very curiously similar to those given above. In addition to the Holarctic (Palæarctic and Nearctic), Mr Pocock recognizes a Mediterranean, Ethiopian, Oriental, Australasian (excluding Celebes and Timor), Sonoran, and Neotropical region, so that the sole difference between this and the mammalian scheme is the non-recognition of a distinct Malagasy region. Even here, however, the difference is more apparent than real, since it is stated that the scorpions of Madagascar entered that island at an earlier date than those now found on the mainland, which are strikingly different from the Malagasy forms; a similar explanation is generally applied to the case of the Malagasy mammals. The geographical distribution of scorpions, however, does not support the division of the land surface of the world into three primary "realms."

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[1] "Geographische Fragen aus der Säugethierkunde," *Verhandl. Ges. Erdkunde*, Berlin, 1896, pp. 245–256.

[2] "Scorpions and their Geographical Distribution," *Natural Science*, vol. iv. pp. 353–264 (1894).

[3] In the map of the Ethiopian region facing p. 132 in Messrs. Sclater's *Geography of Mammals* (1899), southern Arabia is referred to the Ethiopian region, but in the map of the world forming pl. i. of the same work the whole of Arabia, together with the Sahara, is coloured as Ethiopian.

As regards the distributional areas indicated by other vertebrates, those of the land tortoises, lizards, and snakes, which differ essentially from one another, will be found in the article (ninth edition) on REPTILES, by Dr A. Günther, who gives the divisions indicated by fresh-water fishes in the article on FISHES. The distribution of amphibians has been studied by Mr G. A. Boulenger, who recognizes (1) a Northern Zone, in which the tailed forms (*Caudata*) are abundant and the limbless forms (*Apoda*) absent, and which is subdivided into a European–Asiatic and a North American region; and (2) an Equatorial Southern Zone, divided into two sections, one of which comprises an Indian and an African region, and the other a tropical American and an African region. The regions are therefore not very dissimilar to those given in the article in vol. vii. of this work. But Madagascar has strong claims to recognition as a distinct region. It may also be mentioned that, in the regions indicated by land and fresh-water tortoises, tropical America and Madagascar are grouped together, owing to the occurrence in both areas of forms like *Podocnemis*. Since, however, that genus occurs fossil in the early Tertiary deposits of the northern hemisphere, its peculiar distribution may be accounted for without the necessity of invoking a direct land connexion between the two areas to which it is now restricted.

Reverting to the consideration of mammals, this point brings us face to face with two diametrically opposite views as to the mode in which a large number of forms have reached their present habitats in the southern hemisphere. According to what may be called the old-fashioned hypothesis, as advocated by Huxley and Wallace, at least a very large proportion of the animals now restricted to the southern continents originated in the northern hemisphere and made their way south by various land routes. This hypothesis receives support from the circumstance that a large number of such southern types are represented in the Tertiary deposits of the northern hemisphere, whereas they are quite unknown in those of the south. On the other hand, according to a more modern theory, all or most of such southern types, in spite of the above-mentioned fossil evidence, are regarded as having originated in the southern hemisphere. Not only is this considered to have been the case with modern forms now confined to the south, but it is inferred to have been so with Mesozoic types which are at present known only from the northern hemisphere. For instance, it has been suggested that the few Mesozoic mammals known from the European Jurassic were stragglers from a southern land where such forms were abundant.[2] Apart from the boldness of a hypothesis which transfers the origin of creatures from localities where they certainly did exist to others where there is no evidence of their occurrence, it may be pointed out that the rarity of such remains in Europe is quite what might have been expected from the rarity of fresh-water deposits in the Jurassic series. Moreover, whenever such deposits do occur, there mammalian remains are invariably met with. On the older hypothesis, a large amount of evolution in respect of the more modern types must have taken place in the southern hemisphere, and such evolution must in some cases have taken place while the three great southern continents were still connected with one another at certain periods.

Taking these three continents seriatim, it may be noticed that Dr Wallace adopted the view that Australia received its population of marsupials from Asia by way of the Austro-Malayan islands, as has certainly been the case with its limited and later rodent fauna. This view was supported and expanded by the present writer.[3] One of the arguments employed is the occurrence of remains of opossums (*Didelphys*) in the lower Tertiaries of both Europe and North America, these animals being nearly allied to the Australian *Dasyuridæ*. Professor B. Spencer,[4] on the other hand, is of opinion that the Australian marsupials reached their present home from Antarctica by means of a land connexion subsequent to the insulation of New Zealand, and that consequently the group is of southern, instead of northern, origin. However this may be, the discovery in the Tertiary deposits of Patagonia (which are probably of Miocene age) of remains of extinct marsupials, such as *Prothylacinus* and *Amphiproviverra*, nearly related to the existing *Thylacinus* of Tasmania, seems to afford indisputable evidence of a land connexion between South America and Australia at a time when the marsupials of the latter area had already become differentiated into their present types. Probably the occurrence in South America of another family of marsupials—the *Epanorthidæ*—of which all the representatives save *Cœnolestes* are extinct, affords additional evidence in favour of the same land-connexion. Still more important is the occurrence in both areas of large tortoises belonging to the extinct genus *Miolania*, which is quite unknown in the northern hemisphere. Moreover, seeing that in Australia the remains of this genus occur in strata which are probably of Pleistocene age and are certainly not older than Pliocene, it would seem likely that the land-bridge occurred at a comparatively late epoch. The land connexion must, however, apparently have been either very imperfect or must have lasted for only a very limited period, as, had it been otherwise, the resemblances between the faunas of Notogæa and Neogæa would have been much more marked than is now the case. All who have written on this subject are practically in accord as to the existence of this land-bridge; the only discrepancies are as to how and when it occurred. According to the views suggested by the present writer, it took place (possibly by way of Polynesia) subsequently to the peopling of Australia with its marsupials from Asia, whereas according to Professor Spencer it was the means of supplying Australia with its marsupials from the Antarctic continent.

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[1] *Op. cit.*, and "The Geographical Distribution of the Arachnida of the Orders Pedipalpi and Salifugæ," *Natural Science*, vol. xiv. pp. 213–231 (1899).

[2] See A. S. Woodward, *Vertebrate Palæontology*, p. 417 (1898).

[3] *Geographical History of Mammals*, p. 127.

[4] *Report of the Horn Expedition to Central Australia*, pp. 187 and 188 (1896).

Admitting, then, some form of land-bridge between Australia and South America by means of which the common types of marsupials passed from the one area to the other, the next point for consideration is the origin of the other members of the peculiarly isolated fauna of Neogæa, this isolation being especially marked in middle Tertiary times. Now, there is a considerable amount of evidence to indicate the separation by sea of this area from North America during much of the Tertiary period, and if this be the case there would seem to be strong *primâ facie* probability that the ancestors of the peculiar South American Ungulata, Edentata, Primates, and Rodentia effected an entrance into their present habitat by some route other than that afforded by the Isthmus of Darien. If the necessity for such an alternative route be admitted, Africa is the only country which will serve as the means of communication. This view has been advanced both by Professor W. B. Scott[1] and the present writer,[2] the former remarking that the connexion "is much more likely to have been due to the junction of both continents with the Antarctic land mass than to a transatlantic bridge. Such a mode of connexion would explain the very wide divergence in the character of the mammalian faunas which still exists between Africa and South America, for a circumpolar land would very likely oppose climatic barriers to migration and confine that migration to comparatively few groups." Considerable difficulty, however, is now experienced in accepting this hypothesis, on account of the circumstance that the Eocene Ganodontia—the presumed ancestors of the Edentates—appear to have attained their chief development in North America. Professor Osborn[3] is inclined to regard the latter country as the feeder which supplied Neogæa with the most characteristic elements of its fauna. He is, however, compelled to admit that there has probably been also some land connexion between South America and Africa, which is presumed to have been by way of Antarctica. This connexion is considered to have led to the introduction of the Hyrax-like Ungulates met with in the Patagonian Tertiaries, and to have taken place at a later date than the presumed connexion with North America. It is further urged that during the connexion with Africa the latter country received from South America the ancestors of its pangolins and aard-varks. From the evidence of the scorpions and their allies, Mr Pocock[4] likewise inclines to the opinion that Neogæa received the bulk of its fauna from North America, but that certain elements in it may be traced to a connexion with Africa. Possibly it may prove that this is the true explanation with regard to the mammals, and that while the ancestral Edentata, and probably some of the Ungulata, effected an entrance during a transient connexion with North America, the Hyrax-like Ungulata came in from Africa together with the Hystricomorphous Rodents and perhaps certain other types.

Amid this uncertainty it is satisfactory to be able to touch firm ground in one place. After a long period of more or less complete isolation from the north, it is certain that about the close of the Miocene epoch a land connexion was established between Neogæa and North America, and that by means of this bridge not only did a certain number of characteristic South American types effect an entrance into the latter area, but a host of northern forms, such as bears, sabre-toothed tigers, raccoons, deer, llamas, peccaries, tapirs, horses, mastodons, and squirrels made their first appearance in a land where glyptodons, ground-sloths, ant-eaters, armadilloes, sloths, and a host of peculiar ungulates had previously been the dominant types.

Turning to the Ethiopian region, it is mentioned in the ninth edition (vol. xii. p. 275) that this area received its present fauna of large mammals from the north, and it is abundantly proved that a number of generic types now restricted to this region flourished during the Pliocene epoch in southern Europe and Asia. It has further been urged that this great immigration of modern types took place subsequently to the insulation of Madagascar, which had been populated by an earlier immigration of more lowly types. Professor Osborn,[5] however, has propounded the theory that, instead of being of foreign origin, the present Ethiopian fauna is autochthonous, and that Africa has been at first a great centre of evolution and subsequently of dispersal, so that it has formed the feeder of southern Europe and Asia, instead of having drawn its fauna from these areas. Several migrations northwards from Africa are assumed to have occurred, the scale-tailed squirrels (*Anomaluridæ*), with perhaps the aard-varks and pangolins, being some of the earlier emigrants. The mastodons and dinotheres, he says, started later, while a third emigration included antelopes, giraffes, hippopotamuses, horses, and rhinoceroses. It is urged that by this hypothesis alone can be explained the apparently sudden appearance of the Proboscidea in the European Miocene. But there is decisive evidence to show that the evolution of the elephants from the mastodons took place in south-eastern Asia during the Pliocene epoch, and this renders it highly probable that the African elephant is of Asiatic origin. This being so, and since nothing is known of the vertebrate palæontology of that area below the Upper Miocene, it is a fair inference that the evolution of the Proboscideans themselves from other Ungulata should have occurred there also. Again, in the face of evidence that modern types of African mammals flourished in Europe and Asia during the Pliocene, and in the absence of any evidence of their existence in Ethiopian Africa previous to the present epoch, it is a very bold statement to say that the latter area was their birthplace. Moreover, the fact that many of these Asiatic mammals, such as the hippopotamus, are more generalized than their modern representatives is against their African origin. There are also difficulties with regard to Madagascar. In the first place, on the assumption that Africa was the ancestral home of its present fauna of large mammals (which, on this hypothesis, must date from the Miocene), it is not easy to explain why this fauna failed to effect an entry into the adjacent island before its separation from the mainland. In the second place, it is still more difficult to account for the intimate relationship which has been demonstrated to exist between the extinct *Adapis* of the European Oligocene and the existing Malagasy lemurs—a relationship which it is perfectly easy to understand on the old hypothesis that Madagascar received its fauna from Europe *viâ* Africa before the immigration of the higher types into Ethiopia took place and at a period when it was still united with the mainland. (R. L*.)

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[1] "Antarctic Palæontology," *Science*, ser. 2, vol. iii. pp. 308 and 309 (1896).

[2] *Geographical History of Mammals*, p. 127.

[3] *Annals New York Acad.*, p. 54.

[4] *Natural Science*, vol. xiv. p. 236.

[5] *Annals New York Acad.*, vol. xiii. p. 56, and "The Geographical and Faunal Relations of Europe and America during the Tertiary Period, and the Theory of the Successive Invasions of an African Fauna," *Science*, ser. 2, vol. xi. pp. 561–574 (1900).

Zorilla, Manuel Ruiz, Don (1834–1895), Spanish politician, was born at Burgo de Osma in 1834. He began his education at Valladolid, and studied law afterwards at Madrid University, where he began to show a strong leaning towards Radicalism in politics. In 1856 he was elected deputy for the first time, and soon attracted notice among the most advanced Progressists and Democrats. He took part in the revolutionary propaganda that led to the military movement in Madrid 22nd June 1866. He had to take refuge in France for two years, like his fellow-conspirators, and only returned to Spain when the revolution of 1868 took place. He was one of the members of the first cabinet after the revolution, and in 1869, under the regency of Marshal Serrano, he became minister of grace and justice. In 1870 he was elected president of the House of Deputies, and warmly seconded Prim in offering the throne to Amadeus of Savoy. He went out to Italy as president of the commission which had received from the Cortes the mission of carrying to the prince at Florence the official news of his election. On the arrival of Amadeus in Spain, Ruiz Zorilla became minister of public works for a short time, and resigned by way of protesting against Serrano and Topete entering the councils of the new king. Six months later, in 1871, he was invited by Amadeus to form a cabinet, and he continued to be the principal councillor of the king until February 1873, when the monarch abdicated in sheer disgust at the resistance he met with in the army, and at the lack of sincerity on the part of the very politicians and generals who had asked him to come over and ascend the throne. After the departure of Amadeus, Ruiz Zorilla resolutely advocated the establishment of a republic in Spain. Notwithstanding this, he was not called upon either by the Federal Republicans to help them during the year 1873, or by Marshal Serrano during 1874 to join Martos and Sagasta in his cabinet. Immediately after the restoration of Alphonso XII., early in 1875, Ruiz Zorilla went once more to France and became the most persevering adversary of the new state of things. He was for nearly eighteen years the soul of the republican conspiracies, the prompter of the revolutionary propaganda, the chief inspirer of the persistent intrigues concerted by discontented military men of all ranks. He gave so much trouble to the Madrid Governments that they organized a special watch over his movements and doings, with the assistance of the French Government and police, especially when it was discovered that the two military movements of August 1883 and September 1886 had been prepared and assisted by the exile. During the last two years of his life Ruiz Zorilla took less active part in the propaganda of the Progressist Republicans, who still looked up to him as a leader. Failing health and the loss of his wife had decreased his energies, and at last the Madrid Government allowed him to return to his native land some months before he died at Burgos, 13th June 1895, of heart disease. (A. E. H.)

Zorrilla y Moral, José, Don (1817–1893), Spanish poet and dramatist, son of a magistrate in whom Ferdinand VII. placed special confidence, was born at Valladolid on 21st February 1817. He was educated by the Jesuits at the Real Seminario de Nobles in Madrid, wrote verses when he was twelve, became an enthusiastic admirer of Scott and Chateaubriand, and developed his taste for the theatre by taking part in the school performances of plays by Lope de Vega and Calderon. In 1833 he was sent to read law at the University of Toledo, but the study had no interest for him, and, after a year of elaborate idleness, he fled to Madrid, where he horrified the friends of his absolutist father by making violent speeches and by founding a newspaper which was promptly suppressed by the Government. The young editor narrowly escaped transportation to the Philippine Islands, and passed the next few years in great poverty. The tragic death of the satirist Larra brought Zorrilla into notice. His elegiac poem, declaimed at Larra's funeral on 15th February 1837, was much admired, and served as an introduction to the leading men of letters. In 1837 he published a book of verses, mostly imitations of Lamartine and Hugo, which was so favourably received that he was encouraged to print six additional volumes of verse within three years. His subjects are treated with fluency and grace, but the carelessness which disfigures so much of his work is prominent in these juvenile poems. After collaborating with the popular playwright, Antonio García Gutiérrez, in a piece entitled *Juan Dándolo* (1839), Zorrilla began his individual career as a dramatist with *Cada cual con su razón* (1840), and during the following five years he wrote twenty-two plays, many of them extremely successful. His *Cantos del trovador* (1841), a collection of national legends versified with infinite spirit, showed a decided advance in technical skill, and secured for the author the place next to Espronceda in popular esteem. National legends also supply the themes of his dramas, though unfortunately in this department Zorrilla has somewhat compromised his fame by merely adapting older plays which had fallen out of fashion. For example, in *El Zapatero y el Rey* he recasts *El montañés Juan Pascual* by Juan de la Hoz y Mota; in *La mejor razón la espada* he borrows from Moreto's *Travesuras del estudiante Pantoja;* in *Don Juan Tenorio* he adapts from Tirso de Molina's *Burlador de Sevilla.* But his clever rearrangements usually contain original elements of value, and in *Sancho García*, *El Rey loco*, and *El Alcalde Ronquillo* he apparently owes little to any predecessor. The last and (as he himself believed) the best of his plays is *Traidor, inconfeso y mártir* (1845). Upon the death of his mother in 1847 Zorrilla left Spain, resided for a while at Bordeaux, and settled in Paris, where his incomplete *Granada*, a striking poem of gorgeous local colour, was published in 1852. In a fit of profound depression, the causes of which are not known, he emigrated to America three years later, hoping, as he says, that yellow fever or small-pox would carry him off. During eleven years spent in Mexico he produced little, and that little was of no merit. He returned in 1866, to find himself a half-forgotten classic in a Spain which had not seen him for nearly twenty years. His old fertility was gone, and new standards of taste were coming into fashion. A small post, obtained for him through the influence of Jovellar and Cánovas del Castillo, was abolished by the republican minister. He was always poor, but for some twelve years after 1871 he was in the direst straits. The law of copyright was not retrospective, and, though some of his plays made the fortunes of managers, they brought him nothing. In his untrustworthy autobiography, *Recuerdos del tiempo viejo* (1880), he bitterly asked if it were just that an author who each year filled every theatre in Spain and Spanish-speaking America during the month of October should be driven to die in the hospital or in a madhouse. A small pension of 30,000 reales secured him from actual want in his old age, and the reaction in his favour became an apotheosis. In 1885 the Spanish Academy, which had elected him a member many years before, presented him with a gold medal of honour, and in 1889 he was publicly crowned at Granada as the national laureate. He died at Madrid on 23rd January 1893. Zorrilla is so intensely Spanish that it is difficult for foreign critics to do him justice. It is certain that the extraordinary rapidity of his methods has seriously injured his work. He declares that he wrote *El Caballo del Rey Don Sancho* in three weeks, and that he put together *El Puñal del Godo* (which owes much to Southey) in two days; and, if these stories be true, his deficiencies need no other explanation. An improvisator with the characteristic faults of luxuriance and verbosity, he wrote far too much, and as in most of his numbers there are numerous technical flaws, the reading of his verse is seldom an unalloyed pleasure. Yet the richness of his imagery, the movement, fire, and variety of his versification, will preserve some few of his choicest songs in the anthologies. His appeal to patriotic pride, his accurate dramatic instinct, together with the fact that he invariably gives at least one of his characters a most effective acting part, have enabled him to hold the stage; and, unless some very unforeseen change of taste should occur, it is not impossible that *Don Juan Tenorio* may still be played sixty years hence. In any case, it is by *Don Juan Tenorio*, the play of which he thought so meanly, that Zorrilla will be best remembered. (J. F.-K.)

Zug, the smallest of the Swiss cantons. Its total area is 92 square miles. Population (1888), 23,029; (1900), 23,276, or 253 per square mile, the canton in respect of density ranking eleventh in the Confederation. The population is mostly Catholic and German-speaking. The capital is ZUG, with 6471 inhabitants; Baar has 4481, and Cham 3019. A railway runs from Zug to Arth along the east shore of the Lake of Zug. There are eleven administrative districts in the canton.

A new cantonal constitution was adopted in 1894. The legislature (one member to every 350, or fraction over 150, inhabitants) and the seven members of the executive are elected directly by popular vote, proportional representation obtaining in both cases if more than two members are to be elected to similar posts in the same electoral district. Besides the former "facultative Referendum" in certain cases, and the "Initiative" at the demand of 1000 citizens in case of amendments to the cantonal constitution, there is now also an "Initiative" in case of Bills, to be exercised at the demand of 800 citizens. In 1897 the state revenue of Zug was 444,727 francs (a rise of 91¾ per cent. since 1885), and the state expenditure 442,815 francs (a rise of 66¾ per cent. since 1885), but in 1898 there was a deficit of 2220 francs. In 1897 the public debt was 843,000 francs. Herr Karl Bürkli has shown that the battle of Morgarten in 1315 certainly took place on the eastern shore of the Lake of Aegeri, between Haselmatt and Buchwäldi, so that the battlefield is wholly in the canton of Zug, and not in that of Schwyz, as formerly imagined.

See BLUMER. *Staats u. Rechtsgeschichte d. Schweiz. Demokratien*, 3 vols. St Gall, 1850–59.—BÜRKLI. *Ein Denkmal am Morgarten: wo ist sein Platz?* Zug, 1895.—STADLIN. *Die Topographie d. Kant. Zug*, 4 vols. Lucerne, 1819–24.—STAUB. *Der Kant. Zug*, 2nd edition. Zug, 1869. (W. A. B. C.)

Zuider Zee, an inland gulf or sea of the Netherlands, bounded on the north by a chain of islands, namely, Texel, Vlieland, Terschelling, Ameland, and Schiermonnikoog, and on the west, south, and east by the provinces of North Holland, Utrecht, Gelderland, Overyssel, and Friesland. The Zuider (*i.e.*, southern) Zee was once bounded on the north by a line of land stretching between Stavoren (Friesland) and Enkhuizen (North Holland). In the early centuries of our era the Zuider Zee was still a land-locked lake, Flevo, surrounded by fens and moors, into which the Vecht, Eem, and Yssel discharged their waters. Thence these waters issued as the Vliestroom, which, winding its way through the low clay and fens of North Holland and Friesland, reached the North Sea by the Vliegat, between Vlieland and Terschelling. High tides and north-west storms swept away the western banks of Vliestroom and Lake Flevo. In 1170 the land between Stavoren, Texel, and Medemblik was washed away. The open waterway between Stavoren and Enkhuizen, such as it now exists, dates from 1400. In the south and east the work of destruction was arrested by the high sandy shores of Gooi, Veluwe, Voorst, and Gasterland.

This brief sketch of its history will suffice so far to account for the shallowness of the Zuider Zee, the condition of its shores, and the nature of its bottom. In its actual state it measures 85 miles from north to south, has a maximum breadth of 45 miles; area, 2027 square miles. Its mean depth is 11·48 feet; depth in the southern basin of the former lake, 19 feet; at Val van Urk (deep water to the west of the island of Urk), 14½ feet. If a line be drawn from the island of Urk to Marken, and thence westwards to Hoorn (North Holland) and north-north-east to Lemmer (Friesland), these lines will connect parts of the Zuider Zee having a uniform depth of 8 feet. The other parts on the coast are only 3 feet deep or less. This shallowness of its waters served to protect the Zuider Zee from piracy and the invasion of large ships of war. It also explains how in our times many commercial towns, only accessible at high-water to ships of 4·8 to 8 feet draught, have declined to the rank of provincial trading and fishing ports. Eighty per cent. of the bottom consists of sea clay and the more recent silt of the Yssel; 20 per cent. of sand, partly in the north about Urk and Enkhuizen, partly in the south along the high shores of Gooi, Veluwe, &c. The shallowness of the sea and the fertility in its bottom have for many years occasioned various projects of drainage, the more serious of which emanate from the Zuider Zee Vereeniging (1886), two of them forming the subject of a report in 1894 by a State Commission. The two projects agree in building a dyke from the island of Wieringen to the coast of Friesland. The area to the south of this would be divided into four polders, with reservation, however, of a lake, Ysselmeer, covering the part where the sea was deep and the bottom less fertile, whence branches would run to Yssel and the Zwolsche Diep, to Amsterdam, and, by sluices near Wieringen, to the northern part of the sea. The four polders with their areas of fertile soil would be:—

(1) North-west polder, area 53,599 acres; fertile soil, 46,189 acres.
(2) South-west ,, ,, 77,854 ,, ,, ,, 68,715 ,,
(3) South-east ,, ,, 266,167 ,, ,, ,, 222,275 ,,
(4) North-east ,, ,, 125,599 ,, ,, ,, 120,783 ,,

The Lake Ysselmeer would cover 358,150 acres. The gain would be the addition to the kingdom of a new and fertile province of the area of North Brabant, a saving of expenses on dykes, diminution of inundations, improvement of communication between the south and the north of the kingdom, protection of isles of the sea, &c. The costs are calculated as follows: (1) enclosing dyke, sluices, and regulation of Zwolsche Diep, £1,760,000; (2) reclamation of four polders, £5,200,000; (3) defensive works, £400,000; (4) indemnity to fishermen, £180,000; total, £7,540,000. (C. M. K.)

Zululand, a British protectorate in south-east Africa, forming part of Natal, bounded on the N. by Portuguese possessions, on the S.E. by the Indian Ocean, on the S. and S.W. by the river Tugela, and on the W. by Transvaal and Swaziland. After the defeat of Cetewayo by the rival chief Zibebu (1883), and his death in 1884, his feeble successor, Dinizulu, held his ground for some time, and was even able by the aid of the Transvaal Boers to expel Zibebu. But the Zulu nation, exhausted by a long series of foreign wars and dynastic feuds, were no longer in a position to resist the steady advance of the Boers, who had already absorbed the Wakkerstroom and Utrecht districts, and set up the "New Republic" within the recognized frontier of Zululand proper (1880). The acquisition of this territory was a direct infringement of the spirit if not of the actual letter of both the Pretoria and London Conventions. The Boers in 1885 were so encouraged with the success of the policy which had given them the "New Republic" that by the end of that year their claims extended to nearly three-quarters of Zululand. These claims were finally dealt with in 1886 by the British Government, who agreed to recognize the "New Republic," but with boundaries considerably less extended than the Boers desired. In May 1887 the British Government at length decided to annex what remained of Zululand, and accordingly proclaimed the country British territory, under the title British Zululand. The British flag had actually been hoisted at St Lucia Bay in 1886, when it was evident that Germany had designs on this coast, but the annexation at that time on the part of the British was not formally extended to the "hinterland" (see SOUTH AFRICA). In 1888 the "New Republic" was, with the consent of the British Government, incorporated with the South African Republic, and subsequently became known as the Vryheid district of that state.

From 1883 to May 1887 "the Zulu Native Reserve" was under the administration of a resident commissioner. The resident was under the control of the British special commissioner for Zulu affairs, and a mounted native police force was maintained to keep order. The same organization was extended after annexation to the whole territory. The governor of Natal was created governor of Zululand, and had supervision of the administration of the country. The resident commissioner's headquarters were at Eshowe.

At the end of 1889 and beginning of 1890 some small tracts of territory lying between Zululand and Tongaland, under the rule of petty semi-independent chiefs, were added to British Zululand; and in 1895 the territories of the chiefs Sambana and Umtegiza, 688 square miles in extent, lying between the Portuguese territories, Swaziland, Zululand, and Tongaland, were also added. In the same year a British protectorate was declared by Sir Henry Loch, acting under instructions from Lord Ripon, over Tongaland. The coast-line was thus secured for Great Britain up to the boundary of the Portuguese territory at Delagoa Bay. The advisability of securing this coast-line will be obvious when it is borne in mind that in the first instance Germany had endeavoured to obtain St Lucia Bay in 1884, and that the Boers were intriguing with native chiefs in order to obtain the territories of Sambana and Umtegiza in 1895. In reference to the British annexation of the territories under these two chiefs, Mr Kruger telegraphed a protest, in which he said: "Taking into consideration previous negotiations, and the fact that the two territories are not of the least importance to her Majesty's Government, this annexation cannot be regarded by this Government otherwise than as directed against this Republic. They must therefore regard it as an unfriendly act, against which they hereby protest." This protest must be considered in connexion, not only with the natural desire of Great Britain to prevent another Power from establishing itself on the south-east African seaboard, but also with the fact that the Boers had been the first to reap the benefit of Great Britain's defeat of the Zulu power by acquiring the "New Republic," and further that a similar policy of more or less irresponsible annexation had enabled them to establish themselves in Swaziland. For a time Tongaland was administered by the governor of Zululand as special commissioner for Tongaland. On 27th December 1897 Tongaland was annexed to Zululand, and on 30th December of the same year the whole of Zululand became a portion of Natal, being represented by one member in the Legislative Assembly.

Zululand comprised a total area of 11,000 square miles, with a population approximately estimated (1900) at 185,000, thus distributed :—

	Area in Square Miles.	Population.
Province of Zululand . .	9,000	143,000
South (British) Tongaland . .	2,000	42,000
Total . . .	11,000	185,000

When the country was incorporated with Natal, certain reservations were made with a view to safeguarding the material and moral interests of the natives. None of the public lands can be sold to European settlers without the sanction of the Imperial Government, nor can any change be made in the tribal customs in respect of land tenure or other matters compatible with orderly government. Thus, while witchcraft and all sanguinary rites are abolished, the former regulations affecting the sale of arms and spirits are maintained in full vigour. Dinizulu, who had been exiled to St Helena after the revolt of 1888, was at the same time restored to his country.

AUTHORITIES.—RUSSELL. *The Story of Natal. Natal Statistical Year-Books.*—INGRAM. *Natalia.*—PRATT. *Leading Points in South African History.* (A. P. H.)

Zürich, one of the Swiss cantons, ranking officially as the first. Its total area is 665 square miles. Of this 620·3 square miles are classed as "productive," forests covering 191·4 square miles and vineyards 19·3 square miles. The population was 316,074 in 1880, and 337,183 in 1888, while in 1900 it was 430,336. In 1900 there were 648 inhabitants to each square mile. The Protestants were then estimated at 344,206, Roman Catholics at 81,424, and there were 2987 Jews. Classified according to language, 414,105 spoke German, 4019 French, 11,081 Italian, and 614 Romonsch. The state revenue of the canton in 1897 was 16,988,089 francs (a rise of 167¼ per cent. since 1885), and the state expenditure 16,645,822 francs (a rise of 194½ per cent. since 1885), while the surplus in 1898 was 912,193 francs. In 1897 the public debt was 28,678,876 francs. The budget for 1901 showed 19,889,426 francs expenditure as against 18,204,879 francs revenue, *i.e.*, a deficit of 1,684,547 francs. The cantonal constitution of 1869 is still in force, but in 1898 it was decided by a popular vote that the legislature has power to fix the number of the members of the executive. Zürich and Winterthur are the two chief towns of the canton. There are many railways in the canton, as well as a partly electric and partly funicular line from Zürich up the Zürichberg, where is the Dolder Hôtel.

Zürich, the capital of the Swiss canton of the same name, and the most populous and most important town in the Swiss Confederation. In 1893 the nine outlying communes or townships were incorporated with the town proper. Population (1888), 90,088; (1900), 150,703. The majority of the inhabitants, nearly four to one, are Protestants, and they are almost all German-speaking. In 1898–99 the University had 65 professors and an attendance of 403 matriculated students, besides 20 "hearers" (in the summer session of 1900, 1039 in all). In 1899–1900 the Federal Polytechnic School had 1007 full students and 449 "hearers." The town has grown very rapidly in size, wealth, and prosperity. Much land has been rescued from the lake, and is now covered with fine public buildings and splendid private villas. One of the most magnificent of the newer buildings is the Swiss National Museum, behind the railway station. This museum, which was opened in 1898, contains a wonderful collection of Swiss antiquities and art treasures of all kinds, some of which are placed in rooms of the actual date, removed from various ancient buildings. To the stranger this museum is now the chief object of interest in Zürich.

AUTHORITIES.—BÜRKLI-MEYER. *Geschichte d. Zürcher Seidenindustrie.* Zürich, 1884.—EGLI. *Actensammlung z. Gesch. d. Zürcher Reformation, 1519–1533.* Zürich, 1879.—MEYER VON KNONAU. *Der Kant. Zürich,* 2 vols. St Gall and Bern, 1834 and 1846. *Mittheil. d. antiq. Gesellschaft von Zürich.* From 1841.—STÄHELIN. *Huldreich Zwingli,* 2 vols. Basel, 1895–97. (W. A. B. C.)

Zutphen, a town in the province of Gelderland, Holland, at the influx of the Berkel into the Yssel, about 10 miles by rail south of Deventer, and 18 miles north-north-east of Arnhem. Its provincial trade has been improved by the railway connexion with Amsterdam, Arnhem, and Germany. Population (1900), 18,490.

Zvenigorodka, a district town of Russia, in the government of Kieff, 35 miles from Tsvyetkovo (a junction on the railway from Kieff to Nikolaieff). It has several flour-mills and distilleries, and carries on trade in grain and animal products. Population (1897), 16,972.

Zwickau, a town of Germany, capital of the circle of Zwickau, on the Zwickauer Mulde, 20 miles by rail west-south-west of Chemnitz, kingdom of Saxony. There is a gymnasium, with a public library of 20,000 volumes, a *real* gymnasium, a higher-grade and six other burgher schools, a mining, a technical, two commercial, and several guild schools. The archives of the town hall include documents of the 13th century and MSS. of the works of Hans Sachs. The coal-fields in the precincts comprise 55 pits reaching to a depth of over 2000 feet, employing upwards of 11,000 persons and yielding over £1,000,000 annual value. Population (1880), 35,005; (1890), 44,198; (1900), 55,825.

Zwolle, capital of the province of Overyssel, Holland, on the Zwarte Water, near the influx of the Vecht, 55 miles by rail north-east of Utrecht, connected by canals with the Yssel and the Zuider Zee. Its cattle-market is, next to that of Rotterdam, the most important in the kingdom. Population (1901), 30,848.